MA4-URB2, June 2010
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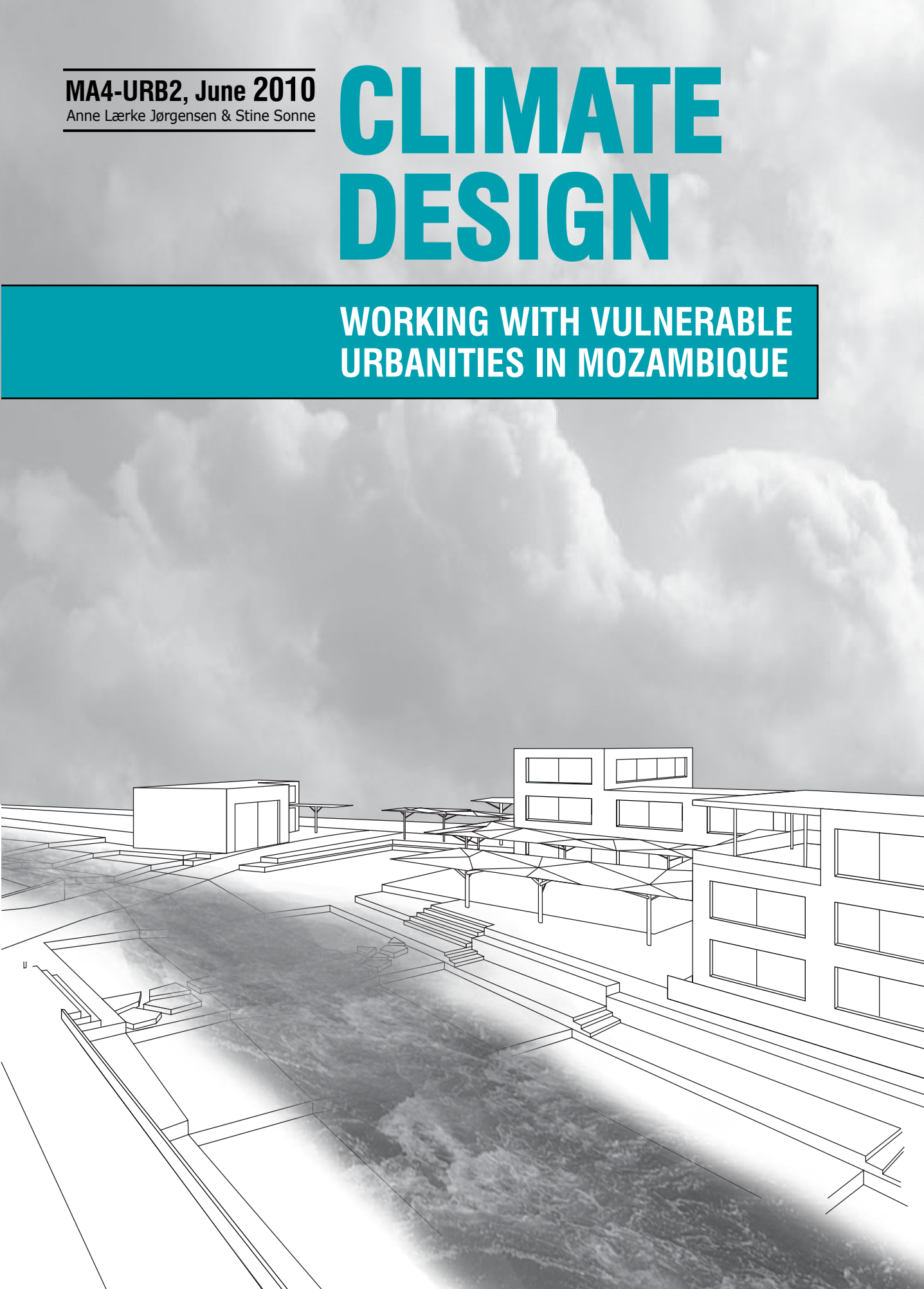
CLIMATE DESIGN

WORKING WITH VULNERABLE URBANITIES IN MOZAMBIQUE



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Anne Lærke Jørgensen

Stine Sonne

SYNOPSIS

The project of 'Climate Design – Working with vulnerable urbanities in Mozambique' deals with the challenges of climate change adaptation in vulnerable informal areas. The project takes place in North-eastern Maputo, the capital of Mozambique. The area is attractively located close to the ocean and the city centre and has lately experiences a rapid uncontrolled growth in housing developments. The areas low elevation makes it vulnerable to a rising sea-level and run-off water, which already now coursing unstable conditions for the build environment and will due to the prospect of climate change only worsen in the future. The first product of the report is a strategic process and action plan focusing on how the elements of infrastructure, barriers and landscape modification can form a flexible solution for how the area can adapt to climate change, through projects that benefit development in North-eastern Maputo. The second product is a zoom in design of an 8 ha large area located on a hillside bordering North-eastern Maputo. It focuses on how a new road and a wadi can be implemented in an area around an erosion trench in such a way that they accommodate the present local urban concerns. More specifically it addresses issues of water treatment, accessibility, densification, programming and creation of community generators.

Preface

This report reflects the Master Thesis of Stine Sonne and Anne Lærke Jørgensen at the Civil Engineer master program of Urban Design at the faculty of Architecture and Design at Aalborg University in Denmark. The product consists of the present report and the appurtenant drawings, design process and appendix CD. The CD contains research material and sources not jet published and additional research and analysis material such as registration pictures and transcribed interviews, with both locals and professionals done during our stay in Maputo in February 2010.

We have through the execution of the report gained great help of both very practical and scientific character and from this we thank; Architect Carlos Trindade and Architect Mahomed Narotamo of the Faculty of Architecture and Physical Planning, Eduardo Mondlane University for background knowledge and material on the development of the city and arrangement of contacts and for knowledge about the new municipal master plan and future development of Maputo, Maputo, Architect Paulo Da Conceicao Jr. from the UN-Habitat for information of the intention of CCCI project in Maputo; Geologist Mussa Achimo for clarification of the geological aspects of North-eastern Maputo and last but not least Architects Farnando Ferreiro and Eduardo Feuerhake for general help and arrangement of contacts. For more practical help in relation to conducting the interviews with the local residents we would like to thank Otelo Uetera, Wacela Macamo and Pedro Coimbra

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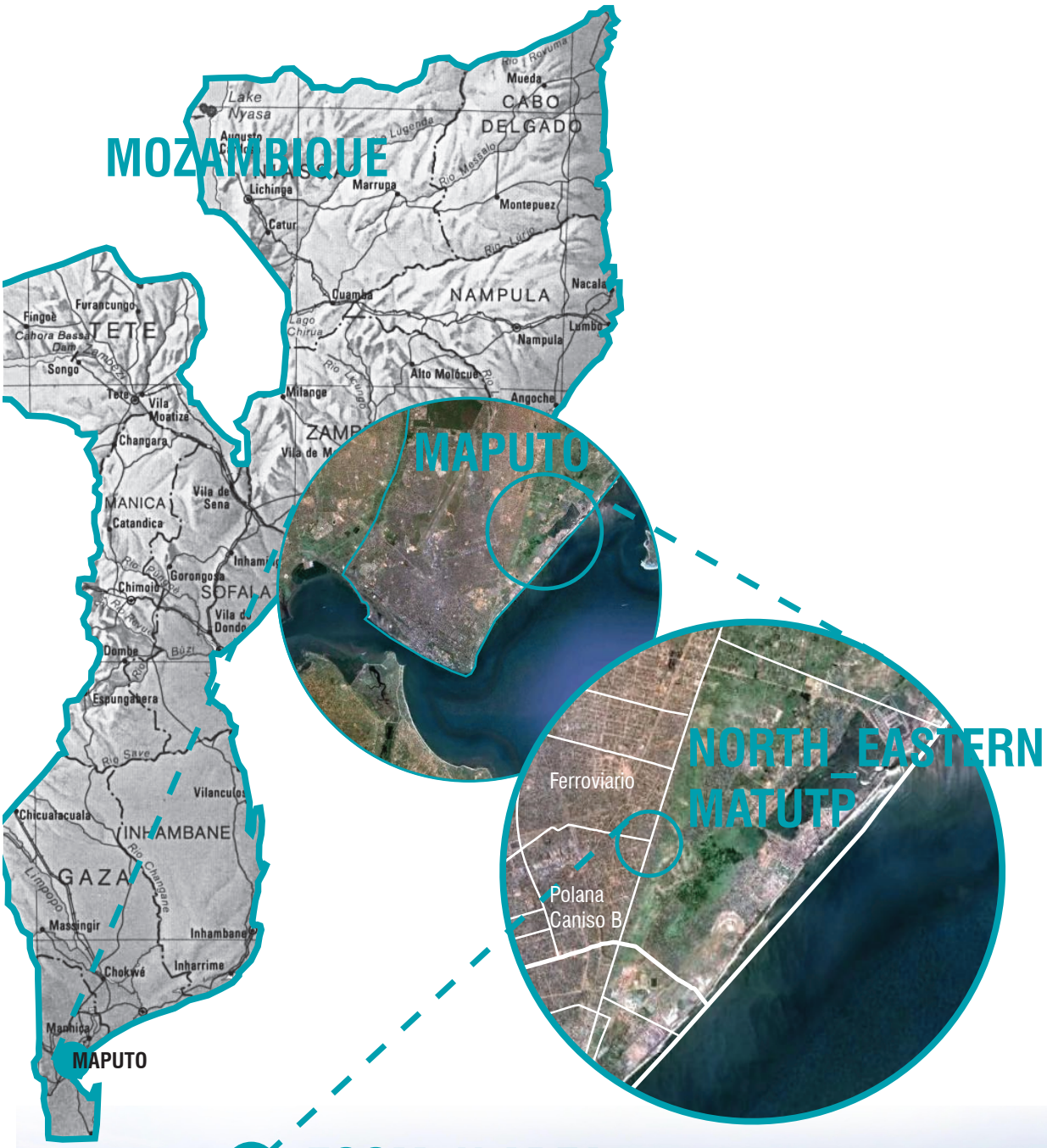


ZOOM IN AREA

Erosion trench between the areas Ferroviario and Polana Canico B

INTRODUCTION

What are the most critical facts about climate change? And how are we going to deal with their consequences? The swarm of discussion surrounding our changing climate has introduced a range of 'most critical' facts, and consequently a range of suggestions for possible scenarios and solutions. This climate adaptation design project is based on analyses of the Intergovernmental Panel on Climate Change (IPCC). These analyses were also the foundation for the discussions at COP15 in December 2009.

The immediate consequences of climate change are extreme weather events and sea level rise. These two phenomena alone concern, and must be acknowledged by, most countries. Unfortunately not all countries are able to withstand and defend themselves against these changes, especially not countries with small political and economic means. It is these countries that are most vulnerable to climate change. The IPCC (2007b: 21) defines vulnerability as: "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character magnitude, and rate of climate change and variation to which a system is exposed, its sensibility and its adaptive capacity."

This project takes as its point of departure Mozambique that, due to its location on Africa's east coast, is highly vulnerable to climate change, especially those of hydro metrological origin. Mozambique has 2700 km of coastline, 9 rivers discharging into the Indian Ocean, and is one of the poorest countries in the world. Mozambique is already experiencing consequences of climate change and, as indicated by IPCC (2007), it is one of the most vulnerable countries in the world. Zooming in on Mozambique's capital, Maputo raises another issue. Like most urban areas in Africa, Maputo is experiencing uncontrolled urbanisation.

Maputo's problems are accumulating due to rapid and uncontrolled growth in informal settlements and slum areas. One of these areas is North-eastern Maputo, a large low-lying coastal district at the edge of the city. Although this area is one of the only remaining places in Maputo with space for urban development, several areas are not suitable for development at its present state. The topography of North-eastern Maputo causes numerous problems related to hydrology. It serves as a run-off area for higher elevated and densely populated neighbourhoods and therefore suffers from severe flooding. Furthermore, it is facing the prospect of being permanently flooded by the rising sea level, which is already now challenging the coastline.

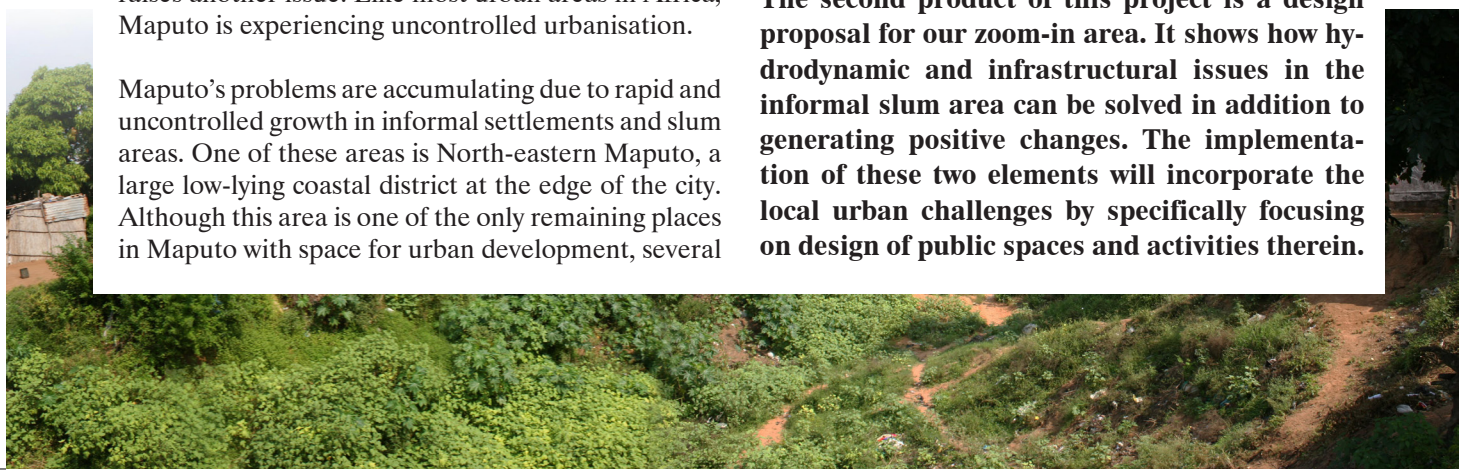
The project focuses on how the North-eastern Maputo can deal with climate change and uncontrolled urban growth on two scales, focusing on urban planning and design.

The first product of this project is a 'strategic process and action plan', which provides strategic and flexible solutions for urban development in North-eastern Maputo.

The elements of the plan are a connected series of individual projects that together form a flexible backbone structure and planning tool for urban development with room for uncertainties and bottom up initiatives in a planning process over the next 100 years.

One of the first and most important elements in the strategic process and action plan is to create a less vulnerable build environment by managing the hydrodynamic flow. There are vast run-off issues along the hill bordering North-eastern Maputo to the west, resulting in erosion tranches and vulnerable environments both on the hillside and at the foot of the hill. Moreover, the areas along the hill are poorly connected to the rest of the city and are therefore in need of infrastructural upgrading. We will zoom in on one of these erosion trenches.

The second product of this project is a design proposal for our zoom-in area. It shows how hydrodynamic and infrastructural issues in the informal slum area can be solved in addition to generating positive changes. The implementation of these two elements will incorporate the local urban challenges by specifically focusing on design of public spaces and activities therein.



Escadaria D' Água seen from the lake side

Chapter 01

DESIGNING IN THE CONTEXT OF VULNERABLE URBANITY AND CLIMATE CHANGE

"Much of the growth in emissions in developing countries results from the provision of basic human needs for growing populations..." (WRI, 2010)

After years of discussing whether or not anthropogenic climate change is a fact or an exaggeration of natural fluctuations, the debate has come to a point where most researchers and politicians agree that human activity, and the resulting greenhouse gas emissions, is significantly responsible for a foreseeable changing climate (for further details see Appendix 1). With the recognition of the primary source of climate change and our common responsibility the debate now focuses what to do and how. The most recent world event focussing on the common responsibility was the 15th Conference of the Parties (COP15) in December 2009. The conference resulted in the Copenhagen Accord, which was broadly criticised.

COP15 and Climate Change

The Copenhagen Accord states:

- The countries acknowledge that climate change is one of our times larges challenges
- The countries agree that according to science, deep cuts have to be made in the global emissions
- The countries acknowledge the scientific point of view that the increase in the global warming should be kept under 2 degrees (Copenhagen Accord, 2009)

The criticism of the Copenhagen Accord mostly focuses on that COP15 was not able to constitute its results in a legally binding document. Another issue in the debate during the conference was climate justice; raising the question of who suffers from climate change and who is responsible. In finding answers for these questions the COP15 participants did not agree and there were collisions of thought between some of the developed countries and some of the developing countries.

On one side several of the developed countries argue that based on today's emissions, all nations should commit in reducing emissions, especially since some of today's big "sinners" are the newly developed coun-

Fig. 1.1
CO^2 emission

tries like China and India. They argue that the efforts of developed countries be futile if these developing countries do not cut down their CO2 emissions (Shah, 2009).

On the other side the World Resource Institute brings climate justice into the debate by arguing that:
"Much of the growth in emissions in developing countries results from the provision of basic human needs for growing populations, while emissions in industrialized countries contribute to growth in a standard of living that is already far above that of the average person worldwide" (WRI, 2010).

The above-mentioned discussion and their arguments are of course a simplification of the debate, but it serves to illustrate why the COP15 goal of reaching an ambitious and legally binding agreement for reducing greenhouse gas emissions was difficult.

Moreover, the Copenhagen Accord does acknowledge that the developed and developing countries hold different capabilities to cut down emissions. It states:
"The countries should cooperate to secure that global and national emission will peek as soon as possible, and the countries recognise that the time frame for when the curve peaks must be longer for the developing countries."

Additionally, the COP15 participants also agree that the developing countries are most vulnerable and least adaptable to climate change. Therefore these countries are in need of immediate and long-term financial aid to minimize the present and future effect of climate change (Copenhagen Accord, 2009).

Fig. 1.2
Boys in slum area

Vulnerable Urbanities

Over the last two decades, a series of extreme weather events in urban areas has set focus on the vulnerability of cities to the effects of climate change. Meanwhile, cities themselves are significant contributors to the emissions of greenhouse gases through housing, transport and consumption. A situation that looks only to exacerbate if current global urbanisation trends continue (United Nations, 2008).

The effects of climate change are especially severe in dense slum areas in developing countries where people do not have the economic means or the political support to either adapt to the changes or to move away (Aromar, 2008). Beside the obvious lack of economic resources and governance, the political complexities of slums and informal areas magnify their vulnerability and make them extremely hard to work with. Many governments do not even acknowledge their existence in the city and therefore not the problems they face and even those that do do not have the economic and political tools to deal with such problems efficiently.

Coping with climate change is one aspect, but many urban areas are also dealing with a rapid urbanisation trend which is a great challenge particularly in slum areas. The rapid urbanisation puts pressure on slum areas, with high population densities, which again sets higher demands on the infrastructural systems like drainage and sewers. These areas are already stressed with an overload of residents for its capacity and therefore it creates a vulnerable environment. Even small changes in population density can make physical systems like drainage inefficient. This may again lead to floods during annual rainfalls and have harsh consequences in the event of heavy rain falls (ActionAid, 2006).

IPCC (2007: 21) define climate change vulnerability of a system as:

"The degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity."

As IPCC (2007) argues, systems become vulnerable when they are unable to cope with the stress put on them. Consequently, the regions that are already at high risk in the present day are also more likely to be adversely affected by the increasing number of extreme weather events. The effect of this can already be seen and predictions point to an escalating exacerbation since the intensity and duration of the droughts and floods will worsen in developing countries (Dodman, 2009).

With the predicted consequences and the time aspect of the climate changes lined up, there is no questioning that the time to act is now. And for architects and planners it is time to evaluate and adapt their approaches to design, taking the changing climate into consideration and integrating it as a variable element in their work.

Fig. 1.3

Chapter 02

THE DESIGN CHALLENGE OF CLIMATE CHANGE

What does design for climate change look like?

It is not until recently that design projects have become a part of the debate about climate change. Reports have been written on how to deal with climate change, and how to work towards sustainable urban development, but how does it look? To start the debate of how to design while acknowledging climate change, we need to start a creative process, asking ourselves, what can urban architects do to solve the problems?

This section presents four cases exemplifying how climate change and climate adjustment has been tackled different places in the world and at different scales. The two first cases discuss overall landscape and urban design strategies, while the latter two cases discuss adaptation and upgrading of vulnerable urbanities on a local community level. All four cases focus on solving problems on the basis of a holistic design approach.

Fig. 2.1
Extreme weather event

PLANNING FOR CHANGE

The first case "Facing Up to Rising Sea-levels: Retreat? Defend? Attack?" deal with future threats and extreme scenarios that generally are met with doubt and scepticism. The fact that the projects presented are hypothetical show the lack of existing examples of how to deal with climate change problems in existing large scale urban environments.

CASE: FACING UP TO RISING SEA-LEVELS: RETREAT? DEFEND? ATTACK?

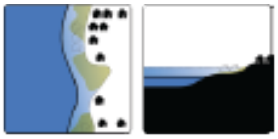
Building Futures (2009) launched together with Institution of Civil Engineers a project and exhibition with the purpose of provoking the general environment of architects, engineers, planners and politicians to debate the future consequences of climate change for coastal cities in Britain.

Britain has 12.000 km of coastline and around 10 million people will be affected by the rising sea-level. In recent years Britain has been plagued by large floods, which, due to climate change, will increase in frequency and intensity. In light of the prospects of a rising sea-level and a sinking landmass, coastal flooding is the primary future threats of the cities, and it is this threat that the project "Facing Up to Rising Sea-levels: Retreat? Defend? Attack?" considers. The project presents ideas on how to tackle the future situation in the two coastal cities of Hull and Portsmouth and, as the title indicates, three different design approaches are elaborated upon: retreat, defend, and attack.

As the project from Hull shows, the three solutions are all extremely radical if carried out to their fullest. 'Retreat' indicates a retraction of the entire city to locations that are more elevated and, thus, more secure. 'Defend' relates to the strategy of creating fortification around the existing city defending it from the sea. 'Attack' suggests that the city to gradually adapt to the rising sea by simply moving out into it, building a new city on poles and partly abandoning the old city and leaving it to adapt to climate change.

Building Futures (2009) does not only take design into consideration but takes the discussion further, according to them there are three overall challenges

Retreat?



"To retreat is to step back from the problem and avoid a potentially catastrophic blow. It is to move critical infrastructure and housing to safer ground and to allow the water into the city to alleviate flood risk." (Building futures, 2009: 11)

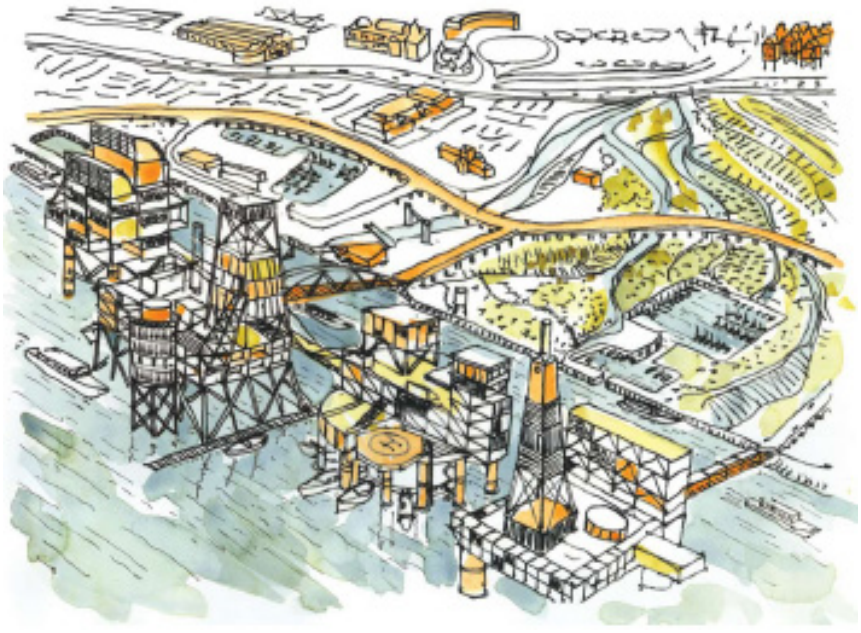
Fig. 2.2
Retreat

to handle next to the climate change related issues. The first one being limited resources, which they propose to enhance via a strong partnership between the public and private sector, where innovative design solution can be beneficial for private sector investments. Second, that communication is important to secure an overall strategic overview in addition to a strong leadership. It is apparent that if all stakeholders have clear responsibilities and communication lines, some of the scenarios of retreat, defend and attack can begin to emerge. The third issue is the timescale of how infrastructure and urban development are planned now and how that affects future planning. The spatial planning framework today is developed for 10- 20 year periods, but with the climate change prospect there is a need for planning 50, 75 or even 100 years into the future. There is a need to look beyond short-term cycles of political decision-making and start planning for the long-term (Building Futures, 2009).

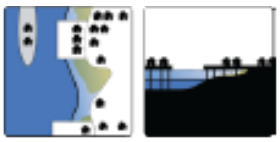
Defend?

"To defend is to ensure the sea water does not enter the existing built environment. This will require built defences to ensure the standard of protection will be met in the distant future as sea-levels rise." (Building futures, 2009: 11)

Fig. 2.3
Defend



Attack?



"To attack is to advance and step seaward of the existing coastline. There is massive development potential to be gained for coastal cities by building out onto the water." (Building futures, 2009: 11)

Fig. 2.4
Attack

PLANNING FOR CHANGES

The following case shows an example of how Curitiba, Brazil, in the 1950s and 1960s, took an entirely different approach to city development than what was common at the time. They chose to 'adapt', and to some extent 'retreat', in order to secure the population and future urban development of the city. Although the generating factor for Curitiba was not climate change, the case is inspiring for dealing with challenges of climate change in vulnerable urbanities due to its focus on upgrading living standards through a holistic approach of working with floods, landscape and urban development.

CASE: CURITIBA – SUSTAINABLE URBAN DEVELOPMENT

During the 1950s and 1960s Curitiba experienced massive growth and all prospects indicated that it would continue in the decades to follow. Heavy migration put a heavy load on infrastructure, service structures and environment in the city and led to a growing need for housing. This increased social and economic problems in the slum areas and indicated severe problems to come. The city had to create a plan to solve such problems fast while constrained by limited funds. The municipality had three overall focus points in their strategy for the city; designing with nature, access and mobility, and ensuring better land tenure ship for the citizens(Rabinovitch & Leitman, 2006).

'Designing with nature'

In the same period that the city started to address urban development, a need occurred for controlling the annual flooding. The drainage system was outdated and could no longer hold the water masses. The municipality chose to solve the problem in a radical different way by reserved land along the riverbanks and restricted surrounding low-lying areas against housing development. They transformed the riverbanks into public spaces, which let them function as buffer zones during the annual floods. Moreover, artificial lakes were created in buffer zones to serve the purpose of water magazines. By prioritising the green areas as so, the city found a cheap way of solving their flood problems and at the same time increasing the recreational value of Curitiba. In addition, the areas around the new green parks experienced a general upgrade (Rabinovitch & Leitman, 2006). This strategy of designing with nature had a number of positive effects for the city as a whole, but the obvious question from a planning perspective is how this affected other areas of the city. Due to its very nature, there is not a lot of information regarding this issue. One can make an educated guess that restricting low-lying areas from further settlements increases density in other areas and this may in time have decreased living standards.

Access and Mobility

Another element in the planning strategy was to increase the inhabitant's accessibility and mobility. With a growing population, the municipality realised that accessibility was crucial for the city to develop. If not, introverted ghetto-like slum areas like in Rio de Janeiro, Nairobi or Mumbai could be the outcome. Good infrastructural systems were also important to increase economic development in the city (Graham and Marvin, 2001). Therefore, the municipality made a radical decision to ensure better accessibility in the city, creating five large transport corridors connecting the outskirts of the city with centre. These corridors prioritised two-way bus lanes that paved the way for effective bus services. This resulted in an environmental and social improvement by generating employment in the privately driven busses and provided low-income groups with increased mobility. Additionally, this led to easier access to greater geographical areas with a larger variety of jobs and provided a better chance for citizens to change their living standards (McKibben, 2006).

Fig. 2.5
Curitiba: double programmed park and flood magazine

Land use governance

The demands for houses skyrocketed in the 1980s and Curitiba was faced with a new-old challenge of preventing the formation of slums. The municipality took a different approached than in the 1950s and 1960s by providing basic infrastructural systems in a new development area. One of the first elements established was a bus station linking the area to the rest of the city. Thereafter, the municipality allowed citizens to build their own houses and in a short time the new development housed 50.000 families. The newly established inhabitants received a convey for their plot in addition to two trees and were offered an hour consultation with an architect. In this way the municipality tried to encourage people to establish a green environment in the city (McKibben, 2006).

The focus on developing Curitiba by adapting to nature's rhythm and integrating the different areas into a holistic urban development, constitutes a good example of a city that has moved towards a more sustainable development; thereby resulting in an upgraded standard of living, especially for the low-income groups (Rabinovitch & Leitman, 2006). As highlighted throughout this case, there are almost always unanticipated problems when developing in build environment. At the same time, this case also demonstrates that drastic measures may be necessary in situations were planning has not foreseen and planned based on long time strategies.

UPGRADING LOCAL COMMUNITIES

As discussed in chapter 1, low-income groups in urban areas are some of the most vulnerable to climate change. As so, it is of utmost importance that these people and their cities are able to adapt to such changes. In this perspective, the three strategies in Curitiba are useful. Specifically, their focus on land tenure illustrates how important ownership is for generating upgrades in living standards. Lacking land tenure means that people have no rights to the land on which their home resides, and therefore there is often less interest in upgrading their houses.

The following case shows an upgrading program from Bangkok, where cooperation between the government and the community successfully upgraded a neighbourhood. This was achieved via focusing on land tenure and infrastructure and building conditions (ACHR, 2008).

Fig. 2.6
Example of upgraded houses

CASE: UPGRADING KLONG BANG BUA, BANGKOK

The upgrading program Klong Bang Bua is a part of is called Baan Mankong "Secure Housing". It is the first initiative in Thailand recognising the existence of slum dwellers and providing resources to change their situation (ACHR, 2008).

It is definitional that it is the slum dwellers that have the fewest resources to change their environment. Their insecure land tenure results in an unstable future and very few invest in their houses. To kick-start the development process the Community Organisation Development Institute set up a subsidy program for members of the slum dweller community to take a loan and pay it back over 15 years. Most families could afford the loan. The community provided those who could not with other options. At the same time, the municipality agreed to make a renewable leasing agreement on the land lasting 30 years.

With land tenure at hand, the community organised itself to the extent of initiating a planning process. The goal was primarily to upgrade the physical structures such as the quality of houses and infrastructure,; but also to establish a strong network within the community to improve a social security system.

Prior to the project, the infrastructure between the houses was a myriad of small paths which amounted to flat pieces of wood atop bamboo stilts. The paths were often narrow and had dark alleys resulting in an undesirable and unsafe environment. By the time the project came to an end, the community managed to make a new concrete path along the riverside and other roads. These new paths helped to improve security. In this way, the aspect of security was integrated into planning the development.

Correspondingly, where there had been problems with drugs, robberies and blackmailing, there are now activities for children and youngsters and programs to help the poorest families with school money. These initiatives seem to have had a positive effect on the level of crime in the area. The funding for these endeavours comes from the welfare savings, which everyone in the community contributes to (ACHR, 2008).

Based on the data available, this case provides a good example of how slum upgrading can take place. In this case study, there is a strong cooperation among the community, the municipality and the local NGOs. Through negotiations, this has in turn found solutions and changed the lives of 3.800 families (ACHR, 2008). The evaluation by ACHR (2008) was carried out shortly after completion of the project and therefore the question arises, what is the long-term effect of this project? This answer depends greatly on the next steps in Klong Bang Bua's development and how these steps influence the surrounding areas. Namely, the strong cooperation between the actors needs to continue and stable financial aid might be necessary for many years. For instance, as of yet, both the loan options and the focus on land tenure points in a truly positive direction.

Fig. 2.7
The condition before the upgrading, and the process

COMPLEX ISSUES-SIMPLE SOLUTIONS

Community driven projects like Klong Bang Bua are often most successful if the scale of the project as well the number of issues it deals with are taken into consideration. Considering this often makes it easier to communicate and easier to implement. The following case from Mafalala is good example this. Mafalala is one of the oldest slums in Maputo, Mozambique. The case shows, how serious and complex issues can be changed in a simple way on a local community scale.

CASE: SIMPLE INITIATIVES CAN IMPROVE LIFE QUALITY, MAFALALA, MAPUTO

In the past, Mafalala has experienced annual floods because of its location in the lowlands along the coast where the groundwater level is high. The annual floods made the people of Mafalala at risk of waterborne disease due to the lack of sufficient sanitation systems. A related issue was the lack of waste management. The locals used to bury their waste resulting in putrid smell and health problems when the rainy season would carry the waste into runoff channels. Health issues were also caused by the lack of access to clean drinking water (Government of Monaco, 2010; UN-Habitat, 2010).

Consequently, the municipality established a sanitarian and health-upgrading program with support from UN-Habitat and the Government of Monaco. The timeline for this project is 2008 to 2011. There are five focus points in the project: increase local associations' powers regarding the management of solid waste, waste collection, health education, building drainage channels and constructing latrine (Government of Monaco, 2010).

This project has a strong focus on community education and participation. This is one way that the program can be regarded as a long-term sustainable upgrading. Also, the local community is involved in the upgrading process and maintenance. This is exemplified by the newly established communal group responsible for cleaning and an interest group dealing with issues related to water. Furthermore, locals are educated in how to use a new waste system and containers are distributed in the area for the community to dump their waste.

According to Government of Monaco (2010) the project has already improved the living conditions for 21.000 inhabitants for less than 250.000$. The funding allocated for this has provided sanitation systems, two schools, five water points, the construction of four waste containers, and education material. Generally, improving drainage systems in developing countries has shown to have a positive effect on living standards and often it leads to upgraded housing conditions on the specific sites (WHO, 1991).

The upgrading of Mafalala is part of the 'Slum Upgrading and Vulnerability Reduction in Flood Prone Cities in Mozambique', of which Maputo is a part.

Fig. 2.8
The situation before the project started

Fig. 2.9
The situation after the project

Conclusion

The four cases have different characters, problems and solutions, but they all deal with a certain level of flexibility in their planning approaches. Designing is challenging in the context of climate change as indicated in the title of 'Facing Up to Rising Sea-levels'. As pointed out in the case study it is crucial to both act now and plan ahead. Acting now is discussed through the three approaches of retreat, defend and attack and these may very well be used individually or combined depending on the situation. Planning ahead is a very important point because it must be connected with a new way of thinking about strategic planning. For instance, not only is it essential to plan in accordance with a longer timeframe (50-100 years) but moreover to make planning flexible and adaptable to changing conditions. This is going to be very challenging. The Curitiba case showed how mobility focused planning based on infrastructure and public transport sustained the cities economy and upgraded the citizens' standard of living. It also showed, how the municipality, by focusing on flexible planning, provided the citizens with a large green space by double programming of the riverbeds. In this way they did not only solved flood problems but at the same time provided a recreational area. This double programming is a particularly useful approach seen in the context of climate change. In many large cities the slum areas are building up in some very vulnerable locations. Moreover, the restricted green space in Curitiba also function as an urban growth line and thereby supplies a boundary for informal settlements. On a more philosophical level, the green space also lets the citizens develop a relation to nature by being in it and care for it. The cases from Klong Bang Bua and Mafalala show good results based a bottom-up approach to community upgrading. This approach has, through the last decades, gained more and more attention in planning processes especially in the developing countries - foremost are bilateral aid programs. The attention is gained through good results (e.g. Klong Bang Bau and Mafalala) and through awareness among decision makers that local community engagement ensures long-term effects and maintenance of projects after they officially ended. In addition, for the bottom-up approach to be successful high transparency in the planning process is needed since the members of the communities must be able to see how and why they should involve themselves. Having a transparent process also helps to empower locals because they can see that their initiatives are supported. But to ensure empowerment transparency is not enough, the strategic plans are required to be flexible and be able to encompass different ideas along the way.

On the foundation of the case studies and the background knowledge on climate change, we are focusing the project on two design levels, the first being an overall design strategy and the second an architectural design proposal on community level. Both products have focus on how urban growth and vulnerable urbanities and climate change can be integrated in the planning and design solution. The next three chapters will focus on the planning proposal starting with a background description, and site analysis. The product of this scale will be shown in chapter 7 as a strategic process and action plan.

The project will take point of departure in the context of Maputo the capital of Mozambique which is dealing with exact these issues, and where the Northeastern Maputo will be the site for our first product.
The next chapter will briefly introduce Mozambique and Maputo, to give an insight to the context and will form the back ground for the first product.

Chapter 03

THE PRESENT STATE OF MOZAMBIQUE AND MAPUTO

The chapter provides a general overview of these subjects on a national scale as well as on a city scale focusing on Maputo.

Located in southeast Africa facing the Indian Ocean and with nine international river systems coming down from the inland mountain regions, Mozambique is highly vulnerable to natural disasters (Dodman, 2009). Mozambique has always had tropical cyclones, floods and in some parts of the country droughts. These events have always been cyclical, but due to the changing climate these events are occurring with greater frequency and intensity.
Working in Mozambique means working in a fairly new established administrative system and in a country that has experienced major changes in the past decades. In order to have a holistic approach to the project we need to have a broad understanding of the different political, economic, social, environmental and historical contexts influencing it. The following chapter provides a general overview of these subjects on a national scale as well as on a city scale focusing on Maputo.

Governance

The republic of Mozambique became independent from Portugal in 1975. Immediately thereafter, Mozambique endured a 17 year long civil war leaving the country almost completely bankrupt in 1992. The country was left to tackle an enormous debt of 8,2 billion US dollars, twice that of the nation's national product of 3,9 billion US dollars (1992). Today Mozambique is still one of the most aid dependent countries in the world, with a quarter of its annual income as foreign aid. At the same time, it ranks as number 99 out of 163 counties at The World Bank's transparency index scoring 2.8 in a scale where 1 is highly corrupt and 10 is highly clean (UN-Habitat, 2008).
Mozambique is established as a representative democratic republic with elections every fifth year. From the independence until 1992 the country was run as a one-party state by FERLIMO (Front for the Liberation of Mozambique) following the socialist model. The peace agreement in 1992 with the opposing party RENAMO (The National Resistance Movement) opened up the nation for democratic elections. The first national election was held in 1994, the first municipal election in 1998 and

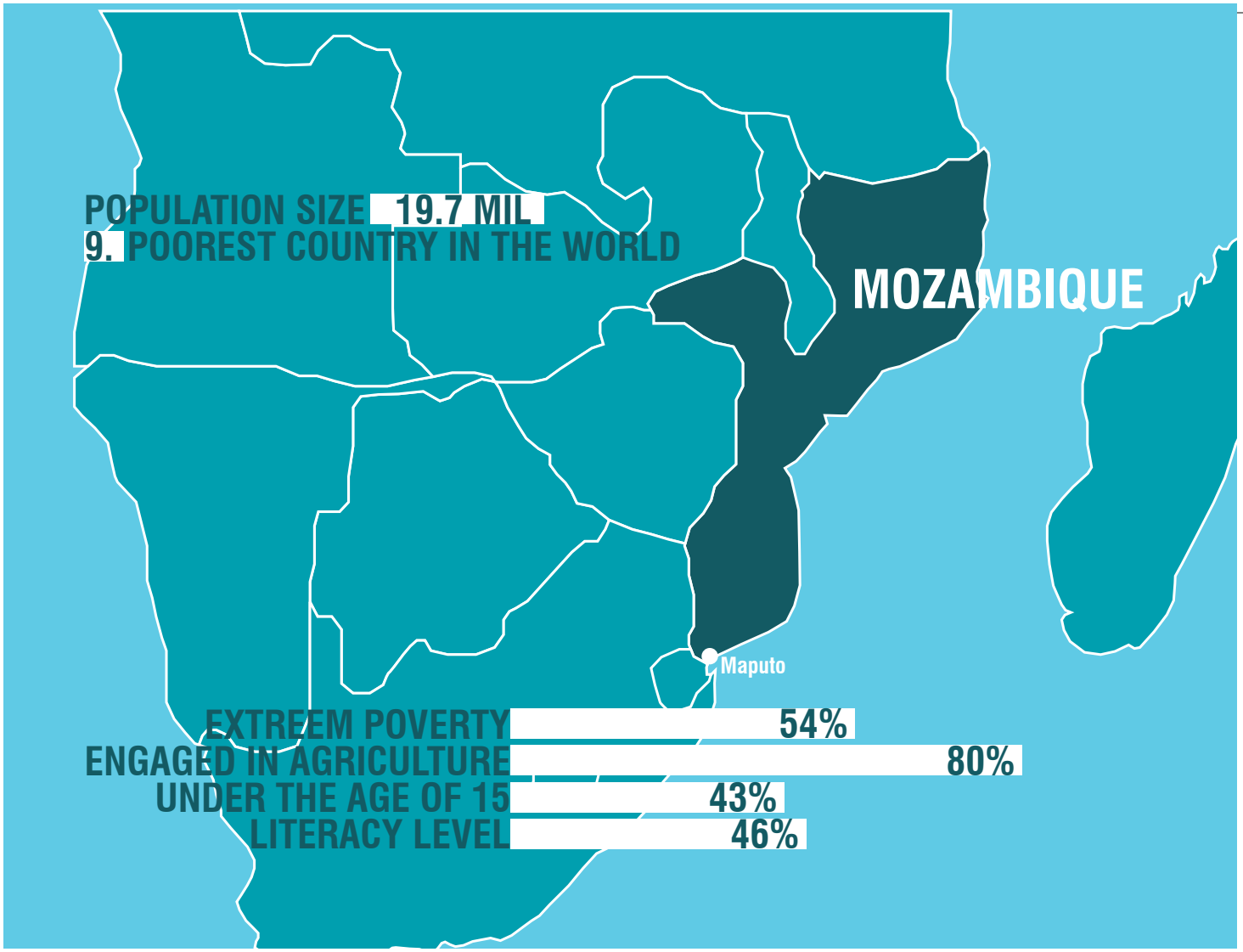


Fig. 3.1
Mozambique is a sub Saharan east African country

representatives for the provincial assemblies were elected in 2008.

Based on UN-Habitat (2008) and CDH & UEM (2006:9) there are two historical political decisions that have been especially important in relation to planning policies on urban development:

First - all land in Mozambique is state owned

Second - The Land Law from 1997 "grants individuals land rights based on historic occupation, accepting oral witnesses for ruling"

Generally, not having property rights in combination with such historical occupancy rights as in the Land Law, leaves very little chance for newcomers to establish themselves in Mozambique's urban areas. Furthermore, the lack of property rights may, as discussed in chapter 1, leave little incentives for the newcomers to maintain or modernise their houses. Moreover, the government declared "the armed conflict in the 1980s and early 1990s made it impossible to control the various levels of the migration phenomenon" (CEDH & UEM, 2006). This puts the two political decisions in perspective. Indeed, the government states that, during the civil war, they had no means for regulating, or even adjusting to, massive urbanisation. All in all, the two political decisions and this declaration of the governments' are resulting in large low-income urbanised areas that are not prepared to tackle climate change related problems.

Demography, Poverty and Education

Even though progress has been made in Mozambique since 1992, it is still one of the poorest countries in the world ranked as number 168 out of 177 countries in the UNDP Human Development Index in 2004. 54 %

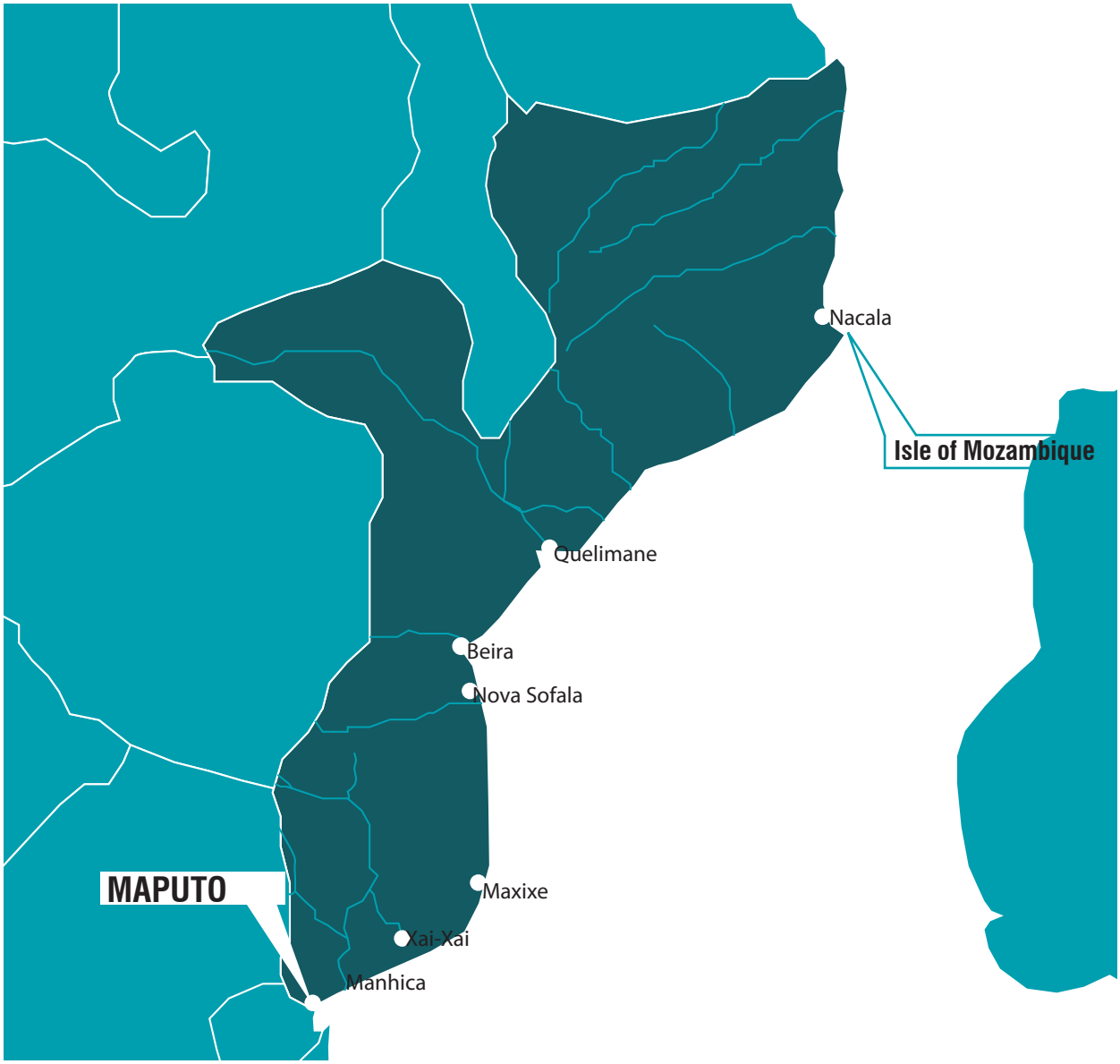


Fig. 3.2
Many of the larger Mozambique cities are located along the 2700 km coastline

of its 19,7 million people are living in extreme poverty (UN-Habitat, 2008). Additionally, CEDH & UEM (2006) estimated that 33 % of the extremely poor live in urbanised areas along the coast and that 94 % out of these live in informal slum areas. The urbanisation rate is annually between 3,2 % and 5 %. With 43 % of the population being under the age of 15, the already high urbanisation rate surely increase in the future (EU, 2007). Another indicator that a wave of migrations to urban areas may be underway is that only 36 % of the population live in urban areas (in Denmark 80 % live in urban areas) (UN-Habitat, 2008).

Issues related to climate change are going to add stress on both land use in the rural areas, which engages a large percentage of the population, and on the vulnerable urbanities, particularly in light of the government's lack of regulation of urbanisation.

Climate Change

According to Dodman (2009) and MICOA (2007), it is Mozambique's geographic location, with its 2700 km long coastline and the confluence of rivers flowing in to the Indian Ocean, which makes the country

particularly vulnerable to hydro-meteorological climate change (i.e. floods, drought and cyclones). In the last 25 years the country has suffered from several extreme weather events including four major floods just within the last decade (CCCI, n.d.). The extreme weather caused serious damage to the water resources, ecosystems, industry and infrastructure, thereby hampering the country's economic development and affecting most of the population (Schneider, 2009). A long-term threat for the large urbanised areas along the coastline is the rising sea level. The growing population, urbanisation and increasing density in the cities combined with ineffective land-use planning, means that if a disaster occurs or the sea level rises, people living in Mozambique will be severely impacted (MICOA, 2007). The capitol, Maputo, itself is one such city faced with this vulnerability.

MAPUTO'S CHALLENGE

Maputo is located in the very south of Mozambique facing Maputo Bay. According to The National Statistic Institute (INE) the number of inhabitants in 2007 was 1,1 million people with a population between 2,5 and 3 million in Greater Maputo, which consists of Maputo, Matola and Marracuene (INE, 2008).
The Cities in Climate Change Initiative, of which Maputo is one of four, seeks to strengthen the climate change response by setting up climate change adaption strategies (CCCI, 2009b). In Maputo this strategy concerns the following vulnerable areas:

- Coastal zones and ecosystems
- Human settlements and infrastructure
- Health, food security and waste management
- Transportation systems
- Wetlands and urban agriculture

The low-income areas in the city are most exposed to climate change and therefore most in need of an effective strategy on how to adapt.

Fig. 3.3
The municipalities surrounding Maputo, and constitute the capital region

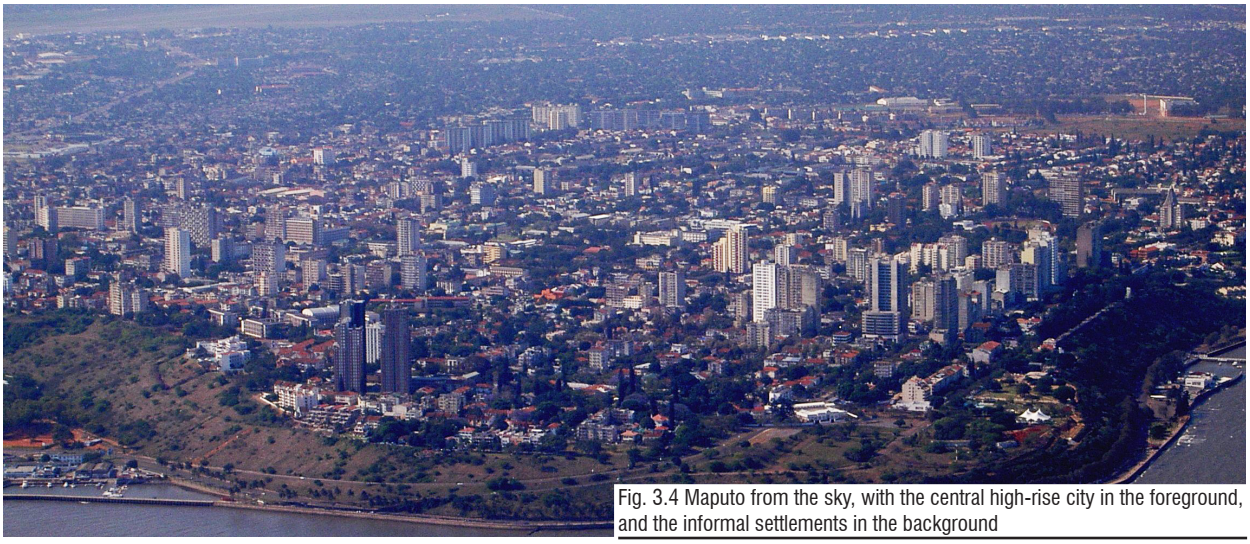


Fig. 3.4 Maputo from the sky, with the central high-rise city in the foreground, and the informal settlements in the background

Fig. 3.5
A family in front of their Cane house

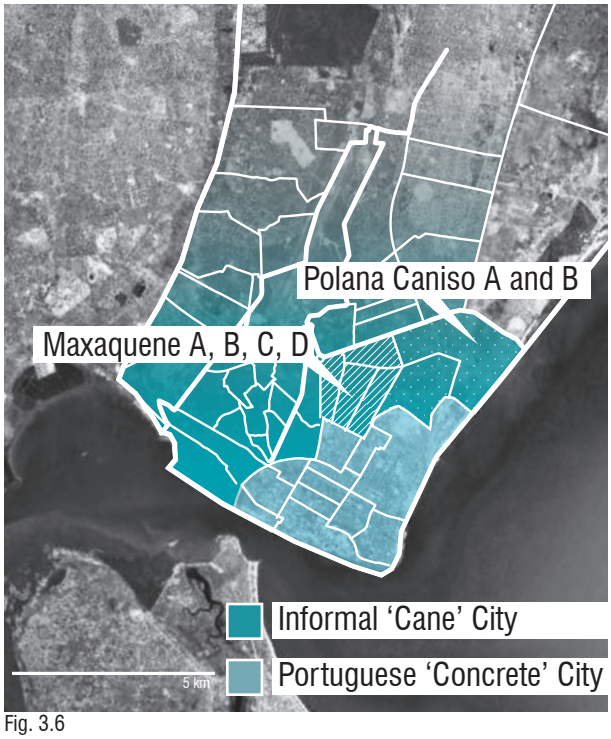


Fig. 3.6
Map of Maputo showing the Concrete city and how the Cane city was improved after the independence

Early Planning and Development

The first plan for the urban area in Maputo dates from 1887, around the time the Portuguese chose to move the capital from The Isle of Mozambique to the small town of Lourenco Marques, which is known today as Maputo. The plan was to change the existing city structure toward a grid system. From the early 20th century the harbour activities grew rapidly and the industry demanded more labour force. This led to the first large wave of migration to the city and around 1919 the first slum formed in the suburban areas (CEDH & UEM, 2006).

The Divided City

The slums were considered temporary and therefore constructed without any overall planning or larger connecting infrastructure. The idea was that these areas (and the people living there) could be easily moved when the planned colonial city would need to expand. Material regulations were therefore strict; only cane and, in rare cases, wood and corrugated iron were allowed. These regulations resulted in a visual and psychological division of the city into Cidade de Canico (Cane City) and Cidade de Cimento (Concrete City). These nicknames are still used today. Still the poorest families in Maputo build their houses out of cane; an example is shown on figure 19 (CEDH & UEM, 2006).

Because no planning attention was giving to the slum areas, they expanded fast as mono-functional residential areas without any open public spaces or services. Not until the early 1970's when the Portuguese saw their colonial power threatened by the growing resistance did the city start to address and improve the living conditions in the slums. In the end, the only portion of the original plan that was implemented was the creation of a number of access roads.

After the Independence

The Concrete City

When the Portuguese left, the Concrete City stopped growing and all its buildings became nationalised (CEDH & UEM, 2006).The houses in the 'formal' concrete city (fig. 21) were administrated and rented out by the Real Estate Property Administration. It was mostly people from the low-income periphery areas or immigrants from other cities who took advantage of this real estate development. Little by little the houses, streets, parks and urban services deteriorated, mostly due to the economic crisis after the war and difficulties in constituting the new economic and social policies. The deterioration was also a consequence of low maintenance by groups occupying the houses. As a result of bad living conditions in the Concrete City and profound urbanisation during the civil war, more informal settlements were established a number of which were in the unhealthy marsh and swamp areas or in unsafe locations such as slopes and arid areas (CEDH & UEM, 2006).

Fig. 3.7
The Concrete city

The Cane City

After Mozambique's independence, a number of projects were launched to improve the conditions in the 'informal' Cane City. These projects starting in the neighbourhoods of Maxaquene later moved on to the Polana Canico areas. The first goals of these projects were to improve service and infrastructure systems such as water distribution, drainage, sewers, access roads, public transport, garbage collecting and electricity. Secondary goals were to establish interconnections such as public latrines, stand pipes, and telephone booths in open public spaces. In relation to these projects, the first initiatives to define housing plots and to incorporate public participation in the process were taken.

The increasing instability in Mozambique during the late 1970s hampered the execution of such plans and the process almost stopped during the 1980s (CEDH & UEM, 2006). Later several other efforts were made to create an overall plan for the expansion of the city, first in 1985 and again in 1999. However, both were never politically approved and therefore never implemented (Maputo Municipal, 2008).

The 2010 reality

Apart from the restructuring in Maxaquene and Polana Canico in the 1970s, there have been few official efforts to improve or adjust the city to meet the needs of its inhabitants. The city's strongest characteristic is still the sharp division between the paved grid structure with its concrete houses and the self-constructed single-family residential areas surrounding the counterpart (Maputo Municipal, 2008). Even though many of the houses in slum areas now are made of concrete blocks instead of cane, the lack of public initiatives denote that services and general accessibility is still very poor.

The urbanisation rate of 3.5 -5 percent in Maputo municipality is mainly in periphery of the city all with slum characteristics (UN-Habitat, 2009). While the rest of the country has experienced a decrease in the population living in poverty, Maputo has, due to the relatively stronger urbanisation, seen an increase of 70 %. Many of these have very little or no access to clean drinking water, sanitation, waste collection or drainage (Manguele, 2009; UN-Habitat, 2008).

Fig. 3.8 The main road separates the informal settlements on one side with Summershield on the other

Maputo has the largest social and economic inequalities in Mozambique (EU, 2007). This is easy to detect as several new middle- and high-income residential areas are appearing in the urban area. These areas are often gated communities built on land that previously was occupied by agriculture or slum and are often constructed without official approval due to the lack of sufficient planning tools and political administration (Narotama, 2010). Despite the new residents' superior economic position, they are in the same situation as low-income groups in as much as they live in areas whose development was not officially approved. But in comparison to the low-income groups the inhabitants in middle- and high-income groups typically has more political influence and therefore are less vulnerable in the event a political conflict.

The gated communities are creating physically segregating city areas; slum dwellers and high-income neighbourhoods lie right next to each other only separated by a wall. The segregation is not only physical but also social, since some low-income groups have to

Fig. 3.9 Top, typical peripheral slum area
Fig. 3.10 Bottom, the concrete city

move to make room for the growing demand for new higher class communities.

Maputo Master Plan 2008

The newest planning initiative that became effective in 2009 is PEUMM - Master Plan of Maputo Municipality and it is the foundation for the overall planning. It is the first politically accepted plan in Maputo since colonial times. The plan is a catalogue of registrations, descriptions, analysis, visions, and strategies and it maps out different types of building structures, infrastructure, public functions, services, commercial activities, green areas, etc. Currently the municipality has made strategies on distribution of service centres, plans for overall infrastructural considerations and for future urban development.

The goal is to have a three-step-plan-system, consisting of the overall master plan (which is done), district plans (which are just started) and local plans (not yet begun). The master plan provides the layout of the overall visions and strategies whereas the district plans provides detailed descriptions of development areas, building percentage and smaller road structures, and the local plan provides descriptions on building typologies, building heights, sanitation etc. This new municipal plan is a tremendous improvement in comparison to previous ways of dealing with planning in Maputo (the ridged top-down Portuguese system or the non-exiting system during the civil war), but it still has a long way to go and will take a time to implement (Narotamo, 2010).

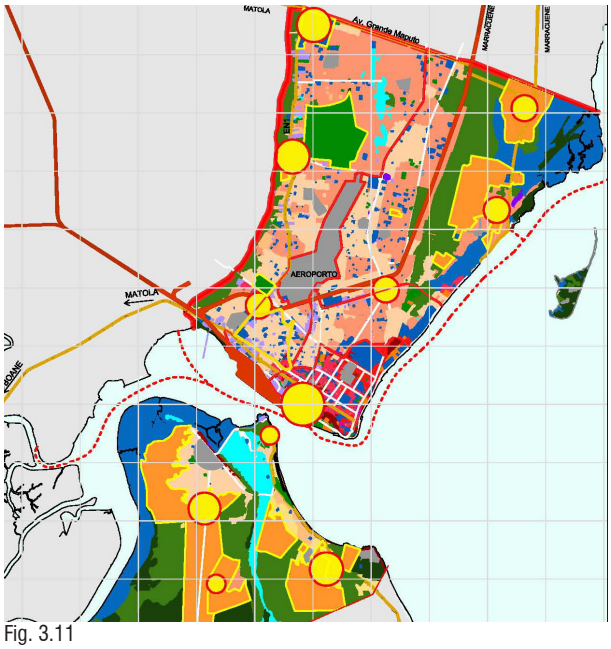


Fig. 3.11
Maputo Master plan: land use, infrastructure and new centers

Future Challenges

It is difficult to implement a new planning system into an administrative system that is currently without, but with limited administrative resources, unstable economic means and extensive social problems it seems almost impossible in Mozambique. The complexity of slum development, poverty and social inequity together with the prospects of climate change sets high standards for the efficiency of such systems. The traditional three-step planning system requires complex administrative systems and a large amount of work to maintain, which means the municipality of Maputo, is facing large challenges.

Mozambique's history and general state and the present day situation in Maputo illustrate the complexity of the context in which climate change has to be addressed. As if the challenges of dealing with climate change in relation to the existing political, economic and social problems were not enough, the rapid urban growth and the related consequences' also have to be considered.

There are many development issues to deal with in Maputo, but one place stands out upon focusing on the problems of urban growth and vulnerability due to climate change. Namely, the large newly developed mixed-use areas of Costa do Sol and east Polana Canico B located in the north-eastern part of the city. The following chapter seeks to get a more specific identification of the character and challenges in these areas, in order to get an idea of how the prospect of climate change can be integrated in the planning of the area.

Chapter 04

ANALYSIS OF THE NORTH-EASTERN MAPUTO

North-eastern Maputo (Polana Canico B and Costa do Sol) is a costal area that covers approximately 900 hectares and is located 8 km from the city centre (see figure 4.2). It borders the ocean on one side and the low-income areas Polana Canico A, Ferroviario and Laulane on the other. To the North there is a huge green delta. In the South is located Concrete City (see figure 4.1).

What makes North-eastern Maputo especially interesting apart from its location close to the centre and by the attractive beach is its intricate and contradictory composition. At one and the same time it is a vulnerable urban area related to climate change and an area that experiences uncontrolled rapid urban growth. These characteristics will be the focus in this analysis. This complexity is outspoken and the future challenges will only intensify the mentioned issues.

At one and the same time North-eastern Maputo is a vulnerable urban area related to climate change and an area that experiences uncontrolled rapid urban growth.

North-eastern Maputo is an attractive recreational area due to its stretch of beach and mild climate. At the same time it is located close to the city centre making it easily accessible for its inhabitants. In other words North-eastern Maputo is a popular area for high- and middle-income groups. Second, the area's topography makes it a very vulnerable urban area in relation to hydrodynamic flows and the predicted sea level rise as a consequence of climate change.

Moreover, Achimo (2010) argues that concentrated rainfall already has, and in the future will, cause changes for both humans and ecosystems in the area. Due to this, Costa do Sol has been pointed out as a possible pilot project by the CCCI. Third, the rapid urban growth in Maputo is greater in this part of the city, and again complex, as both informal settlement and gated communities are being built in the same areas simultaneously. This analysis will now delve into the consequences of North-eastern Maputo's vulnerable urban areas and the rapid urban growth.

Method

The analysis of Costa do Sol is based on three types of data: First, we conducted three expert interviews in Maputo. We interviewed Architect Paulo Da Conceicao, Geologist Mussa Achimo and Architect Mahomed Narotamo, who have contributed knowledge about the intentions of

Fig. 4.1
Near context

Fig. 4.2
Location of the site

UN- Habitats CCCI project, the geological aspects of Costa do Sol and Polana Canico B, and the municipal master plan and future development of the area.

Second, we use analyses on global climate change produced by IPCC (2009), to predict the changes in the Costa do Sol area. The IPCC's report is made on general estimations for the African region, which can vary on a local basis. Because of a lack of data on the Maputo region, it has been necessary to make estimations based on this data.

Third, we use observation-based data combined with interviews with the locals in the area. This is data on everyday life in North-eastern Maputo where standard of life, issues of social life and networks, and user groups have been surveyed.
The original expert interviews, transcriptions and notes are available on the appendix CD together with additional photographs of the site.

Hydrodynamic vulnerability

Terrain has a large influence on hydrodynamic flow in an area. North-eastern Maputo's terrain is characterised by a long sloping hill rising 50 meter above sea-level. The hill is the old shoreline created 100.000 years ago and North-eastern Maputo is located between it and the current shoreline (Achimo, 2010). North-eastern Maputo is facing hydrodynamic challenges from rain water coming down the hill and the prospect of sea level rise (see figure 4.3).

Rainwater

When discussing water issues in North-eastern Maputo it is necessary to involve the bordering neighbourhoods of Polana Canico A, Ferroviario and Laulane, as these areas play a significant role in relation to runoff issues (see figure 4.4). Parts of the densely built settlements in the three low-income neighbourhoods

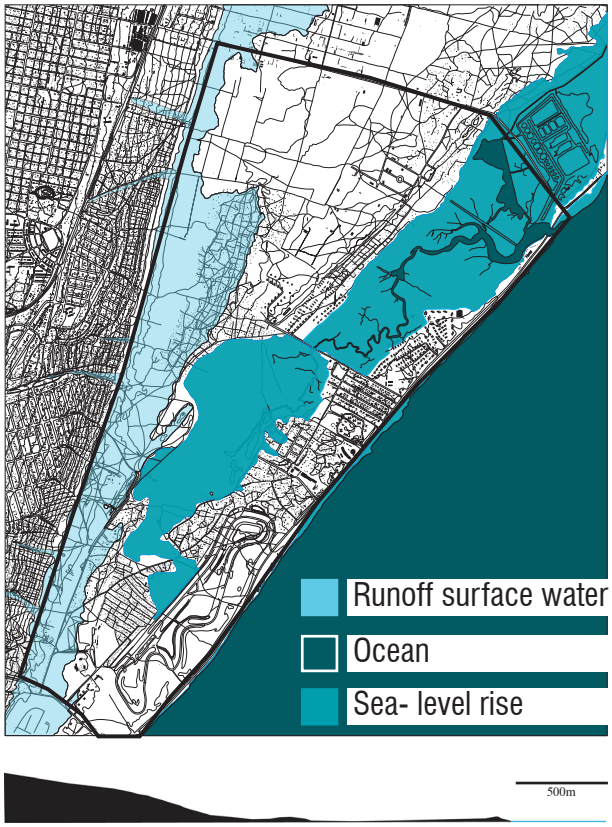
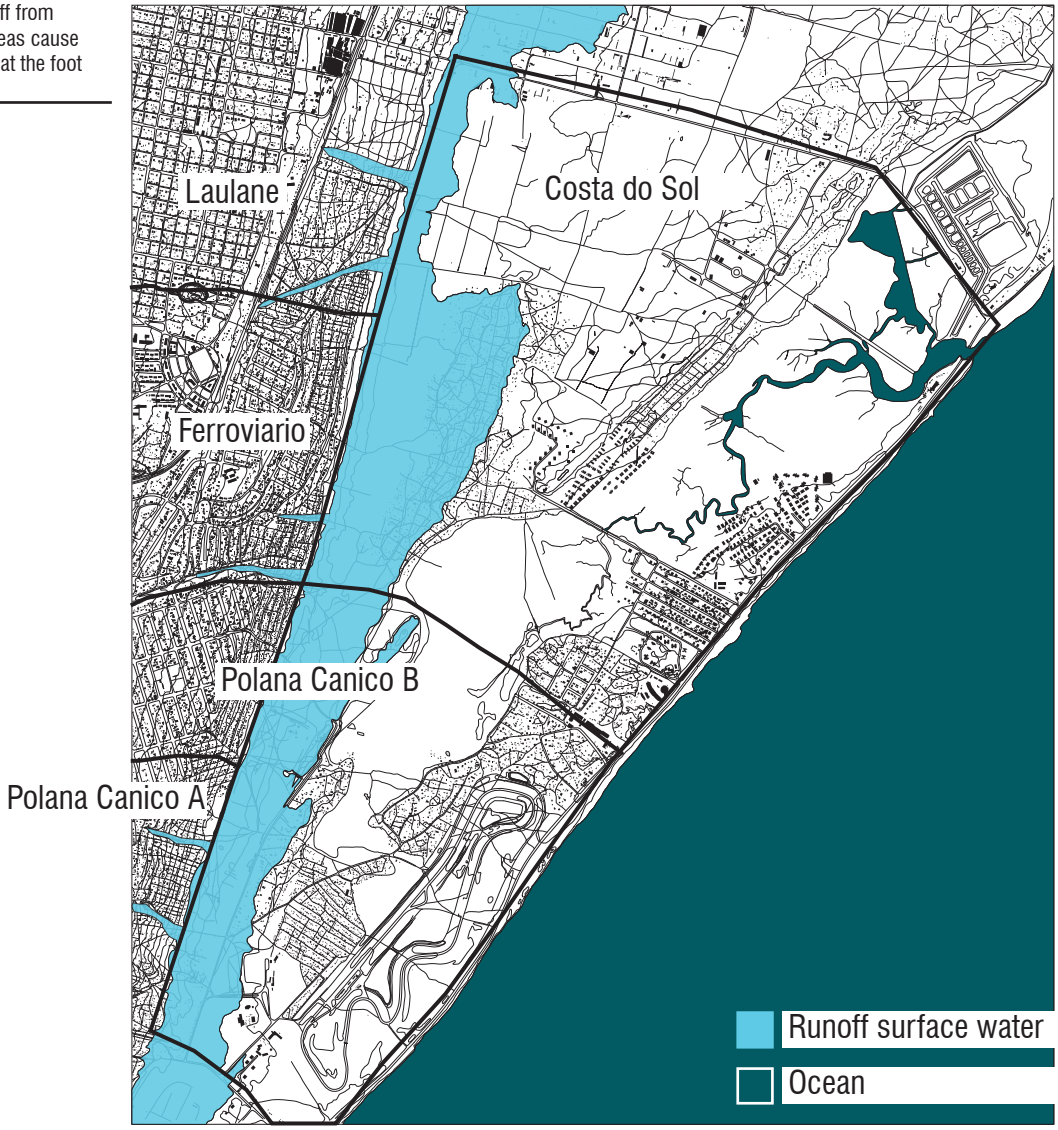


Fig. 4.3 Rain water from the hill and the predicted sea level rise.
Section through the terrain

Fig. 4.6
Puddles in the low lying residential areas

Fig. 4.5
Example of a V-shaped erosion trench

Fig. 4.4 Rainwater runoff from the dense residential areas cause problems with flooding at the foot of the hill



are located on the above-mentioned sloping hill and are, in part, responsible for the runoff problems. This dense development gives little space for rainwater to penetrate, which has resulted in erosion along the edge of the hill (ActionAid, 2006). The water cuts into the hill forming V-shaped erosion trenches due to the relatively sudden alteration in water behaviour (Achimo, 2010) (see figure 4.5). This has already caused much damage to roads and houses in North-eastern Maputo and locals' houses are flooded almost every year. However, due to the rapid urban growth, several houses are now constructed in these areas vulnerable to runoff and IPCC (2009) predictions yet heavier rainfall.

In the event of heavy rainfalls a large green area at the bottom of the hill functions as a water magazine. The green area turns into a swamp, which can persist for long periods while the water slowly soaks into the ground. Unfortunately the low lying residential areas are also influenced by the surface water, which creates puddles on the streets. Furthermore, stagnant surface water in the green area is creating good conditions for mosquito eggs to hatch and thereby enhancing the spread of diseases, notably malaria (see figure 4.6).

The water does not only create problems downstream in North-eastern Maputo, it also creates unstable environments for the people living on the sloping hill. The runoff channels have created erosion cliffs that become increasingly more unstable every year.

Sea-level Rise

Another hydrodynamic challenge is the prospect of rising sea-level. Currently, there is a 2-meter tide (between low and high tide), which overflows low areas along the coast, creating an area of mangrove forest behind the shoreline (see figure 4.9). The area occupied by mangroves is not useful for housing. With the prospect of rising sea-level, the tidal zone will enlarge, thus creating new mangrove territory. The area that today is temporally covered with water will become permanently covered and the landmass will consequently be reduced. Furthermore, there is a sediment flow along the coast that generates erosion problems. The municipality started to address this problem but the initiatives so far have been minor in cohesive and inefficient (see figure 4.8).

Fig. 4.8
Av. Marginal (above and below) along the coast is about to disappear into the ocean. The municipality has started to address the problem

As mentioned in Appendix 1, there are some estimates that the sea level will rise by up to 5 meters come 2100. This will flood North-eastern Maputo entirely. Even in the more resent and more "optimistic" scenario there is predicted a sea level rise of between 0,7 and 1,2 meters. In this event, the general area will be highly affected but not unliveable if effectively protected.

What is highlighted here on the map is the 2-meter contour curve which indicates the approximate high tide level in the year 2100 if nothing is done in the area (see figure 4.7). It covers around 240 hectares of land.

Fig. 4.7
2-meter contour curve which will be flooded with the sea level rise and cover 240 hectares

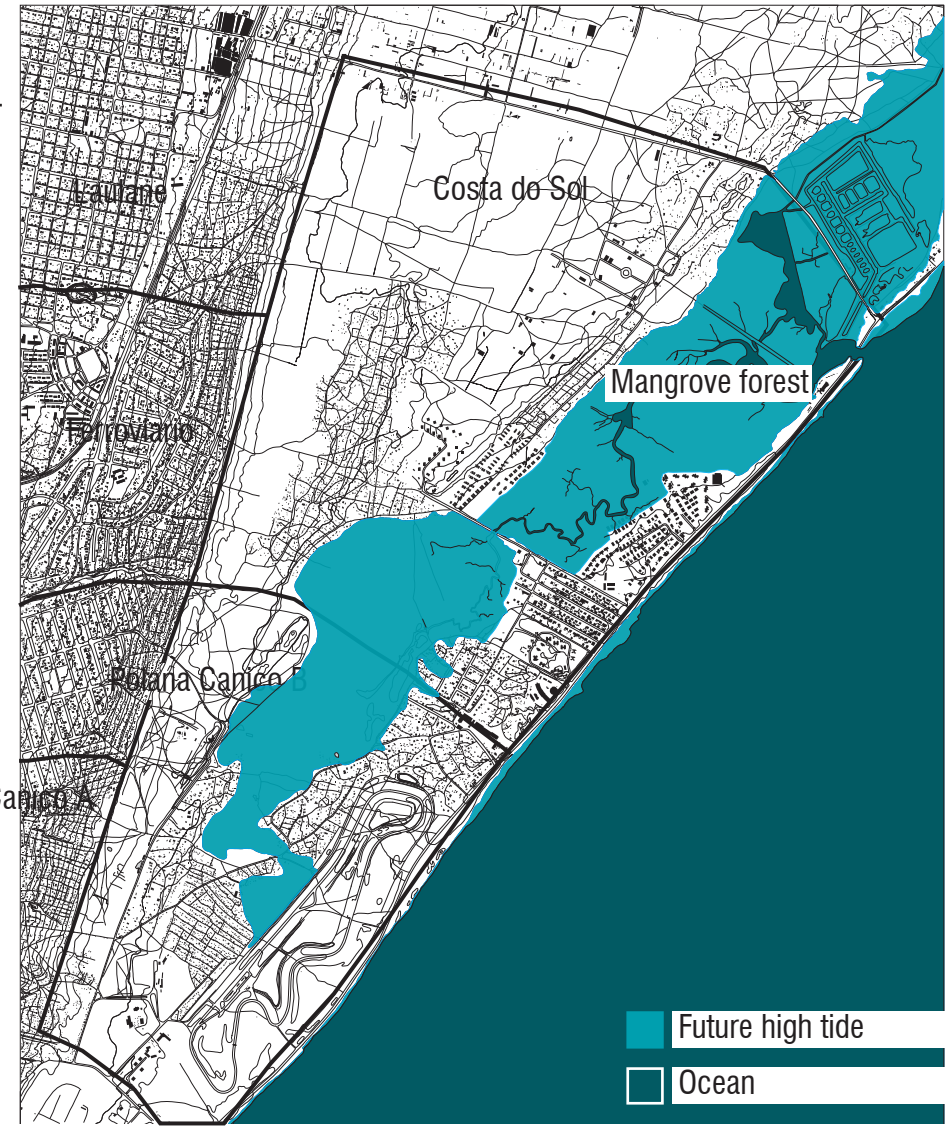


Fig. 4.9
Mangrove forest

Rapid Urban Growth

As disused in Chapter 3 there is rapid urban growth in Maputo. This growth has started to affect the North-eastern region due to its popular location and low population density compared to other areas in Maputo. Other cases (e.g. Curitiba) show that unplanned urban development in unoccupied land is difficult to stop, so one can only expect the current development tendencies to continue. If nothing is done to moderate this and uncontrolled development continues, North-eastern Maputo will become extremely vulnerable and its inhabitants will have an unstable foundation on which to build their future.

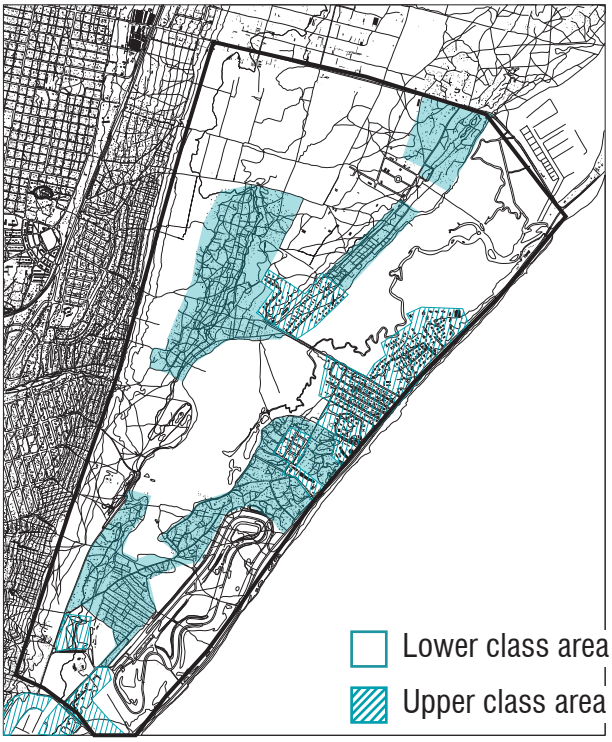


Fig. 4.12
25 percent of North-eastern Maputo is developed

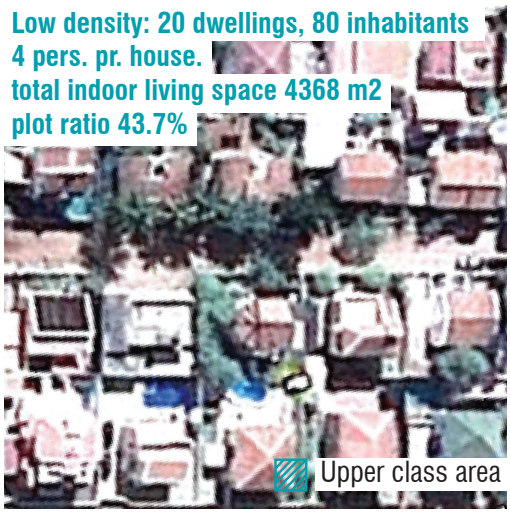


Fig. 4.10
Left: Density example of high class structure. below: street view of a high class build environment

The Build Environment

The estimated population of North-eastern Maputo is 45.184, of which 41.520 live in poor districts (calculated from estimated densities done by Maputo Municipal, 2008). Both the rich and poor neighbourhoods are typically detached houses. In contrast, the rich neighbourhoods consist largely of single-family, whereas approximately 8-10 people live in each house in the poor districts (Maputo Municipal, 2008). Building structures, size of the roads, and scale of buildings are good indicators to distinguish one area from another. The rich areas are organised in the classic grid of the colonial times. Every house has a concrete fence around the property and an electric fence on top. The scale of the houses is mostly 2-3 stories. The streets are wide but unpaved which indicates that the area was built without permission, since only planned roads are paved in Maputo (see figure 4.10). The poor neighbourhoods are characterised by being greener with trees and less schematic property division. Another indicator of poorer districts is narrow crooked roads and uncontrolled development. The poor districts appear self-grown in their structure while the rich districts tend to plan in grid (see figure 4.11).

Maputo Municipality works with different housing densities that are divided into low, medium and high. North-eastern Maputo primarily has low and medium density residential areas, but only 25% of the land occupied by housing (see figure 4.12). This means that there is space for new urban development and at the moment a great deal is happening - building both single-family houses and new service facilities. Even so, there are no holistic development plans; only plans for smaller areas at a time. According to locals in the area, the establishment of new houses happens without authority awareness. Much of the richer population builds their houses during the night; when it is nearly finished they ask authorities for permission which is typically granted. The poor take a different approach. They organise themselves in smaller communities with a local chief dealing with aspects of social and practical character.

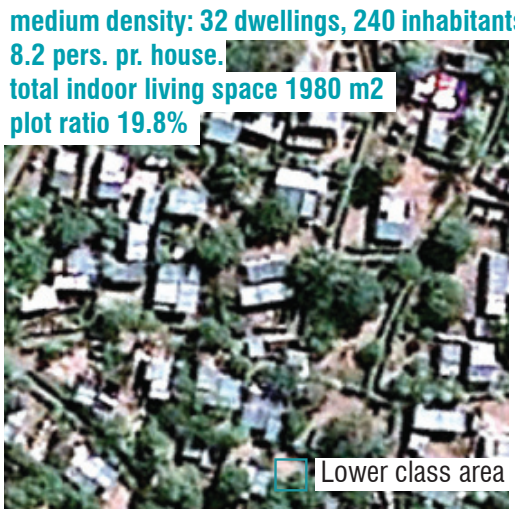


Fig. 4.11
Right: Density example of lower class structure. below: example of a lower class house

Infrastructure and Accessibility

Based on observation road structures in North-eastern Maputo has a large influence on where development takes place and on the distribution of commercial enterprises.
The map (see figure 4.13) shows three categories of roads; Main roads, secondary roads, and tertiary roads. The main roads are leading the main traffic to and from North-eastern Maputo, the secondary roads are easy passable with a car. They indicate where the higher social groups are located as they demand access. The tertiary roads are the main roads in the informal settlements. They are hardly passable with a car, and the side streets are only smaller paths. Besides the marked out roads, there is an endless number of paths crossing the landscape.
One of the main ones connecting the coast with the areas on the hill is the path leading to Chiquelene marked in Ferroviario where many of the lower income groups buy their goods.

Av. Marginal is in many ways the backbone of North-eastern Maputo. Av. Marginal is located along the beach and is the primary access road to North-eastern Maputo from the city. As so, commercial activities are generated along the road (see figure 4.15). Moreover, during the last 10-15 years all new development along Av. Marginal has been big single-family villas. In contrast, 200 meters from these villas are low-income areas with scrubby houses and roads that are hardly passable.
The area is connected to the neighbouring area Laulane only by the resent constructed road Dona Alice. This is the only paved road connecting Costa do Sol and Polana Canico B with its neighbours.

In the low income areas the road structure plays an important role in terms of development. There is a clear hierarchy of development and road structure. Along the streets with car access people, have larger and nicer houses than in areas without car access. Along the narrow crooked streets without car access, housing development undoubtedly happened prior to deciding where the street should be.

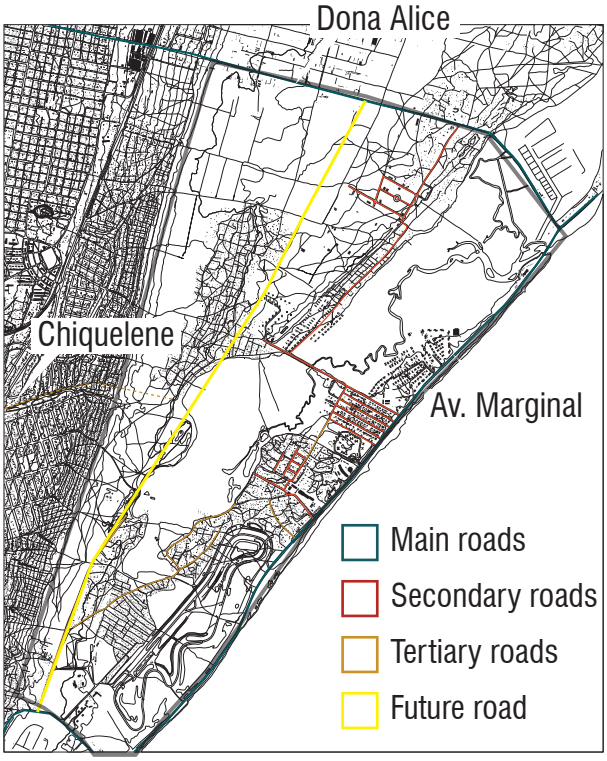


Fig. 4.13
Main roads, secondary and tertiary roads

Fig. 4.15
Left and above: Commercial programming along Av. Marginal

Fig. 4.14
The concrete fences around the property witnesses that an upgrading process is taking place. It is clear that the road has an influence on that.

Roads as Public Space

There are no programmed public spaces in North-eastern Maputo. Instead the roads seem to become social generating points (e.g. Av marginal) (see figure 4.16). That said, the roads do not seem to function as public domains, as there are signs of social interaction. This non-interaction is furthered as the upper class people use their cars and shop in supermarkets, while the poorer people transport themselves in 'chapas' (bus services) or walk and shop at markets.

Future plans for development

In the new master plan for Maputo is suggesting a new north-south bound main road through the north-eastern region in order to ease the pressure on Av. Marginal (see figure 4.13). Experience foresees that this will bring development to the area, and as Maputo Municipal (2008:7) states: "Maputo has large problems with mobility and access. The distribution of the infrastructure in the city is decisive for giving everyone equal rights."

Fig. 4.16
Av. Marginal as a social meeting point

Fig. 4.18 Above: The deserted racetrack
Fig. 4.19 Right: Typical agricultural land

Undeveloped environment

The undeveloped environment in North-eastern Maputo mostly consists of farmland, mangrove, beach and two big recreational areas: a racetrack and a golf course (see figure 4.17). About 25 percent of North-eastern Maputo is farmland (see figure 4.19). The agricultural production is an important contribution for locals, particularly for poor families whose daily lives depend on having an extra piece of land to support their families. The mangroves cover 14 percent of North-eastern Maputo along the coast. It is a biologically diverse ecosystem providing shelter for smaller animals such as crabs, oysters and clams; many locals depend on the mangrove wildlife to supplement their diets (Berhad, 2009) (see figure 4.21). The beach is a recreational area for all of Maputo and, as has been mentioned, a great social attractor especially during weekends. At the same time the ocean and its fish are very important for locals sustain their families and for the local economy (see figure 4.22).

In North-eastern Maputo, a racetrack and a golf course are two types of leisure activities 'leftover' from the Portuguese. The golf course is approximately 58 ha (6,5% of the total 900 ha) and the racetrack is about 66 ha (7,5%). The golf course is primarily used by the wealthy people and as a shortcut to the beach(see figure 4.20). The racetrack is no longer used for official races (see figure 4.18).

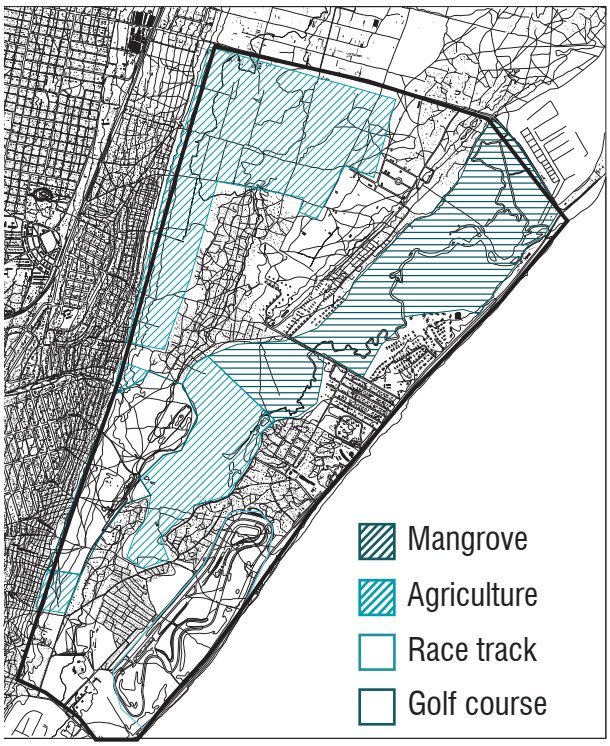


Fig. 4.17 Right: Overview of the variety of green programs

Fig. 4.20
Golf course, which also functions as the main connetion to the beach

Fig. 4.21 The mangrove area lies being the the shore line and contribute to many householdes with its wildelife

Fig. 4.22 The beach attracts allot of social activities and with Av. Marginal it generates a variety of commercial activities

Fig. 4.23 Road crossing the mangrove forest

Fig. 4.24 Commercial activities along Av. Marginal

Conclusion

Having analysed North-eastern Maputo's hydrodynamic vulnerability and issues related to rapid urban growth separately, it is important to note that these massive influences on the area's development are closely interconnected. We will therefore incorporate different examples of these interconnections into the conclusion.

Urban Growth Challenges

North-eastern Maputo is located close to the inner city, the beach and green space making it an attractive residential area for all income groups. Moreover, big parts of the area are still undeveloped and it can therefore be deduced with some certainty that urban growth will not decrease in the future. The lack of a holistic planning approach has already generated uncontrolled development where people occupy new land in vulnerable areas unsuitable for living (i.e. the swamp-area at the bottom of the hill or the mangroves along the beach). Uncontrolled development also has unfortunate consequences both physically and socially. In the rich neighbourhoods, big introvert fenced housing areas (often without common facilities) are being built. These may in time turn into mono-functional areas (i.e. gated communities) with little or no relation to streetscapes around them. In the poor neighborhoods, plots are small and irregular and infrastructure is ad hock. These areas consist of one-story dense developments that are almost impossible to restructure or to make efficient infrastructural improvements without scarifying already established houses. On the city scale the poor and rich neighbourhoods are being constructed side-by-side leaving an impression of inhomogeneous areas with little possibility for interaction among inhabitants.

Along car accessible roads in low-income areas in North-eastern Maputo there is a tendency for houses to be upgraded. This can result in those poor areas with fair infrastructural systems to develop within the existing structure. This in turn can give possibilities for current inhabitants to improve their own situation and for the neighbourhood to become more versatile

by attracting other income groups while remaining strictly residential. Along with potentials in infrastructural systems, North-eastern Maputo also holds potentials in the beach and the green areas (e.g. the golf course and the racetrack) to be reprogrammed to benefit everyone both rich and poor in different ways and at the same time develop the area to be more resilient to climate change.

Vulnerability Challenges

In North-eastern Maputo climate change is predicted with confidence to bring heavier rainfall and a rising sea level. These two different types of hydrologic flows affect different parts of the area and have to be addressed in differently. The rainfall floods coming from the hill are already causing annual problems. To address a runoff problem like this in a sustainable manner one has to solve it at the water's source. The densely built environment further up the hill does however make this close to impossible as it would require eliminating an enormous number of houses. Consequently, this problem needs to be addressed with a different approach in North-eastern Maputo. We will return to this in Chapter 7.

Erosion along the coast is slowly cutting in to Av. Marginal, which, with a sea-level rise and increased erosion, is going to cause major infrastructural problems, particularly if the road decays completely. Because the sea-level rise is such relatively slow phenomenon, people tend to postpone considering its consequences. But in North-eastern Maputo tide-floods are already occurring in the mangroves and these floods will little by little encroach to greater areas resulting in less space for urban development with the current tendency, more vulnerable housing areas. The solutions are right at hand in the shape of dikes, breakwaters and reclaiming the land, however these constructions are very expensive and would be difficult finance if the problem remains downgraded due to political short-sightedness.

Next step

When considering present condition and future challenges of the North-eastern Maputo, it becomes apparent that if people are going to live there (and live under better conditions) a development plan that incorporates issues of climate changes must be created.

We note the approach of Klong Bang Bua and Mafalala to officially support bottom-up planning, of Curitiba to perform large scale upgrading and integration strategies, and of Britain's visionary design in dealing with climate change, in addition to the above analysed situation in North-eastern Maputo.

Based on the conclusions of these approaches and experiences of those who are affected by these conclusions, we suggest a different approach to these challenges than that taken by the municipality in Maputo. The number and degree of uncertainties relating to the political, economic and social context of the area and the effect of climate change means that the plan has to address concrete problems and simultaneously be flexible and adaptable to changes. Because the challenges involve large areas, it necessary to address them holistically. We therefore suggest a large-scale plan, which supplements the municipalities' district plans, focusing on development processes and adaptation to climate change.

Chapter 05

FLEXIBILITY: METHOD AND IMPLE-MENTATION CONCEPT

We focus on Richard Sennett's (2008) notion of 'open planning' and UN-Habitat's (2009) notion of 'strategic spatial planning'.

This chapter provides an understanding of how flexibility can be incorporated into planning through the notions of 'open planning' and 'strategic spatial planning'. The purpose is to operationalise these notions into a 'strategic process and action plan' that provide the necessary tools, to address the issues of urban growth and climate change in North-eastern Maputo.

In a variety of different contexts, authors in geography, sociology, planning and architecture have discussed the concept of 'flexible planning'. We focus on Richard Sennett's (2008) notion of 'open planning' and UN-Habitat's (2009) notion of 'strategic spatial planning'. These notions share a basic understanding: the needs and requirements of today's urban planning are not accommodated by end-state modernistic way of planning, which many western countries use and which many developing counties have adopted from their former colonial rule (UN-Habitat, 2009; Sennett, 2008). Sennett (2008), however, discusses the notion of open planning in the context of western cities' social and spatial demands, whereas UN-Habitat delves into the complexities of informality and rapid urban growth in developing cities.

The need for flexible planning

Through times, planners and architects have tried to control use and development of urban space. With the modernistic manifest, the western world created a need for over-determined form and structure (Sennett, 2008), a planning approach that not only became implemented in the western cities but also in the colonial cities. Sennett (2008) argues that later this philosophy became outdated due to the changed needs of today's urban realm. UN-Habitat (2009:6) argues the same from a different perspective: "The most obvious problem with master planning and urban modernism is that they completely fail to accommodate the way of

Fig. 4.17 Right: Overview of the variety of green programs

life of the majority of inhabitants in rapidly growing, largely poor and informal cities." In a rapidly changing urban environment end-state orientated planning creates problems of both social and spatial exclusion because the planning structures cannot accommodate the fast changes (UN-Habitat, 2009).

Directions and tools of implementation

Planning in developing countries' metropolitan areas require a plan. This plan can incorporate flexibility and uncertainty (UN Habitat, 2009). Sennett (2008:2) gives an example of open planning as a genetic system, which he compares to the urban system, arguing that: "instability contains in fact a structure, or rather, many structures, which respond to uncertainty and coordinate change." Here Sennett (2008) argues that urban planners and architects should broaden their perspectives and look for new and different urban structures. UN Habitat (2009) also calls for a shift in planning. Many planning bodies have experienced that they have good strategy and planning policies, but they lack the capacity to set development in motion and actually improve the quality of life of urban residents. Instead of working towards a fixed goal in a master plan, Sennett (2008) suggests to actively work with the uncertainty, surprises and coordination of change as the basic elements in an open structure. UN Habitat (2009) argues that this can be done by using a mix of top-down and bottom-up planning. Seven overall goals can change the existing planning systems into a more contemporary planning system: strategic rather than comprehensive, flexible rather than end-state oriented, action and implementation oriented, stakeholder and community driven, reflect emerging urban concerns, plan an integrative role and focus on the planning process.

An opportunity to implement these goals occurs for spatial planning as defined by the UN-Habitat (2009). This provides a conceptual way of describing a desired future direction of an urban development. This approach to planning, mixed with Sennett's call for working with open planning by incorporating surprises, is what the area of North-eastern Maputo needs. In this case climate change and rapid urban growth are the major uncertainties that need to be incorporated in making a plan resilient enough to stand the future challenges.

Method of implementation

With the tools proposed by Sennett (2008) and the UN-Habitat (2009), we purpose a 'strategic process and action plan' adapted to North-eastern Maputo. Sennett's (2008) notion of open planning is not related to a specific place or scale, which makes it possible for us to implement his ideas into our holistic planning approach. The seven goals outlined by UN-Habitat (2009) relate to different scales and different challenges. Therefore, we have chosen to implement four of these seven that relate to 'scale' and focus on the 'design and development process'.

- Strategic rather than comprehensive
- Flexible rather than end-state oriented
- Action and implementation oriented
- Focus on the planning process

The above-mentioned goals suggested by UN-Habitat (2009), together with Sennett's (2008) ideas on planning for uncertainties, are the base for our proposal.

We incorporate Sennett's (2008) understanding of uncertainties and surprises by focusing on flexibility to encompass the unpredictability of the political and economic context and the prospects of climate change in North-eastern Maputo.

• We work strategic rather then comprehensive by only focusing on three elements: infrastructure, barriers and landscape modification (these will be discussed below). Moreover, the elements in our proposal work as a backbone structure in forming new local neighbourhood boarders and enhancing the existing. The backbone structure will secure a level of stability, security and lead to possible upgrades.

• We are working flexible rather than end-state oriented by purposing a strategy instead of a detailed plan and by working process-oriented and incremental. In other words, we suggest many projects at different scales shooting for partial aims and hoping that these hold potentials of generating additional initiatives.

• We work action and implementation oriented by solving specific problems through single projects involving many different local, national and international partners. Moreover, to make sustainable planning, actively engaging the community in the process is necessary. This has shown to be motivating, secure a strong foundation and result in long-term maintenance of the projects.

• We focus on the planning process. This is in the core of our strategic process and action plan. This point is in conjunction with 'focusing on action and implementation' in the sense that empowering the local community by participation is essential.

Implementation concept

Based on the conclusion of analysis and the above-mentioned aspects, we propose thee backbone elements in our process and action plan, which can help North-eastern Maputo, adapt to urban growth and climate change issues:

- **Infrastructure**
- **Barriers**
- **Landscape modification**

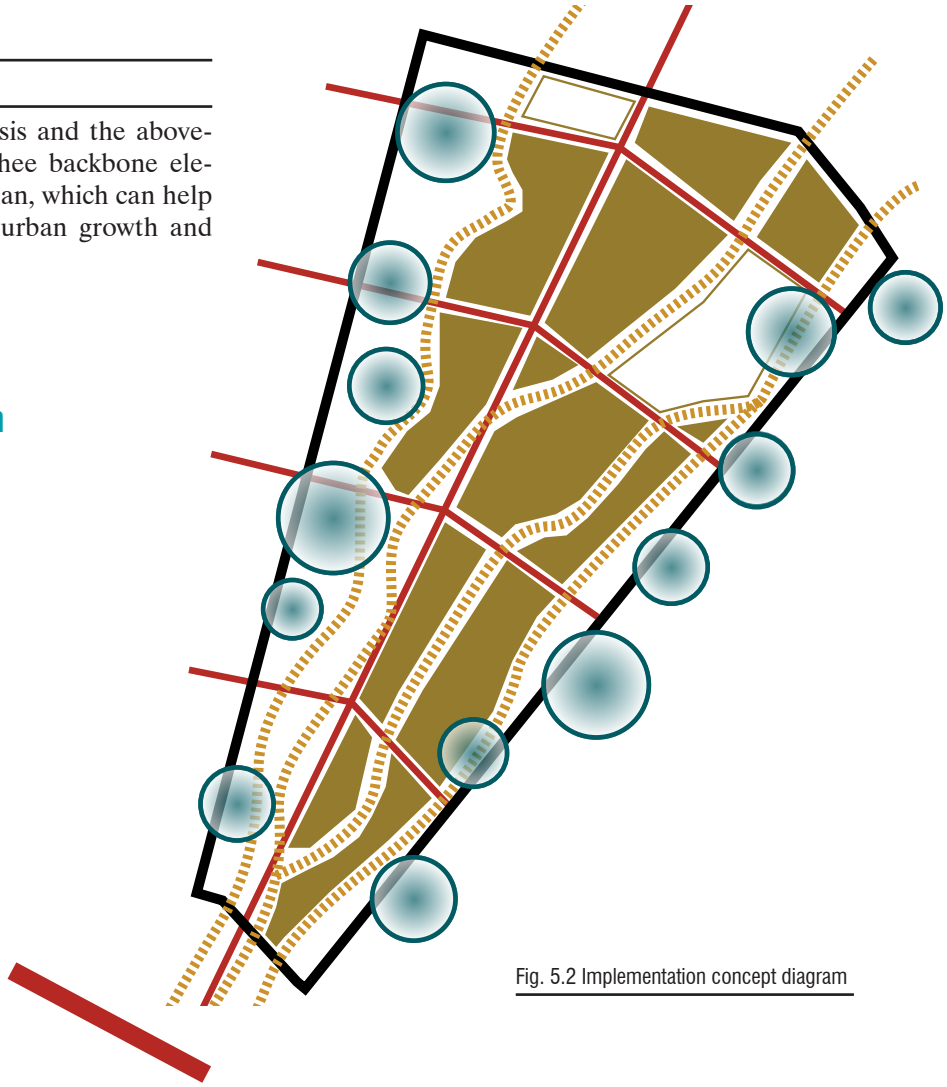


Fig. 5.2 Implementation concept diagram

The purpose of establishing better infrastructural systems is to create equal accessibility and to encourage a general upgrade. Roads bring safety to urban areas in the sense that it provides ac- cess for fire trucks and ambulances. Roads also functions as public space where social interaction happens; this in turn indirectly benefits the surrounding vicinity. Furthermore, infrastructure should be designed in such a way that it additionally functions as barriers (e.g. dikes) for extreme weather events. But infrastructure should also incorporate draining systems that would service the surrounding neighbourhoods and make them less vulnerable to annual and extreme flood events.

'Landscape modification' indicates utilisation of the undeveloped green areas in North-eastern Maputo by altering and preparing these spaces to serve as buffer zones for different water flows ranging from hills to the ocean. These elements of alteration will make the area more resilient to climate changes and simultaneously function as public recreational areas when not flooded.

Barriers are regulation tools can take many shapes depending on the surrounding environment. They create the outer boundaries between where development can take place and where it cannot; this is in turn necessary for preventing informal urban growth in areas that are vulnerable and unsafe to live in due to climate change. The barriers should be designed in a way that meets the locals' needs to move freely and at the same time be able to adapt to shifting circumstances over time.

The time aspect in the strategic process and action plan is determined by the forecast for climate change. The time perspective in planning processes was one of the main conclusions from the case 'Facing Up to the Rising Sea-levels', which argue that if climate change is to be incorporated in a planning process then one needs to plan 50, 75 or 100 years into the future. The following chapter unfolds a strategic process and action plan for the development of North-eastern Maputo, which takes the time aspect seriously.

STRATEGIC PROCESS AND ACTION PLAN NORTH-ESTERN MAPUTO

As disused in Chapter 4 predicting the future consequences of urban growth and climate change in North-eastern Maputo is full of uncertainties. However, we have chosen to illustrate our strategic process and action plan at four stages: 2025, 2050, 2075 and 2100. The four stages should be seen as milestones, indicating approximately which elements should be implemented and at what time, in order for the plan to be efficient. The four stages indicate, where urban development should take place in relation to the process of the constructing infrastructure, barriers and modifying landscape.

As mentioned above, different elements can be established as independent project, making it possible for the municipality, to focus on them individually and also fond them separately. Realisation of one project does not depend on another projects fulfilment as long as the milestones are met.

The strategic process and action plan is illustrated at four stages: 2025, 2050, 2075 and 2100.

MILESTONE 2025

The largest construction in the first phase is the already planned north-south main road and six runoff constructions (wadies) on the hill bordering the area to the west. Those two improvements secure more stable environment and especially the main road will generate new development.

① North-south main road

The main road is already integrated in the PEUMM as a part of the overall infrastructural strategy for Maputo. The road will become the new main connection to the northern city of Marracuene. This will ease the traffic load on Av. Marginal, making it possible temporarily to close and rebuild it, as a mixed protective barrier and road securing the coastal area from flooding.

② East-west road

Another important connection, which will be established due to a large amount of traffic, is an east-west bound road to Chiquelene. Today there is a distance of five kilometres between the east-west roads of Donna Alice and Julius Nyerere, which effectively obstructs accessibility to Chiquelene. Chiquelene is the main shopping hub for locals, when needing something else than their daily needs and at the same time it is an important public transportation hub to western Maputo. The connection was previously laid out in a Portuguese master plan from the 1950s, so the build environment is consequently controlled in such a way that connecting the two areas will not cause much restructuring.

③ Paved local roads

The first paved local roads will as well be constructed in this phase. There will be no more than 300 meters to the nearest car accessible road for all of the present urbanised neighbourhoods in the area. This will bring security to the areas, ensuring that it is possible to get in and out of an area in the event of emergencies. This will also generate upgrades of houses. In the period from now until 2025 the northern part is expected to become urbanized around new north-south road due to improved accessibility and increasing demand for housing.

④ Constructing wadies on the hill

Since the run-off issues in front of the hill cannot be addressed up stream, as this would mean restructuring of a 1400 ha densely build environment, we propose constructing wadies on the hill in the existing erosion trenches. A wadi is a runoff channel which leads the water from one place to another, but is dry most of the time. This will stabilise the environment in the neighbourhoods on the hill and the area in front less vulnerable for flooding and thereby better conditions for new urban development. The wadies end up in large lakes, which will function as water magazines to control the flooding by restricting it to undeveloped green areas.

The southern lakes are constructed in the periphery of the golf course. Part of these lakes will hold water permanently due to their elevation and the lakes will become an incorporated part of the landscape. In the event of floods the lakes are constructed in such a way that the water will overflow the golf course instead of the nearby residential areas.

In the south part, the privately owned golf course work as natural border for urban expansion, this is however not the case further north. In the north it will be necessary to create barriers that prevent people from moving into vulnerable areas that will be flooded both before and after establishing the lakes. The barrier should only deny access for trucks and cars (preventing people from entering with building materials) and still be penetrable for pedestrians using the area for transit or to get to their fields.

⑤ Barriers to protect mangroves and farmland

The mangroves contain valuable ecosystems that supply the livelihood of many locals and at the same time it functions as a buffer for tides. The same is the case for the swampy farmland south of the mangroves. The increase in the hydrological events and the sea level rise will make these areas more wet and unsuitable for urban development. Until further protective constructions have been built, barriers similar to once previously described are required, to prevent people from building in vulnerable areas but not from using them.

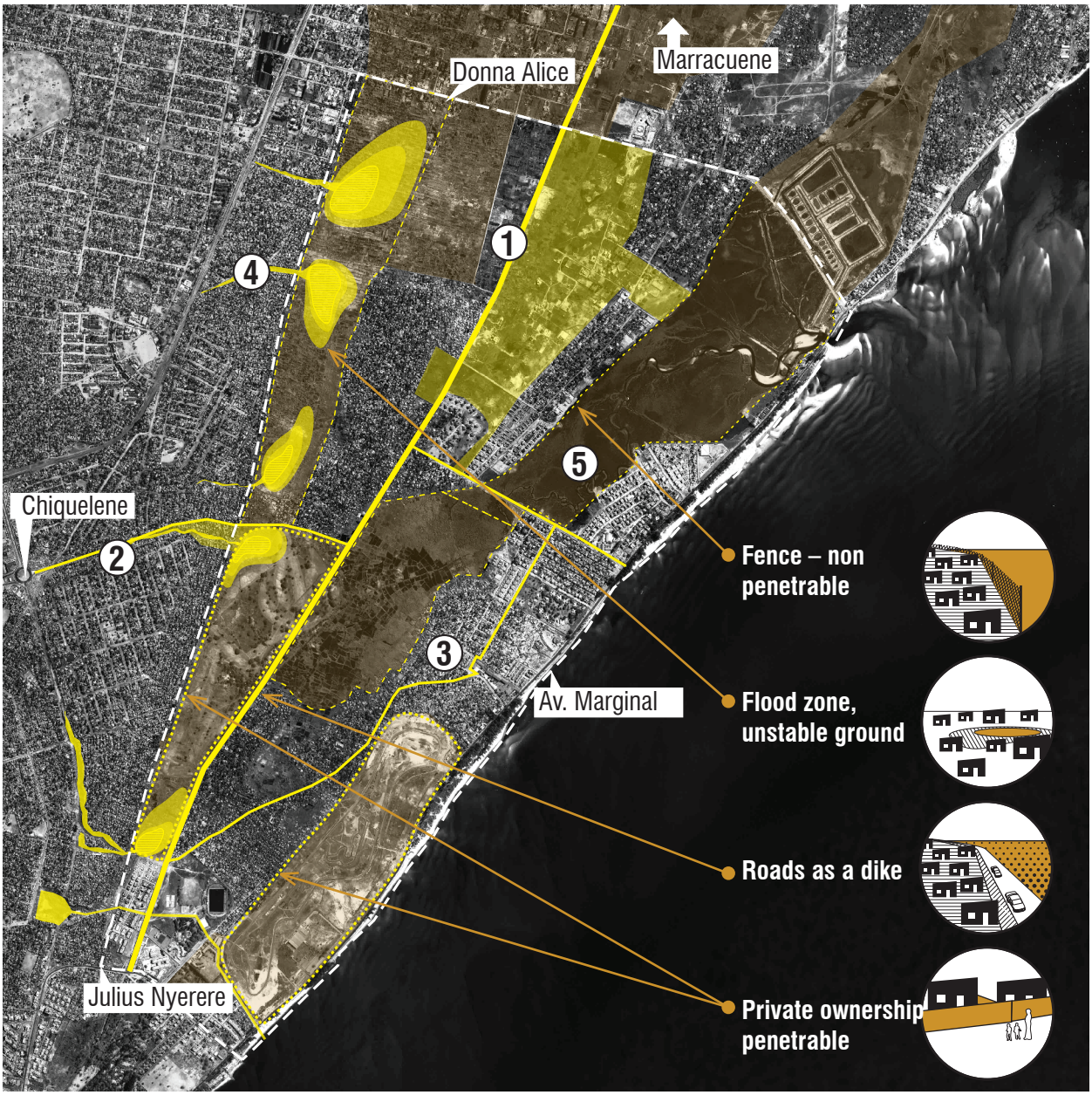


Fig. 4.2 Milstone 2025

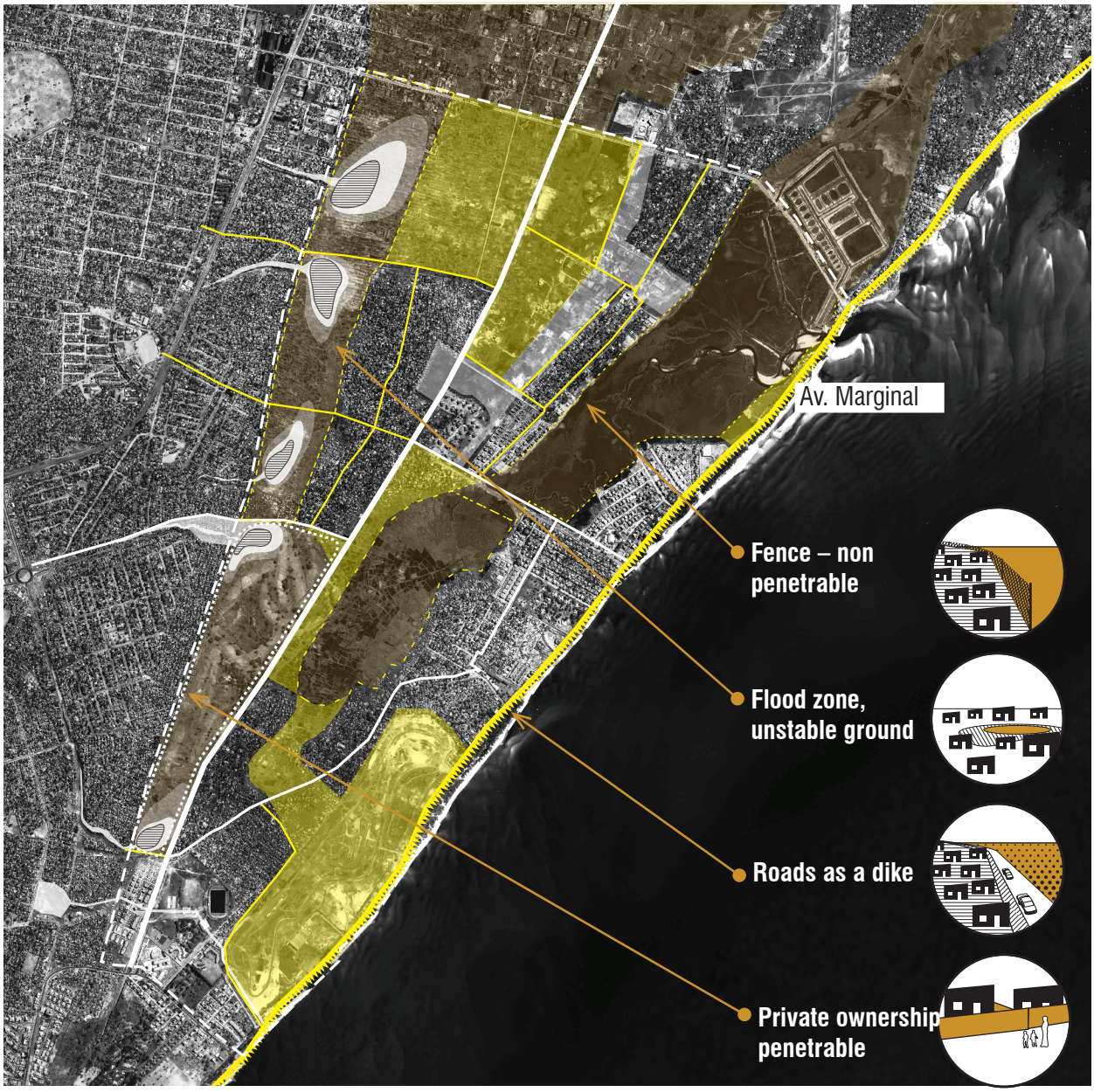
North-eastern Maputo

Urban Development

Run-off Lake

Green areas

New road



North-eastern Maputo

Urban Development

Run-off Lake

Green areas

New road

New road and dike

Fig. 4.3 Milstone 2050

MILESTONE 2050

① Av. Marginal as combined road and dike

By far the most expensive project between 2025 and 2050 is reconstructing Av. Marginal as a combined road and dike. The newly established inland north-south road has begun to work as the main transit road and Av. Marginal have a more recreational character. During this time period Av. Marginal has been elevated and designed so it functions as a dike, protecting the areas behind it from the rising sea-level and in addition making it possible to develop these areas. A big part of the area behind Av. Marginal is mangroves and they will receive less tidal water and therefore gradually change as a consequence of the dike construction. Simultaneously, wadies and lakes along the hill have changed the water flow through the lowlands, creating a dryer and less vulnerable area than before.

② Transformation of the racetrack

The old racetrack is also transformed into a development area; its location by the beach makes it attractive for both housing and programmes such as hotels and embassies. The leasing or selling of plots can be used to finance other projects in the area. The 58 ha racetrack will together with the former farmland by Donna Alice be 150 ha of land in total, which can be developed to accommodate the population growth in North-eastern Maputo. If urbanisation continues with 3.5 -5% annually, the population will have increased between 63.240 and 90.300 persons or between 421 and 600 persons per ha in 2050. This however does not consider the greater urbanisation that is likely to happen in the attractive North-eastern Maputo. This goes to illustrate the demand for new building typologies to increase density and improve the living standard, as the density is going to double up in the future.

③ The network of local roads is expanding

Especially in the northern part of the area, paved local roads have been built amongst those two minor east-west connections improving accessibility in neighbourhoods both on the hill and in the north-eastern part. Drains are integrated into these connecting-roads improving not only accessibility but also draining surface water away from the surrounding areas.

MILESTONE 2075

① Changing the mangrove ecosystem

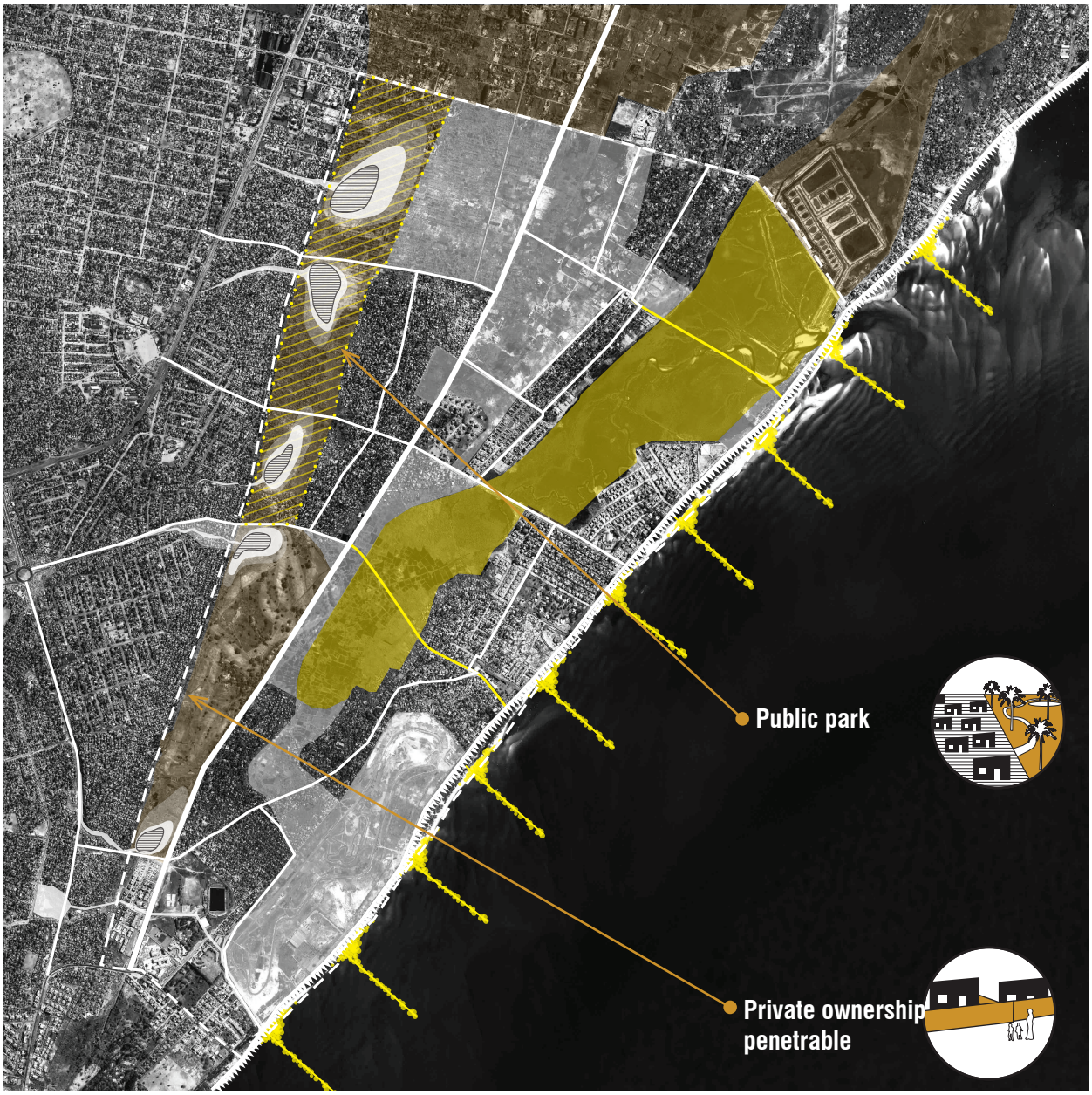
Establishing the dike along the coast closes the hole where the tide came into the mangroves and as a consequence of the changed conditions the mangroves will disappear. This sacrifice is required to accommodate the urbanisation. The specific fauna in mangroves that have supplied the livelihood of locals is no longer available, but we predict that it is no longer needed as economic and social conditions have changed. The 195 ha mangrove area has therefore been implemented in the urban development; the former barriers are completely removed and new infrastructure connects the former mangroves to rest of the city.
The area will then be urbanised and if we estimate the population growth to be constant, the density will be between 200 and 290 pers. pr. hectare.

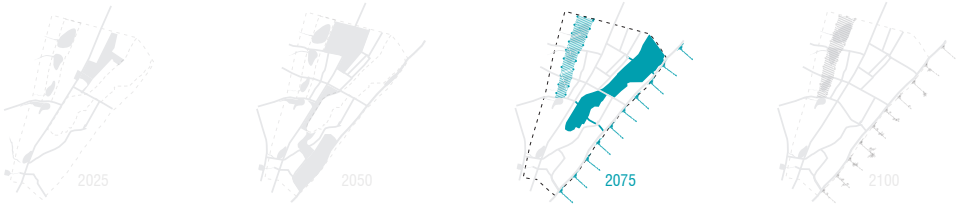
② Connection of piers

To protect the dike from erosion and sediment transportation a series of piers are constructed along the coastline. These will break the waves and prevent erosion. The piers may be constructed combining stones, concrete and reclaimed sand.

③ Public parks

At this point in time, we expect urban development along the new north-south road to be stabilised that the municipality's administrative planning tools to be efficient enough to prevent uncontrolled informal growth. We also expect those 'barriers' around the northern water magazines to be developed into public green spaces that in the event of heavy rainfall will be flooded but the rest of the time they work as recreational space for the citizens.





North-eastern Maputo
Urban Development
Pier
Run-off Lake
Green areas
Park development
New road
New road and dike

Fig. 4.4 Milstone 2075

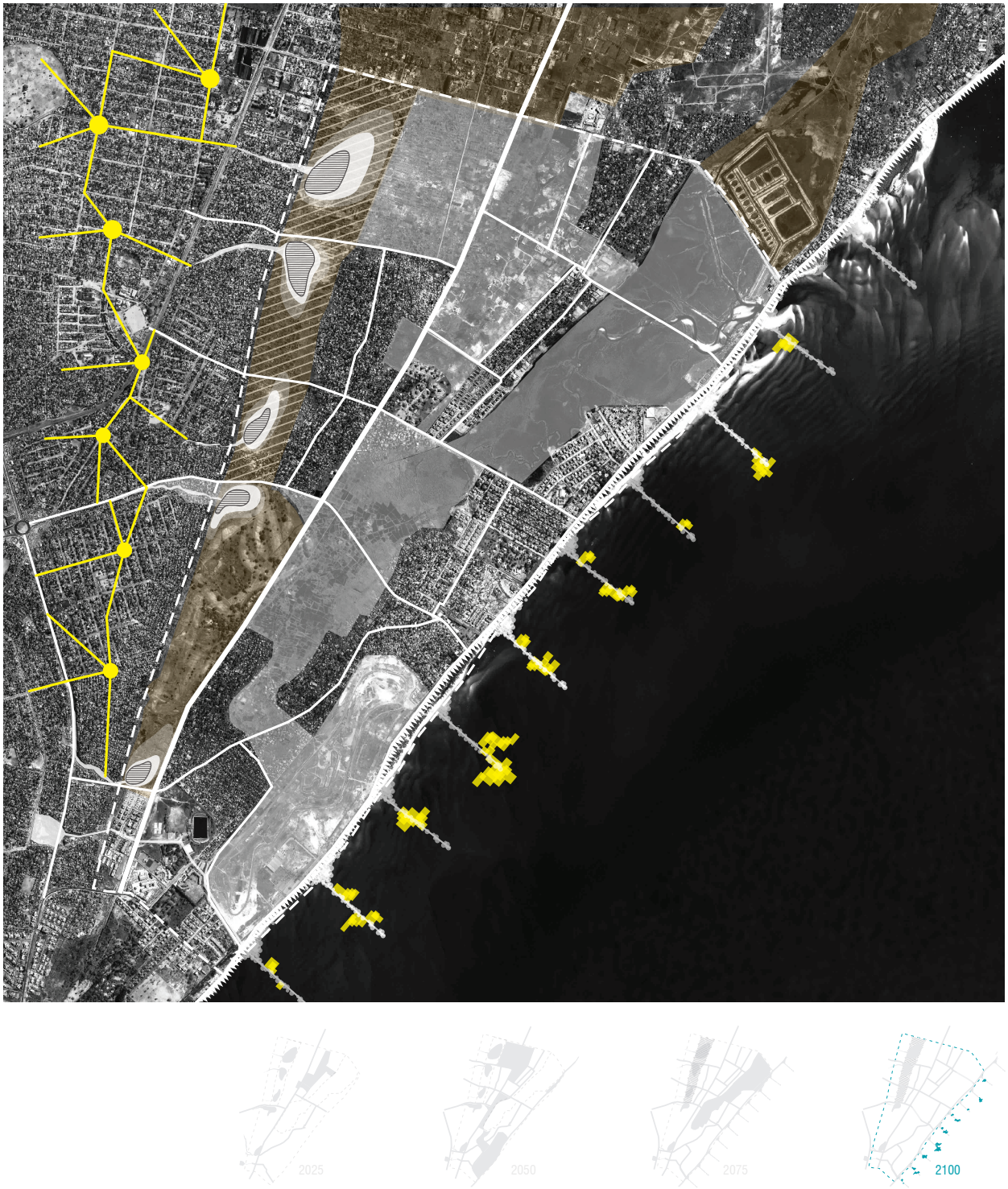


Fig. 4.5 Milstone 2100

MILESTONE 2100

In 2100 all of North-eastern Maputo has been developed and between 187.000 and 250.000 inhabitant live here. The golf course, the new park and the beach function as three large open public spaces and North-eastern area is the most attractive in Maputo with great potential of becoming a central tourist location.

① Further development of piers

The piers have been developed further and now include recreational public programs as well as different semi private and private establishments. The piers have become a new playground in Maputo with a floating environment of people, boats and programs creating a dynamic city on the water. The sea-level has now reach a level 1,2 meters above 2010 level (Appendix 1).

② Implementation of extended drainage system

In the neighbouring districts of Laulane, Ferroviario and Polana Canico A. to the west large draining systems are implemented. The drains work together with the wadies established in 2025 and unify a system of drains and basins that all in all create a stable environment that is able to cope with heavy rain.

Conclusion

Planning 90 years a head means planning for uncertainties and the unpredictability. This implies that even though we have suggested a 'strategic process and action plan' trying to grasp the future, there is no promise that it will be realised. This is however why we have chosen to make our plan strategic instead of comprehensive pining out a few elements, which is the base of the plan. Our plan is strategic and flexible because it uses a backbone structure only focusing on infrastructure, barriers and landscape modification in the development process of North-eastern Maputo. These are large and expensive urban structures to implement, but we see them as essential if the area is going to cope with issues of urban growth and climate change. The backbone structures have been laid out in relation to the existing urban fabric, the shape of the landscape and functions of green areas. We have tried to allocate where urbanisation should take place at different stages by gradually transforming green areas into development areas and simultaneously using the green areas to adapt to the changing climate. We have calculated the urban growth after the 2010 level, but if this level continues or not over the next 100 years we cannot say. But if it does it is clear that solutions have to be found on new building typologies to require space enough.

The prospects of climate change make us to address the possible future scenario already now, before the consequences are too severe to adjust. The philosophy behind is a strong focus on action and implementation and as a result we work incrementally step by step. This allows for flexibility and involvement of local communities in different shorter or longer projects. Moreover, it provides the possibility continuously to evaluate and renew the plan and fit it to the present circumstances.

Chapter 07

ZOOM- IN: THE EROSION TRENCH ANALYSIS

The design of each individual wadi should be customised to its context and to the needs of locals.

The first milestone (2025) in the strategic process and action plan is proposing to construct wadies on the hill in exiting erosion trenches, barriers to protect farmland and mangroves and three infrastructural projects including a new north-south main road through North-eastern Maputo (see figure 7.2). Even though implementing infrastructure is important to establish coherency, securing people and their livelihood by controlling water flows on the hill has the highest priority. Based on this consideration, we will make an architectural proposal dealing with this issue. We will zoom-in on the erosion trench located in the seam of bordering neighbourhoods of Ferroviario and Polana Canico B and Costa do Sol (see figure 7.1).

Fig. 7.3
The erosion trench

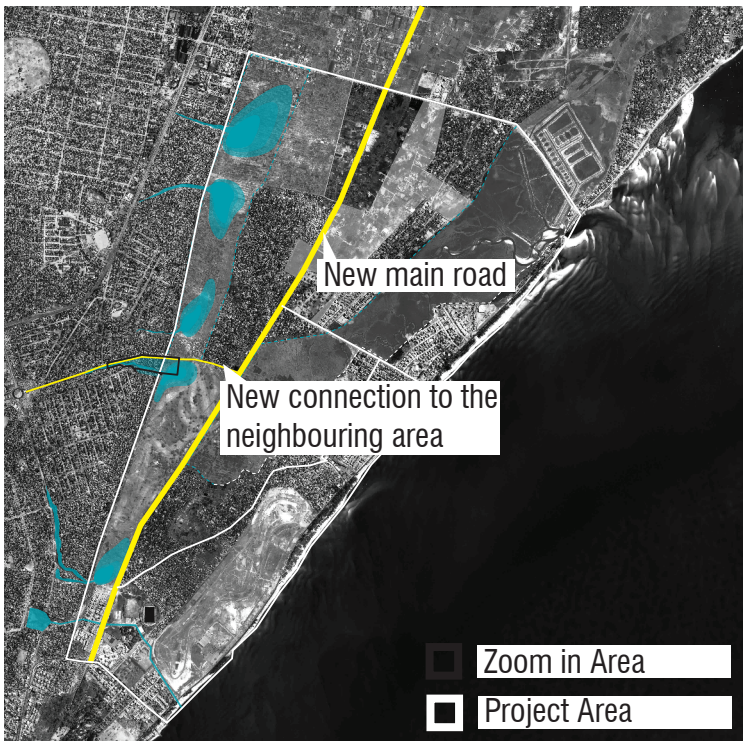


Fig. 7.1 Above: The three neighbourhoods that the zoom in is located between
Fig 7.2 Right: Milestone 2025

As mentioned in Chapter 4 the long sloping hill house a 1400 ha heavily built low-income area, where the density and character of the urban fabric has diminished natural drainage greatly. Consequently, water flow by houses in the streets and in periods with heavy rainfall there are large erosion problems (see fig. 7.3). We propose constructing a wadies on the hill in the existing erosion trenches and large lakes as water magazines along the hill to collect the water.
The design of each individual wadi should be customised to its context and to the needs of locals. In order to do this, we identify the uniqueness of our zoom-in area and in its inhabitants in the following analysis. Information used in this analysis is gained through observations and interview with locals during February 2010. Interview notes and additional pictures can be found on the Appendix CD.

PHYSICAL ENVIRONMENT

Fig. 7.4
Insecure housing on the edge of the trench

Run-off Issues and topography

The erosion trench was created in a massive flood in 2000 because of accelerated and concentrated water flows. The hill is the prehistoric coastline and consists mostly of clay and due to clays low-permeability it is hard for water to penetrate and since run-off water is flowing in the streets, the surface has also been trotted together further decreasing penetration. Furthermore, the hinterland is larger than Polana Canico B and Ferroviario collecting greater quantities of water and as mentioned above the building structures on the hill concentrates the run-off.
The current situation is vulnerable and unstable for people living close to the trench and the increasing demand for houses means that people are still settling in the periphery of the trench (see figure 7.4).

Heavy floods causes major damages on houses and bring clay, sand and waste along with it and leaves this in delta-like areas at the bottom of the hill. Due to elevation at the foot of the hill groundwater level is only 1 meter below the surface. For this reason run-off water penetrates slowly creating swam-like areas that are undesirable and unhealthy for people living in (i.e. creating a perfect environment for mosquitoes) (see figure 7.6).

The water run-off issues are closely related to the topography of the site. The trench is about 300 meters long and rises up approximately 30 meter. This hill is not steep, but because of the large hinterland behind, and the densely build environment it still suffers from erosion (see figure 7.5).

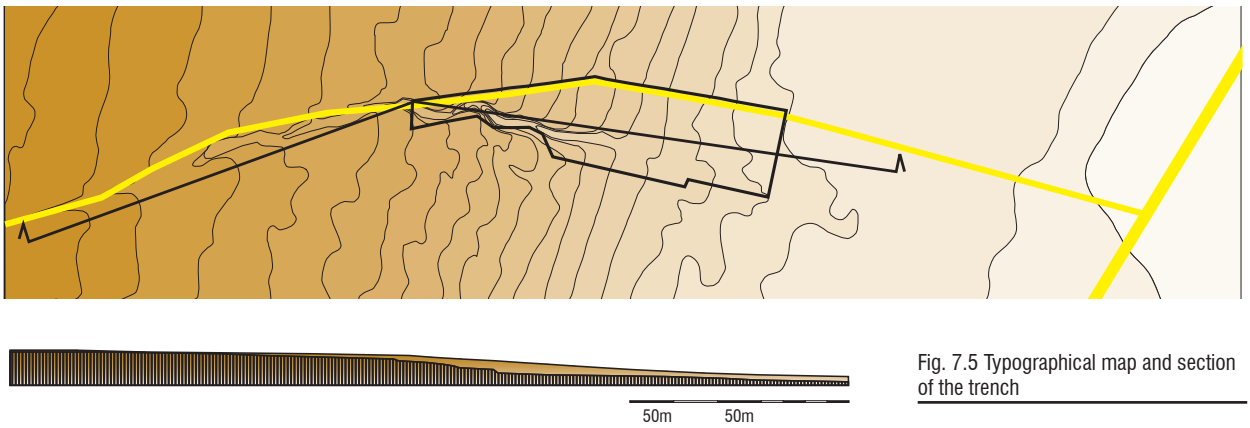


Fig. 7.5 Typographical map and section of the trench

Fig. 7.6 In the lowlands at the foot of the hill the water sits in puddles with increased risk of mosquitoes

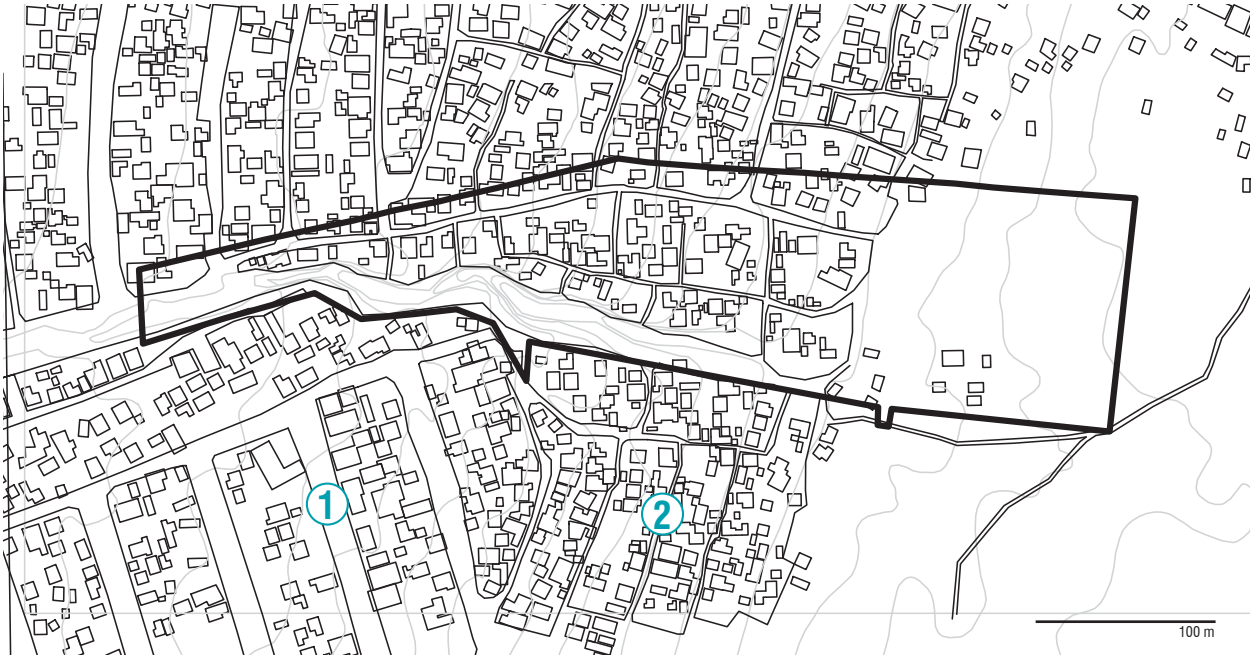


Fig. 7.7
Re-structured housing with 15 meter wide roads

Fig. 7.8 Houses on the hill with a structure after the shape of the hill with 2 meter wide roads

Psychical and mental barrier

Mentally the locals do not consider their neighbourhood area-defined by the municipal defined. Instead they relate to smaller communities within the different neighbourhoods. The trench has however become both a physical and mental barrier dividing the build environment into different part.

Building Structures

As discussed in Chapter 3, Polana Canico B and Ferroviario were originally settled without any planning. The road grid and the regular housing plots on the upper part of the hill are the results a municipal upgrading-plan form the late 1970s. The build environment further down the slope has emerged since, which can be seen in its character (see fig. 7.7). Houses here are arranged in rows (north-south) following the hillside but the area is visibly self-grown. The density in this area is much higher, mostly due small road and passages not wider than 2 meters (see fig. 7.8), moreover there are no open space that could function as public spaces and therefore locals gather on the streets.
The build structures around the erosion trench mostly consist of one-storey houses. The average house is made of unpolished concrete blocks with tin roofs (see fig. xx). The houses in the poorest condition are made of cane while the ones in the best condition are made of polished and painted concrete bricks. The houses wary in size from 40 m2 to 100m2 and most of them are connected to a private outdoor garden with trees. The overall image of the area is green due fertile soil and undeveloped areas like the erosion trench.

Fig. 7.9
Programs in the area

The Urban Fabric and Accessibility

Unplanned development in the area is still going on and there is a strong tendency to clutter the urban fabric by building more then one house on each plot. People even started to work around the limitations of each bloc by constructing new houses directly in the streets. This narrows down streets to paths and worsens accessibility for themselves and their neighbours. In some areas on the hill this is directly obstructing car access and generally there is a total lack of infrastructural hierarchy.

However, the largest everyday obstacle for locals is the limitation in mobility with up to 1,5 km to the nearest public transport. All traffic between North-eastern Maputo and Ferroviario happens on foot. Av. Das Forcas Populares de Liberacao de Mozambique is the infrastructural connected to the rest of Maputo. It is well serviced with public transportation by chapas (small private busses).

Programmes

North-eastern Maputo has always been a residential area, which has resulted in its current mono-functional character. Little attention is given to mixed-use and integration of other functions (e.g. services, industries, public facilities and programs), especially not around the erosion trench. Zooming out, other functions are two primary schools, a police station, the golf course, churches, beverage stores, small temporary food stands, the Chiquelene market and a busstation, which services North-eastern Maputo (see figure 7.9).

Waste and Sanitation

The erosion trench is an area with no ownership and has thus become a local waste dump (see figure 7.11). Glass bottles are being gathered by some and recycled, however the amount of waste in the erosion trench creates a smelly and unhealthy environment. There are not any drains or sewers in the area, which is why the lavatories are private pit latrines dogged in the ground (see figure 7.10).

Fig. 7.10
Private pit latrines

Fig. 7.11 The trench is used to dumb waste, which creates an un healthy environment

SOCIAL ENVIRONMENT

Fig. 7.12 Small businesses, service jobs and casual labour are the most common jobs

Family Structures

Mostly three generations live in each house and between eight and twelve people. Following traditions children live at home until they marry and then the daughters move into the house of her husband's family. Often it is the oldest son and his wife who moves into the house of the parents, and if there is room for more the other siblings live there as well.

Fig. 7.13
Three generations living together in one house is normal

Occupation and Daily Rhythms

The unemployment rate in Maputo is around 40 %. In most families men are the only provider and income from two or three workingmen can support a family of twelve. Many are occupied in small-scale businesses, service jobs in the concrete city or with casual labour. A small number of women do contribute financially to the household by working service jobs or by selling self-grown crops or food. It is however also the women's duty to cook, clean and take care of the children. For 1 out of 4 girls adulthood starts with pregnancy before they are 18 years old, which sustains the tendency of women not working (UN-Habitat, 2008). Most men and women have a basic level of education, minimum 5 years of school. Consequently, many finish school at the age of 12 and work jobs with low salaries. There is a small school fee, which most families can afford, but it is not a priority to finance more than basic education in many families. Schools run in shifts. The younger children go to school in the morning while the older children go in the afternoon, and due to this there is often children playing in the streets.

Public Social Life

The lack of programmed public spaces means that all social activities happen in the streets or in the shadow of a tree. If there is a performance of some kind it also takes place on the streets or in school. Nevertheless, most activities are casual or self established like women branding each other's hair or watching a small grocery stand. The neighbourhoods are generally very lively all day and evening. People have strong relationships with their neighbours and especially women most of days outdoor in the shadow, taking care of their children and talking with their friends.

The residential mono-functionality generates a generic use of the public space/streets and the general lack of public programmes does not invite the people to initiate development in their communities. The strong social network and sense of unity and solidarity that exist among locals, holds great potential that can help develop the local area. Right now these relationships get fostered in the everyday casual activities and meetings on the street and these are the heart and soul of the neighbourhoods. Nurturing and empowering these elements, could generate a possible upgrading process though a common understanding.

Fig. 7.14
Roads as function as public space

Local Governance and Land Tenure

As mentioned above, locals organize themselves in smaller communities. These communities have a central figure in their chief. His functions as an unofficial authority of a certain area, taking care of local and domestic incongruence before locals contact official authorities. The communities are sized differently and each chief is part of a complicated network with other chiefs.

As mentioned in Chapter 1, according to the Land Law from 1997, a person has legal rights to his land when he has lived there for more than 10 years. Even though many have legal rights almost nobody have the official papers, because getting them is often a long, demanding and costly affair (even though legal papers should be free). Another issue is defining one plot from another, as there are no official maps, street names or house numbers. The insecure land tenure is ensuing an uncertain future for residents in North-eastern Maputo; since it is not safe invest in their houses, as the government legally can tear them down.

Fig. 7.15
Marta, the wife of the local chef

Upgrading Processes

In different neighbourhoods of Maputo there are tendency in the way low-income areas (similar to North-eastern Maputo) were transformed. As discussed in Chapter 4, houses located along streets with car access were upgraded faster then in other parts of the same neighbourhood. The upgrading was very visible, changing from a cane house to brick house or changing to polished brick house to a larger house in two storeys. Roads seem to be very important, as locals do not consider their neighbourhoods officially accepted unless its main roads are paved. Indeed the roads are the municipality's responsibility but roads seem to be the last thing in neighbourhoods to be developed (also in rich neighbourhoods).

Fig. 7.16
Upgrading stages from cane to plastered house

Conclusion

The impression of the inhabitants in the area around the erosion trench as well as in other low-income areas of Maputo was, that the people generally wished to change their living standards, but they did not know how to. Of course many living in the area are slowly working towards an improvement but for many the psychical and social obstacles seem too large and too complex to handle.
Following the 2025 milestone in the strategic process and action plan a wadi in the erosion trench and a new north-south main road is going to generate a more stable run-off situation and lead to massive changes in the development process. These developments hold the potential of addressing some of the present local urban concerns. Based on the analysis the four most pressing are:
- Urban growth and housing demand make people built in cluttered areas altering the urban fabric, decreasing accessibility, increasing density and pressure on the few public services available. All of which lead to a decline in each persons living conditions.

- Unexciting run-off control creates vulnerable and unstable environments along the erosion trench. Run-off continuously damages houses, creates an unusable swam-like area of debris and waste at the bottom of the hill and is a physical and mental barrier for locals. Moreover, a single flood event may completely deteriate living conditions along the trench.

- The self-grown building structures on the slope obstruct accessibility to and from building plots. They create unsafe environments, decrease upgrading possibilities and make it close to impossible to improve the land tenure ship.

- Most locals have little income and due to traditions and the lack of resources, possibilities and knowledge normally only men work. Extra income would allow the families to improve their situation and make them less vulnerable to changes.

Fig. 7.17
Panorama overview of the trench

Chapter 08

VISION AND DESIGN STRATEGY

The analysis has given us a list of reasons why and how the neighbourhoods around the erosion trench are vulnerable to urban growth and climate change. The strategic process and action plan has provided the two main elements that shall generate development and change in the neighbourhood: a wadi and a new east-west going main road.

The overall vision for implementing and designing the wadi and the road is to decrease the vulnerability in the area by creating a secure environment and good conditions for the locals to enhance their living standard. This we desire to do through a design that accommodate the local urban concerns and draw upon local qualities and resources. Using the construction of the wadi and the road as a take of for other new initiatives and projects together forming a area that can work as a source of inspiration for other similar parts of the city.

For the design to reflect the local concerns, we purpose five design strategies that each illustrates how we address different parts of the challenges in the design. As a base for these we have four overall design policies that relates to general considerations about what kind of area we desire to create and how it should relate to the context.

Design policies

Keeping the sacrificing of houses to a minimum

The construction of the wadi and the road will no matter how softly lay out mean that houses will need to be sacrificed for the sake of the greater good. It is however a clear policy of ours that as few houses and thereby people shall be move as possible in order to preserve as many of the social relations in area as possible and of course to keep the individual expenses on a minimum.

Design the wadi so it do NOT become a physical barrier

The erosion trench is today an open wound in the landscape and a large barrier for pedestrian flow. It is at the same time effectively separating the neighbourhoods of Ferroviario and Polana Caniço B preventing unexpected social interaction between people from the different thereby adding to the mental segregation of the areas. The wadi has to first and foremost work as run-off channel but the design shall furthermore seek to even out the vertical barrier between the two related neighbourhoods

Designing with the existing environment and landscape

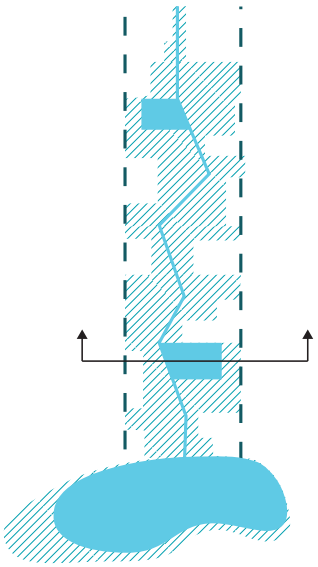
The build environment and net of infrastructure on the slope follows the contours of the landscape. We wish the new elements of the design to do the same in order to visualise the relation to the existing structure and enrol it as part of the neighbourhoods all though physically separated from them by the wadi and the road.

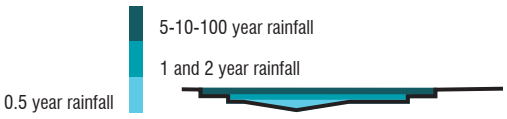
Establishing and re-establishing accessibility

Reading the landscape it is clear that as the water washed away more and more soil in the erosion trench it also washed away infrastructural connections that hampered the accessibility especially for the people living on the slope. To create better access to and from these communities we want to establish and re-establish connections that will (through our area) open then up making them more accessible.

The Wadi

Addressing the hydrodynamic problems

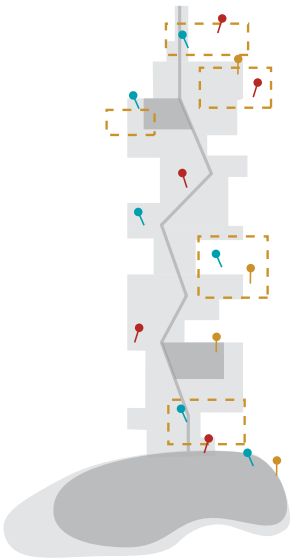


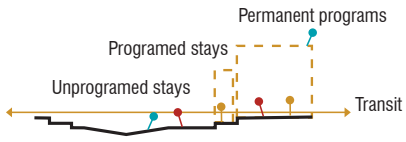


The wadi will create a stable environment and reduce vulnerability, which makes it possible to densify surrounding areas. It will be constructed in different levels and these will relate to different rain return periods (6 mouths, 1, 2, 5, 10 and 100 years). In other words, the wadi appearance will change in accordance with the amount of rain and its design will create a dynamic series of spaces down through the erosion trench. The wadi's shape will contribute as an attractive open urban space in an area that does not have many.

Programs and activities

Increasing the local networks and social relations

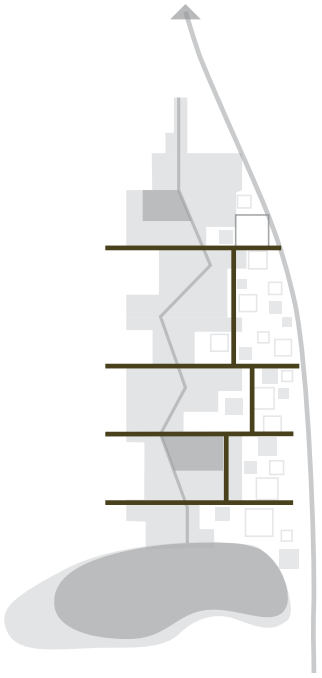


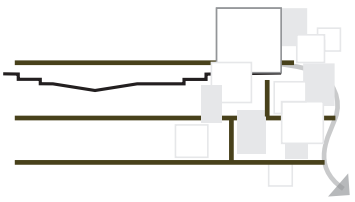


The open space created by the wadi will be double programmed; making room for activities during the long dry periods. The activities will generate life around the wadi, making it a location for common facilities reinforcing the community and creating a sense of ownership of the space. The idea being that if the locals' use and have a relation to the space they will treasure and nurture it. Moreover, the surroundings will be programmed in different ways. Passive recreational programs will generate casual meetings between the two neighbourhoods during the day. More active programmes will involve the many children and teenagers giving them something to do during the day and making them give something back to the community.

Accessibility

Improving upgrade possibilities

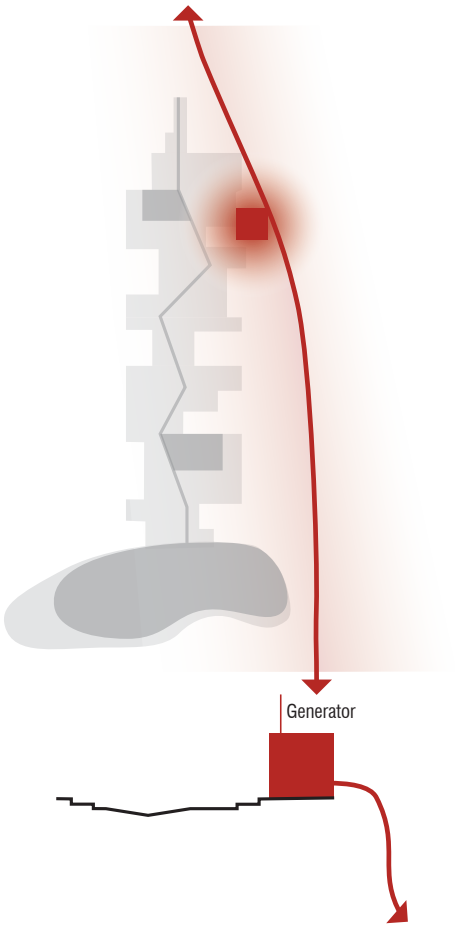




The new main road connecting Chiquelene with North-eastern Maputo, will bring considerable changes to the area. It will transform from being an isolated city part to a central part of the in city network. The implementation of new access roads in the area will be done sensitively, but at the same time create the infrastructural backbone, providing the necessary structure to bring better upgrading possibilities and security to the area.

Neighbourhood generator

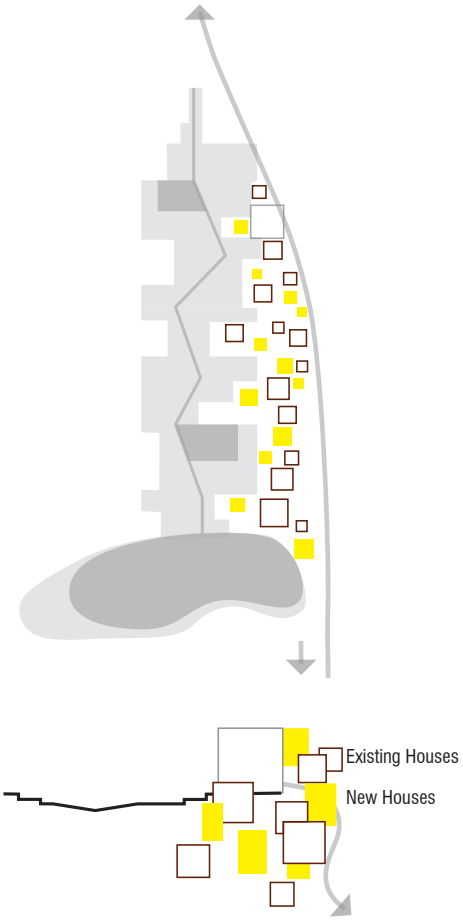
Making possibilities for the people to change their livelihood



To encourage a positive development and generate new economies, we suggest a series of neighbourhood generators to initiate this process. The generators will take the shape a united structure and be located in the centre of the development where the wadi and the road meet; it will contain supportive, educational and workshop facilities. The generators will also include service functions to help the surrounding neighbourhoods to become more sustainable.

Densification

Addressing the increasing demand for houses

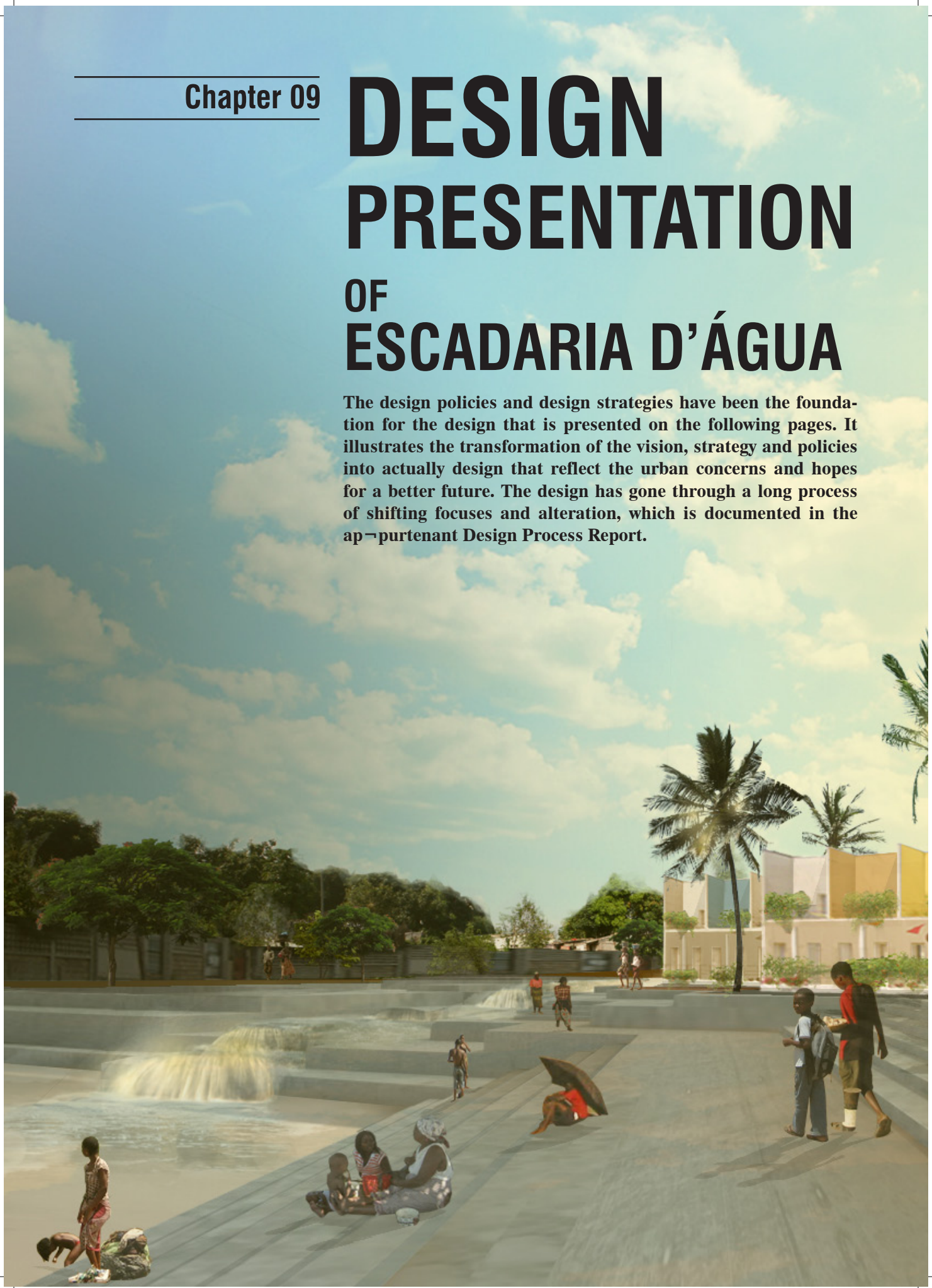


As a consequence of the changes in the neighbourhoods some inhabitants have to move. There will however also bee space to create new housing developments. One design-criteria for these new houses are that they can accommodate at least the same amount of people that are 'forces' to move. The new houses will furthermore be an example of a new typology in the area. Physically illustrating how the problem of density can be addressed through design. As many of the existing houses as possible will be saved, however their surroundings will be transformed giving the areas the best possibilities to densify from within.

Chapter 09

DESIGN PRESENTATION OF ESCADARIA D'ÁGUA

The design policies and design strategies have been the foundation for the design that is presented on the following pages. It illustrates the transformation of the vision, strategy and policies into actually design that reflect the urban concerns and hopes for a better future. The design has gone through a long process of shifting focuses and alteration, which is documented in the ap¬purtenant Design Process Report.

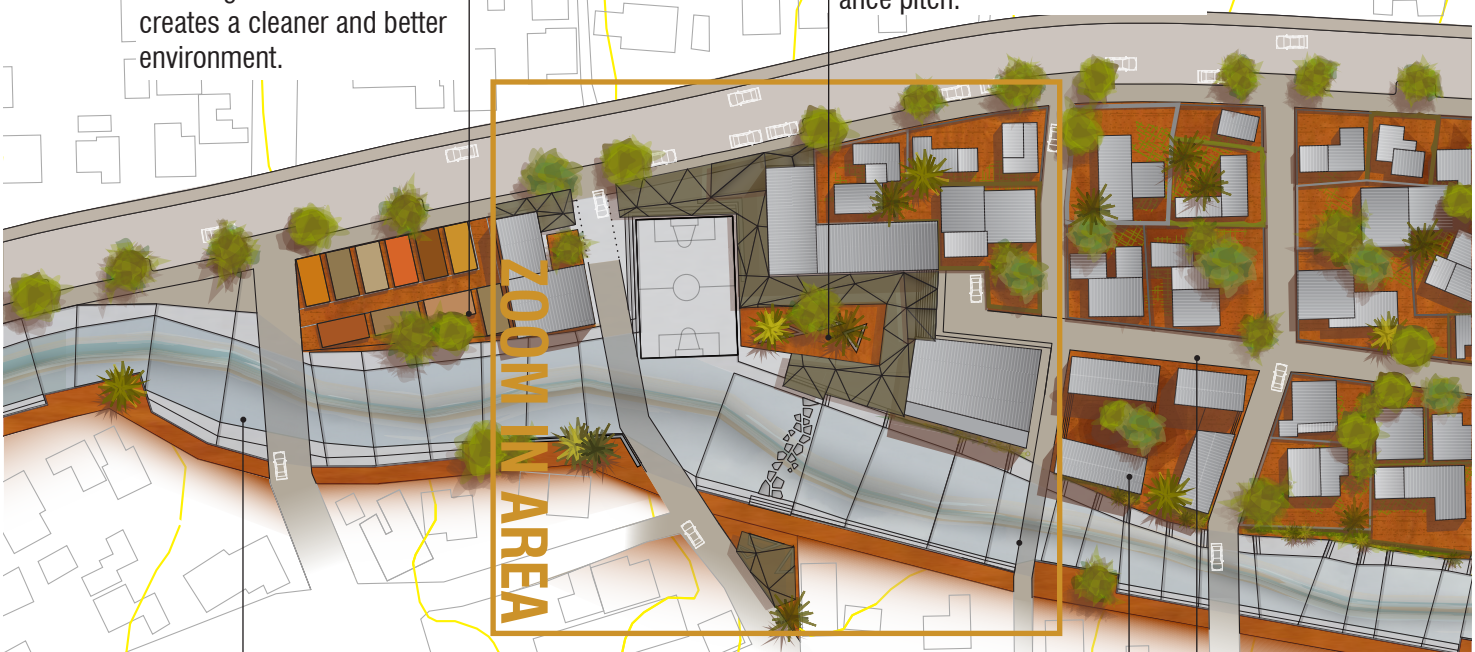


ESÇADARIA D' ÁGUA

- STAIRS OF WATER

The recycling station manages waste from the surrounding communities and creates a cleaner and better environment.

The neighbourhood centre is a generator; providing economical, educational, social and health services for the surrounding communities. Additionally it has outdoor spaces and a multi-use sports and performance pitch.



The wadi is dimensioned to contain rain with a return period of 100 year. The water will run through at different levels and its expres¬sion will vary in accordance with this. Additionally the wadi connects space with a variety of programmed stays.

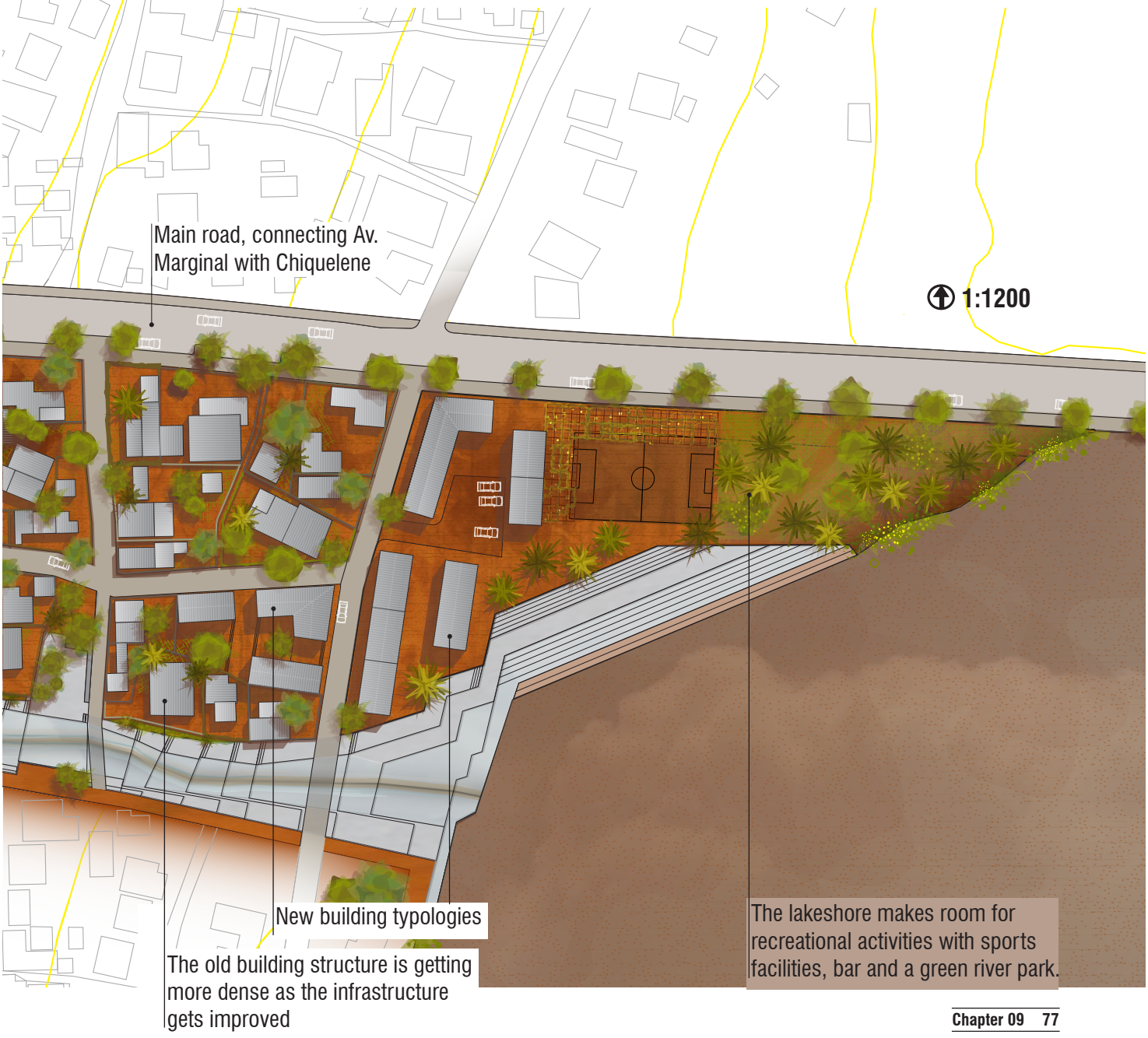
Densification by using new building typologies in two and three stories.

Distribution roads providing access to the existing and new housing developments.

The design area is defined to the north by the new east-west main road connecting Av. Marginal with Chiquelene, while the wadi and its related water magazines define it to the south and west.

The construction of the two elements will be the changing point for the area. A broad main road will change the area for good transforming it into a front-side flow room accessible for locals, who may never have experienced the area. This will change the local context, providing residents better accessibility to their surroundings, more open space around their plots and a stable environment.

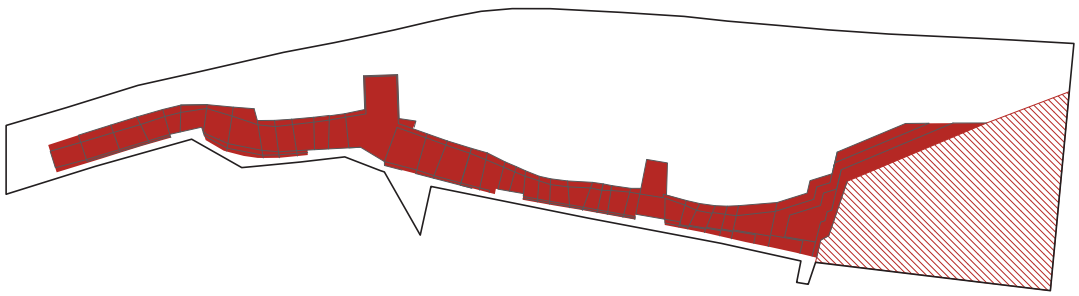
The houses at the bottom of the hill will no longer be flooded due to the wadi and time and money spent on repairing houses can now be devoted to improvements instead. During the wadi construction minor distribution roads are laid down between the existing houses. This pro-vides them with better accessibility and connects the main road to recrea-tional spaces around the wadi and by the lakeshore. A new neighbourhood centre is build at the intersection of the road and the wadi. It is the new official meeting place of the neighbourhoods of Ferroviario and Polana Canico B always alive with people working and relaxing, dancing and learning.



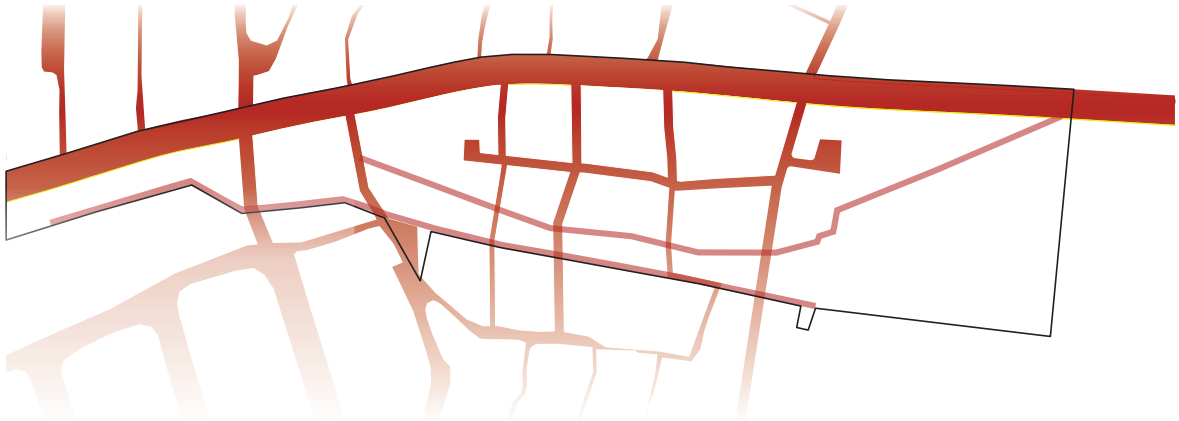
SEGMENTS OF THE PLAN

The design strategy focuses in on implement¬ing five segments; the wadi, accessibility/infrastructure, densification, public programs and establishing a neighbourhood centre. These segments and their interconnections is the foundation for transforming the area. Focusing on each segment, they look like this:

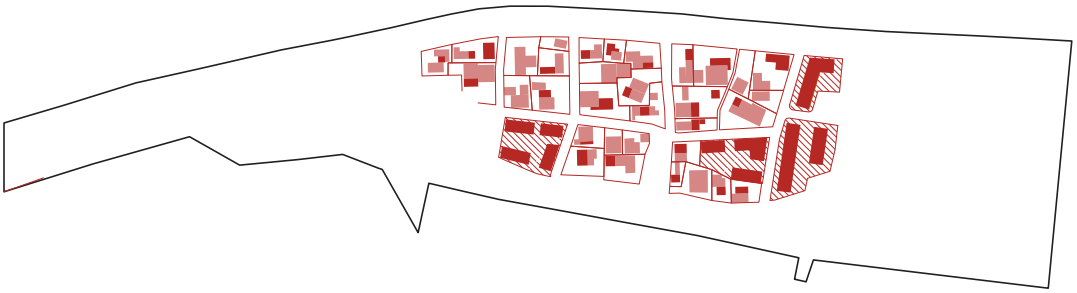
The Wadi



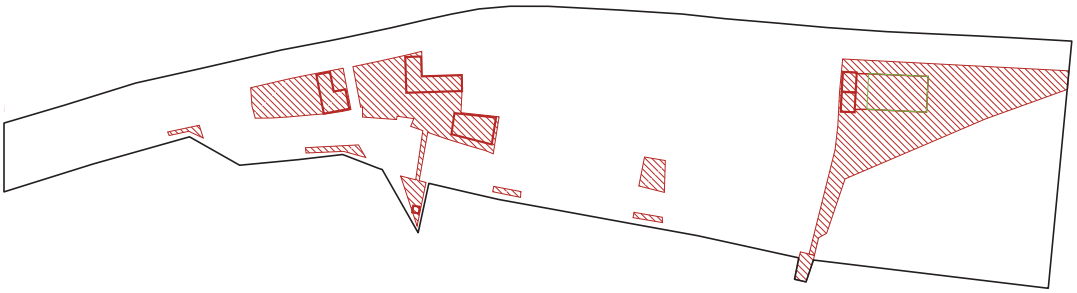
The Infrastructure - accessibility



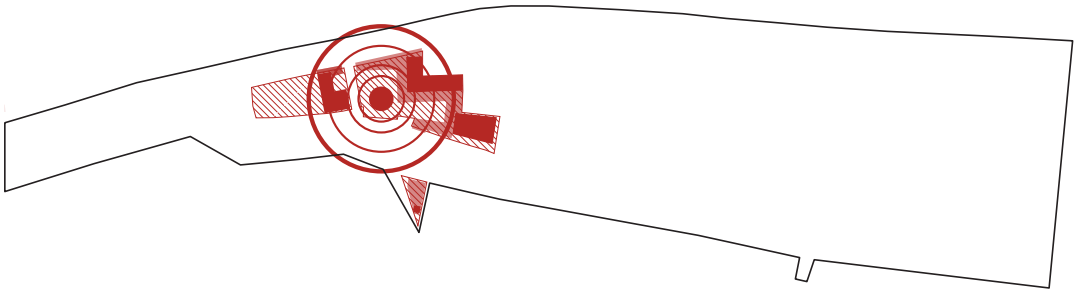
Densification and new housing typologies

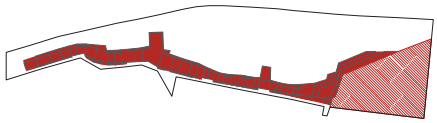


The Public Programs



The Neighbourhood centre





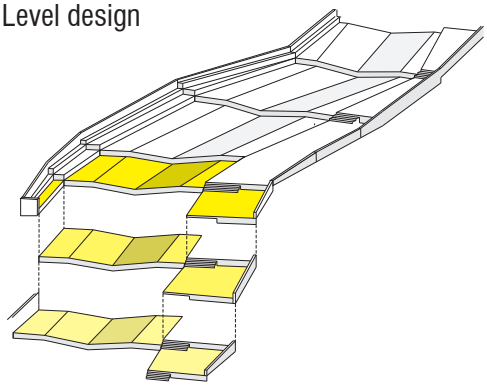
THE WADI

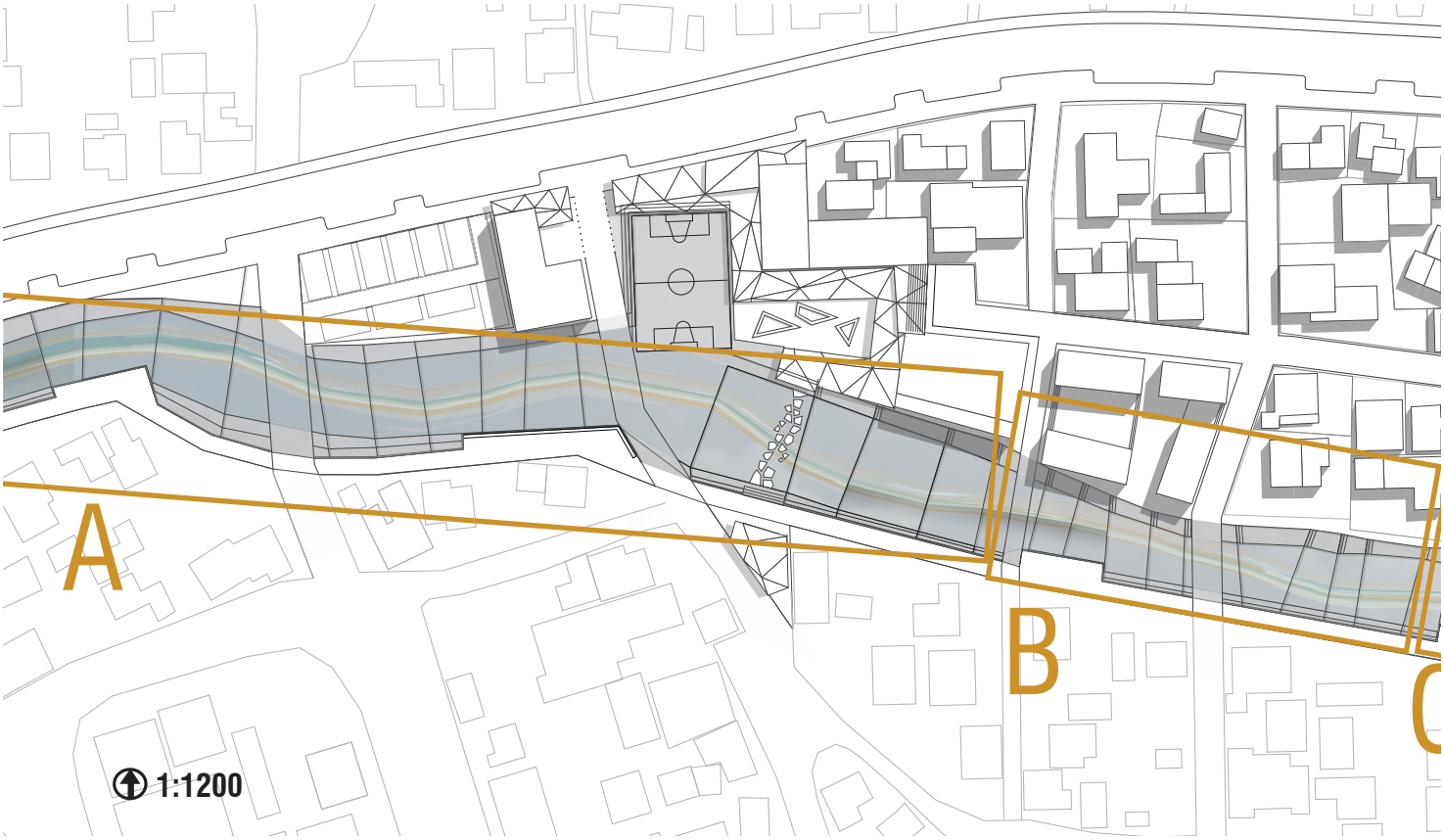
The wadi is laid out in the former erosion trench taking advantage of the landscape and the natural run-off path. Its shape follows the trench, making it possible to construct with few sacrifices of houses.

The wadi consists of in situ cast concrete levels overlaying each other. The shapes of the individual levels are similar in height and profile but vary in depth and width. These vari¬ations make the wadi follow the landscape and integrate nicely in the hillside. The variations are also used to change the wadi's expression as water flows through it by controlling depth and distance between its levels. Through the wadi the water have four different expressions in the four areas A, B, C and D.

In area A in front of the neighbourhood centre the water runs the 'slowest'. The levels are broad and deep. It is in this area most people will be in close to the water and the wadi's rooms will be doublet pro¬grammed with sport activities and leisure.

Level design

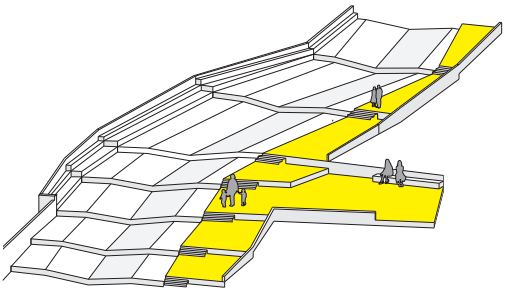




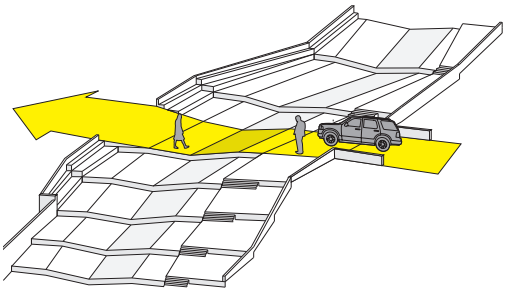
In area B the water gain more speed as the levels narrow in and the distance between them becomes smaller. The programs that surround this area is strictly housing and the use of the wadi to other activities will be limited. In area C water slows down again but not as much as in area A. The levels are a bit deeper and further apart integrating the water space with other minor leisure activities. In area D water speeds up as the levels height is changed to 1 meter. The water has to drop further over a shorter distance to reach the lake. We use this to create a more dramatic expression as the water exits the wadi and enter the lake.

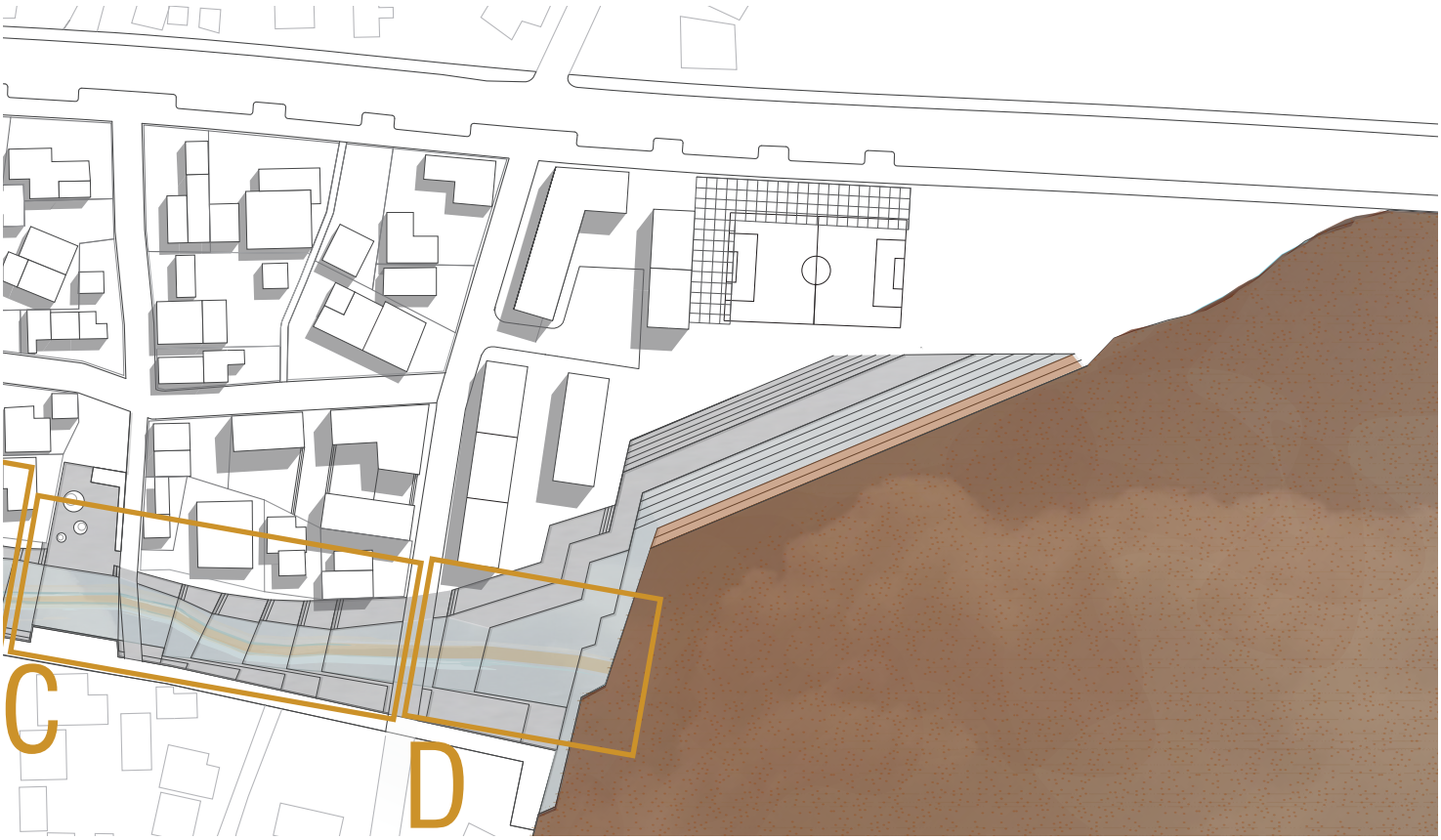
It is immensely important that the wadi does not become a barrier in the sense the erosion trench was. Therefore, the levels inside the wadi are no higher than 50 cm, which makes it possible to cross both by car and by foot. To further implement the wadi in everyday use of and turn it into an active space it is designed with a wider more fluid north side with an internal path from the lake to the neighbourhood centre. As the path runs at the northern side of the wadi it make use of the houses cast shadows making it comfortable to walk there and moreover connecting it to the related roads and residential areas.

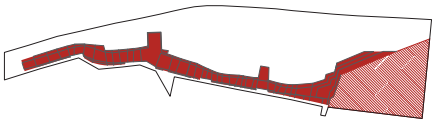
Path



Crossings

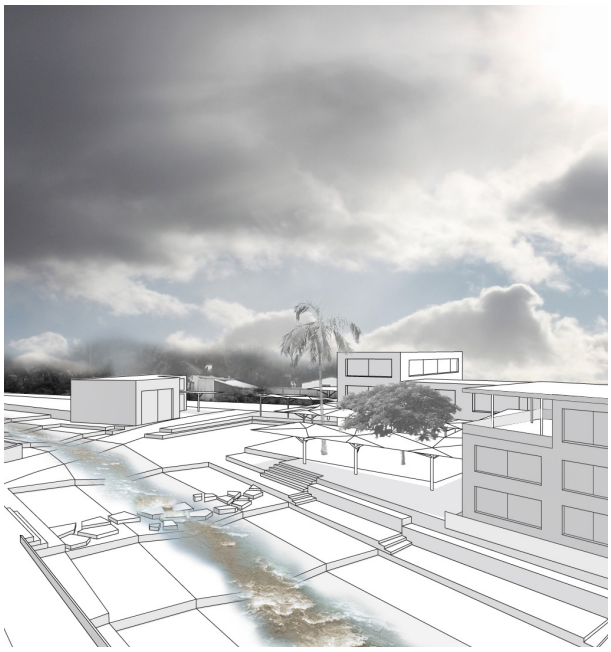






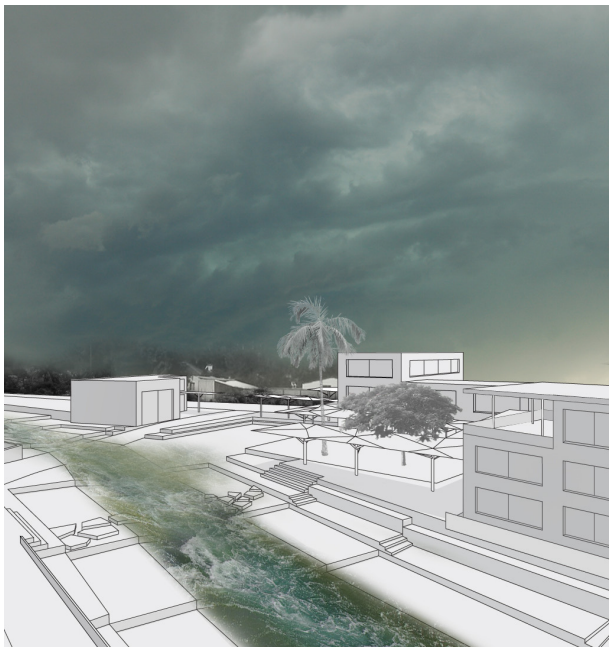
PROFILE DIMENTIONING

The first and foremost purpose of the wadi is however to safely lead the surface run-off water down to the lake without jeopardising the safety of the surrounding houses. The wadi and lake is dimensioned to contain a rain with a return period of 100 years. The calculations and design considerations regarding these can be see in Appendix 2.



Regular rainfall

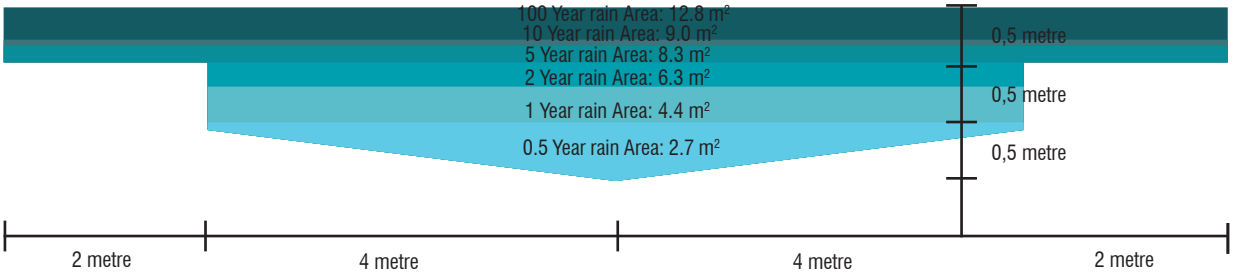
Most of the time the wadi will be dry but due to the changes of seasons. Even the minor rainfalls will generate periods with fast flowing water. These rainfalls are restricted to the ditch in the middle of the wadi and do not affect the daily use of the rest of it, all though one should show caution if crossing the stream. The outflow of the lake is dimensioned to handle this amount of water and the lake will not change in size.

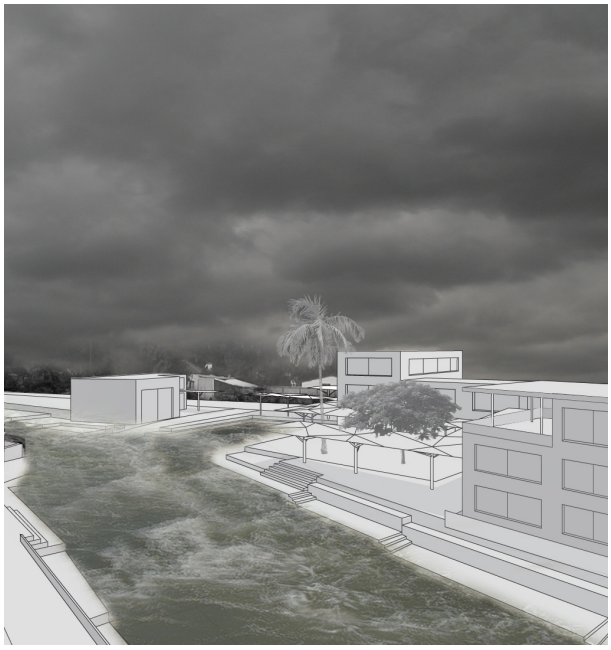


Half year rain return period

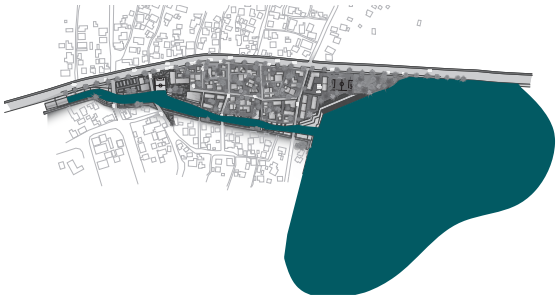
A half year rain will fill up the ditch and start to flood into the first flat level of the wadi. The path along the edge of the wadi can still be used but it has become dangerous to cross the water also by car and other roads should be used instead. The outflow of the lake which runs along the new road is dimensioned to contain the flow of a 1 year rain return period. If it had to be bigger it would become to large a barrier in the landscape

Standard section of the wadi dimensioned to contain a 100 year rain return period



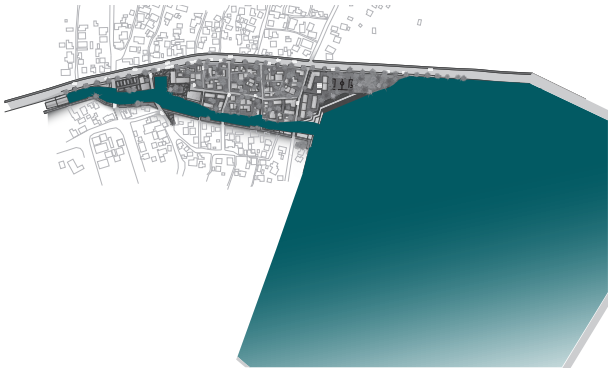


Rain with a 2 year return period

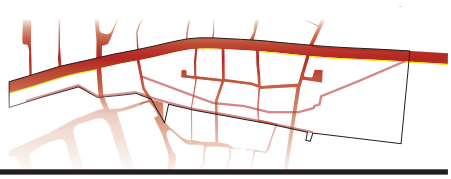


The rain of a 2 year return period will fill up the entire first level and flood the doublet programmed area along the wadi. The path will still be dry but because the water runs through with high speed it would not be safe the walk there. The outflow of the lake will be to small to cope with the amount of water and the level in the lake will rise expanding the lake to a controlled area to the south and east until it reaches the second exit and stabilise.

Rain with a 100 year return period



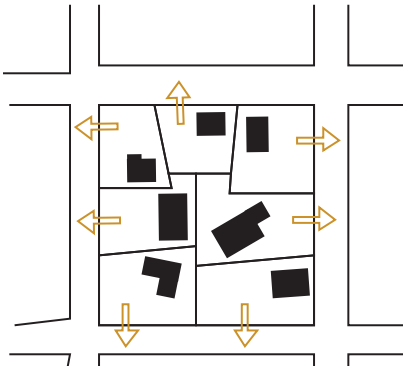
A 100 year return period will fill up the wadi completely but still the houses will be safe. The lake will however rise and flood the golf course turning the entire area into a water magazine bordered by the new road which prevents the flooding of the nearby residential areas. The water will stay at the golf course until the pressure releases.



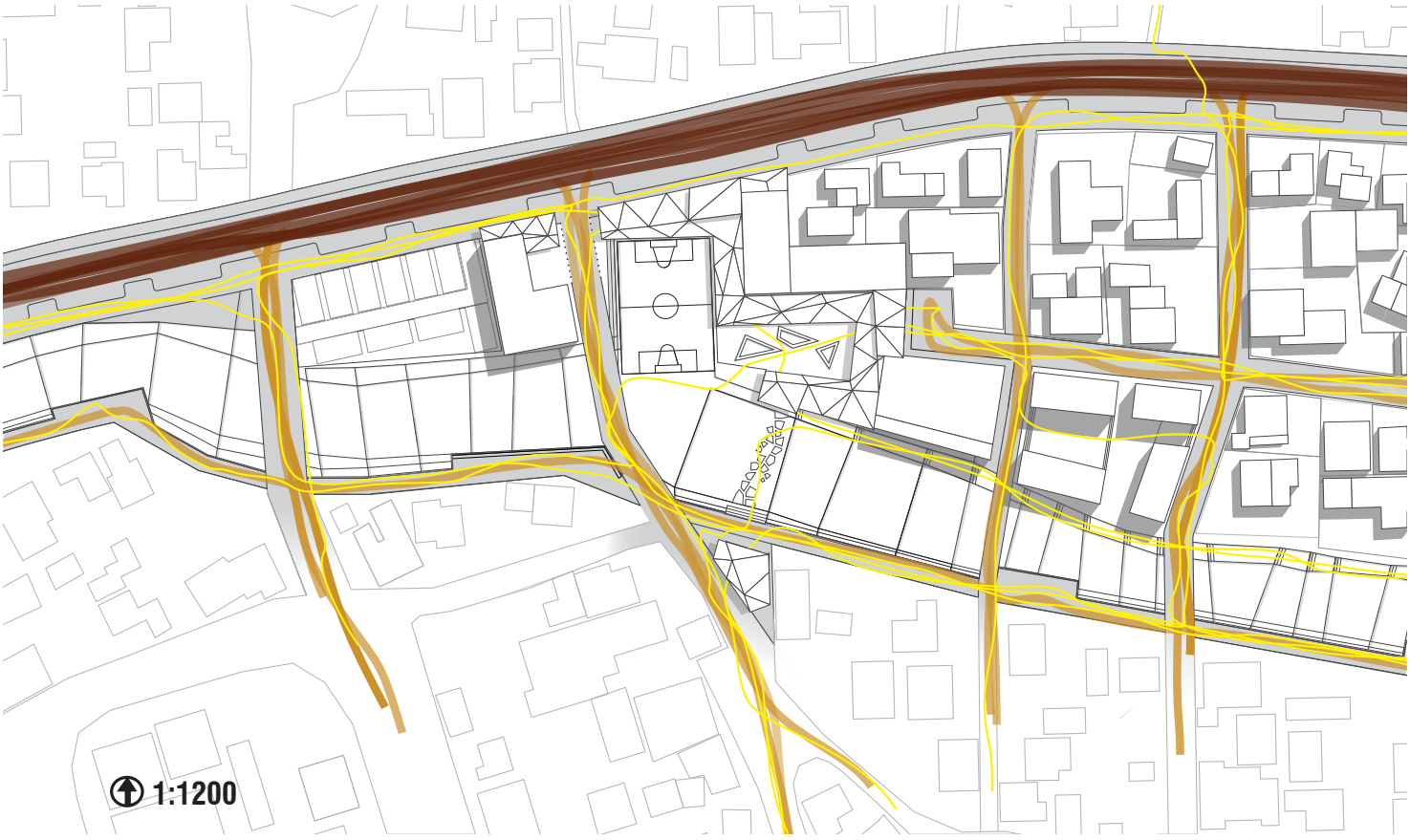
INFRASTRUCTURE AND ACCESSIBILITY

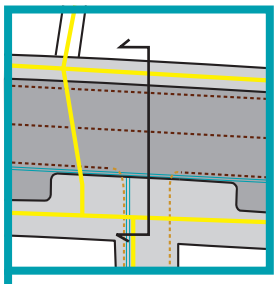
At the same time as the wadi is constructed so are the new east-west going main road connecting Chiquelene with Av. Marginal and Costa do Sol. The road is designed as a wide two-lane road with parking pockets along its southern side.

Minor paved distribution roads lead into the area and connect the communities south of the wadi to the main road. The distribution roads are three and five meters wide and function as shared spaces. They are located on existing paths and re-establish some of the connections that previously got washed away. Internally in the area roads are laid down so that they create car access for all the existing plots. This upgrades their status and makes it easier for the residents to gain official land tenure and thereby more security.

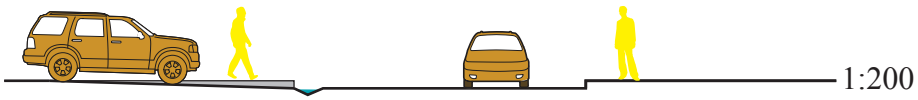


Car accessibility to the existing plots





Detailing of the on of the entrences to the area

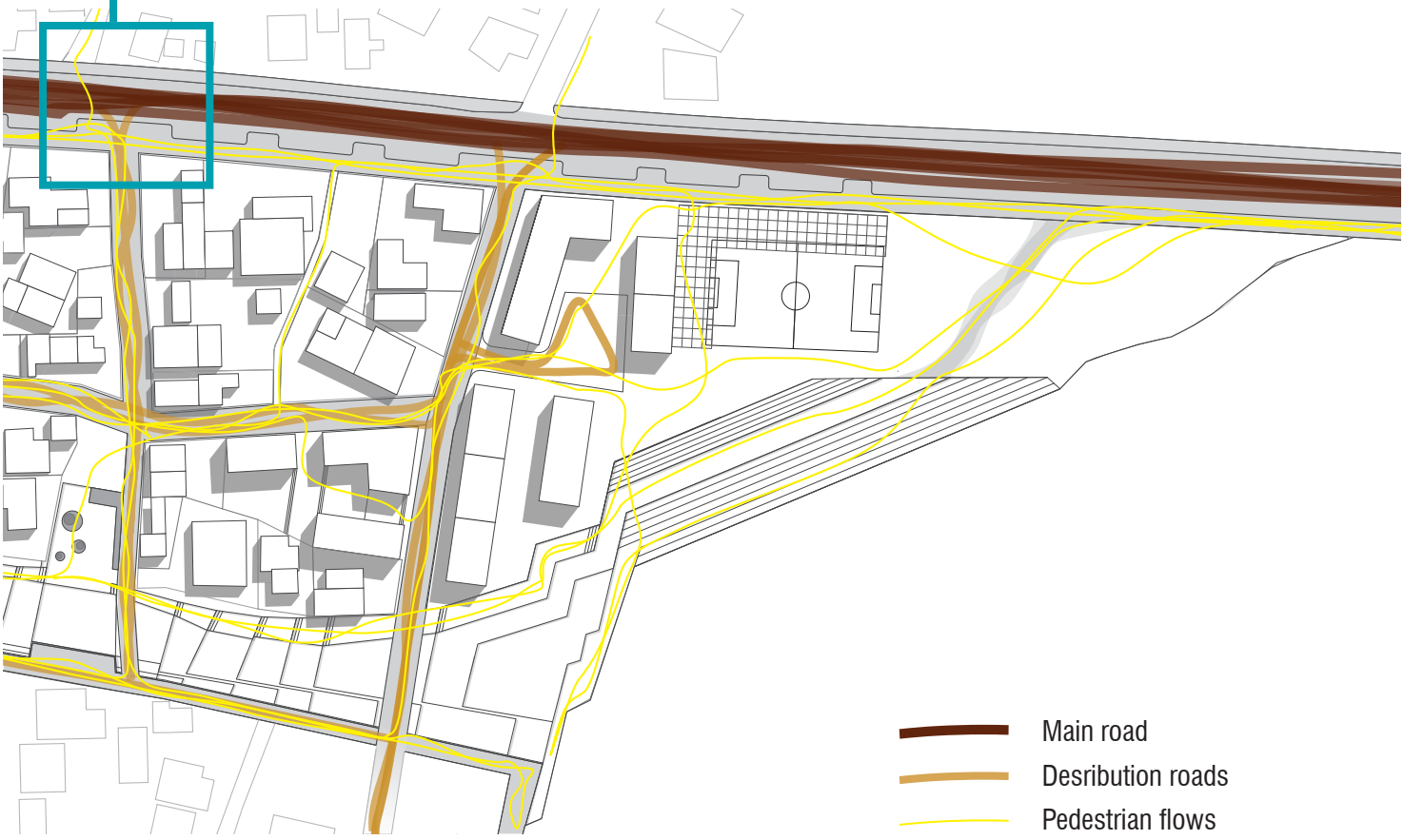


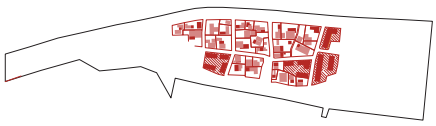
Along the southern edge of the wadi runs a minor unpaved road. It follows the slope and is therefore quite steep. It will mainly function as a pedestrian road and small 'breaks' are design along it to give it recreational value. Visually it defines the edge of the wadi and practically it provides access to the plots bordering it.

Many of the areas pedestrian paths follow roads and the distribution roads a fairly narrow, they will not be heavily trafficked, so pedestrians will be safe there. Extra width of the sidewalk create a safer passage over the main road as it cuts of some of the distance and narrow down the traffic lane.

As the illustrations above shows are all roads constructed with a small drain running along one side of the road leading the water down to the wadi and the lake.

The most interesting path through the area is reserved for pedestrians. It starts where the lake and the road separates turning to the left towards the stairs leading down to the lake and the exit point of the wadi. It continues up through the wadi passing houses, crossing roads and small open spaces ending at the neighbourhood centre. The idea being that the use of the path turn the wadi into a open more active space preventing it from becoming a back-side to the main road and making people relate to it as a public space that should be cared for.

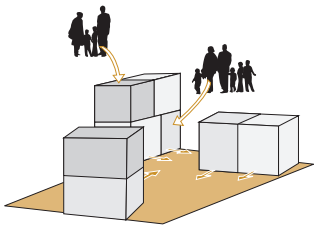




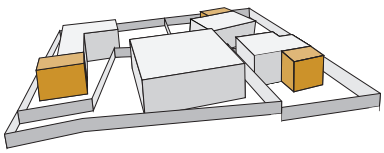
DENSIFICATION AND NEW HOUSING TYPOLOGIES

The intervention in the area caused by the construction of the road and the wadi generates changes in the build environment. Some houses will be eliminated to make room for the new constructions and people will have to move. This does however also make room for new functions. A clear intention throughout the design has been to re-house the people, which are forced to move, within the area. Space available to build on was therefore used for housing.

Because the available land to build on is limited and because the city needs new examples of denser low-cost buildings, we propose a new typology type and a new denser way of living. We predict locals will start to upgrade their living standards by extending and rebuilding their houses as they get better access to the plots and the price of the land increases.



New building typologies



Extension of existing housing

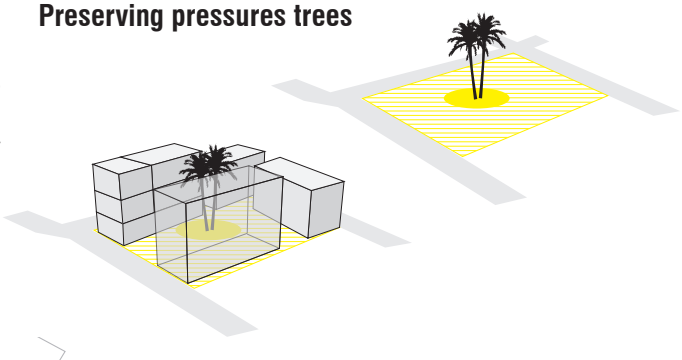
The areas that are transformed into new housing areas are marked A, B and C below. The concept of how they are shaped and distributed is related to the present conditions and the context.

Principle for new houses A

As shown in the analysis outdoor space around houses is often used as an extension of the indoor facilities. In the middle of plot A there is a large existing tree located. The new buildings, which are three and two stories, are situated around this tree creating and semi public shaded courtyard in the middle. As there will be several families living in the buildings this becomes their new common outdoor space. The houses could follow the principals illustrated in the proposed project to the right. The houses meet the demand for a higher density and are built of the materials present in the area.

Fig. 9.1 Incremental Housing, proposal for new low-income houses in India

Preserving pressures trees



Principle for new houses B

Plot B is located on a corner defined by the road and a fence along the buildings behind it. The new buildings have to be located so they allow access to the houses behind. Otherwise is the same principal as in plot A followed, the houses are locate so they faces the road creating a common semi public backyard behind them. The level difference from one end of the plot to the other is two meter and the backyard is therefore divided into four minor levels divided by stairs, three of them relating to the houses and one of them to the access road to the houses behind.

The housing coast must be kept to a minimum if locals should afford to live here. The Quinta Monroy housing complex in Chile showed below illustrate how it might look. In Chile the concept was to create cheep 40 m2 basic house that hold the potential of being further extended to meet the individual needs of the owners.

Ensuring access

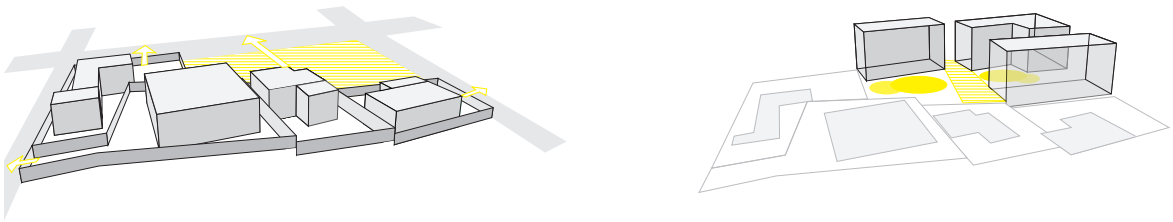


Fig. 9.2 Quinta Monroy, low-income houses for the urban poor Iquique, Chile. Elemental Architects

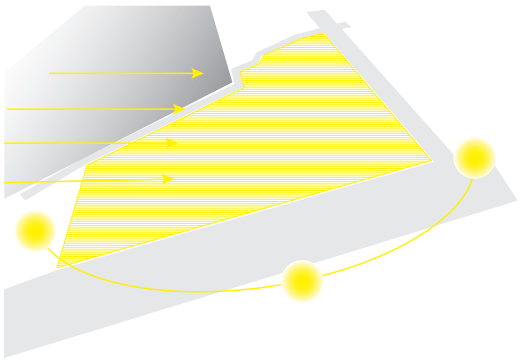
Principle for new houses C

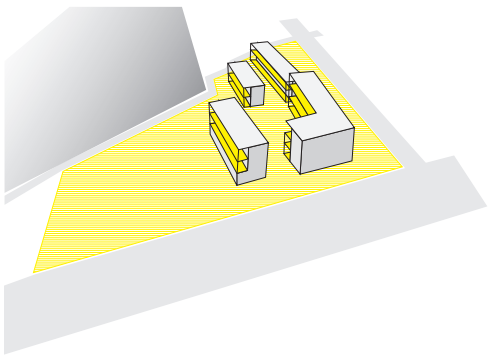
Plot C is overlooking the lake it and the golf course and the houses have a high recreational value. The location is also the shaping factor regarding the orientation and design of the buildings. The houses are orientated east-west minimizing the exposed north facade. The lake breeze is cooling down the eastern facade. The buildings bordering the main road are three floors and the ones closest to the wadi are only two to prevent them from being a large visual barrier for the people living on the hill. Because the location generates a lot of public use, the houses are designed with small outdoor terraces and balconies with the possibility of shielding them off.

Fig. 9.3 Social housing compound with outdoor private balconies, Chile

Fig. 9.4 Lucien Rose Complex, shaded flexible facades, Rennes

Lake atmosphere

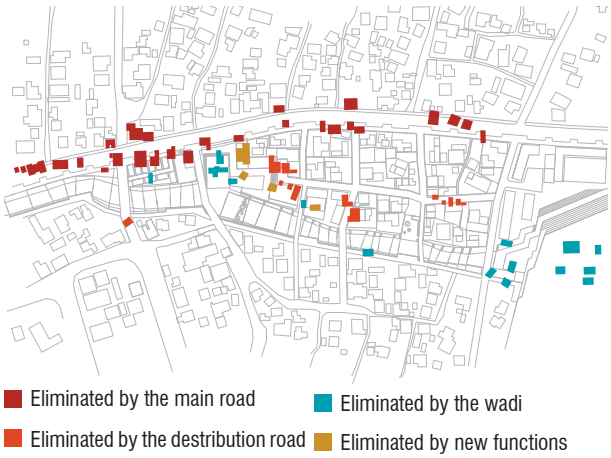


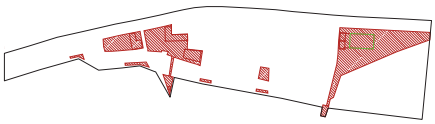


Estimated sacrificed houses

As mentioned above, one of the policies of the design is to sacrifice as few of the existing houses as possible. It did however become necessary to eliminate some for the sake of the greater good. The number of square meters eliminated is 2652 m2 distributed in 49 houses. In comparison the number of residential square meters in the three new housing areas is 3104 m2.

Houses sacrificed





PUBLIC PROGRAMS

One of the shaded gathering places along the path running in the south side of the wadi

Around the space of the wadi programs and activities are distributed. Some are taking place directly in the wadi others around it. The programs vary from small passive places with a benches and shadow to larger sport and performance areas and fishing platforms. The programs will attract people to the wadi drawing them in at the neighbourhood centre and at the lake inviting them to use and be a part of the area. The programs activate people in the two neighbourhoods giving them places to meet and reasons for doing so, developing the common understanding of the community.

The programs also make people relate to the space of the wadi and getting to know its shifting character and understanding the necessity of having it. By understanding this and by using it as part of their everyday life, people will treasure and nurture it and abstain from filling it up with waste.

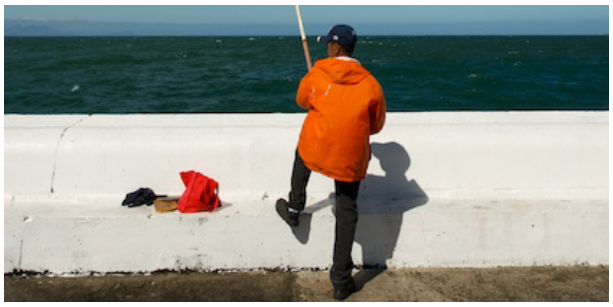
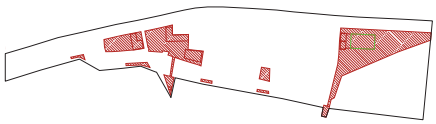


Fig. 9.5 Examples of activities and programs in the area; fishing, performance, sport and relaxing

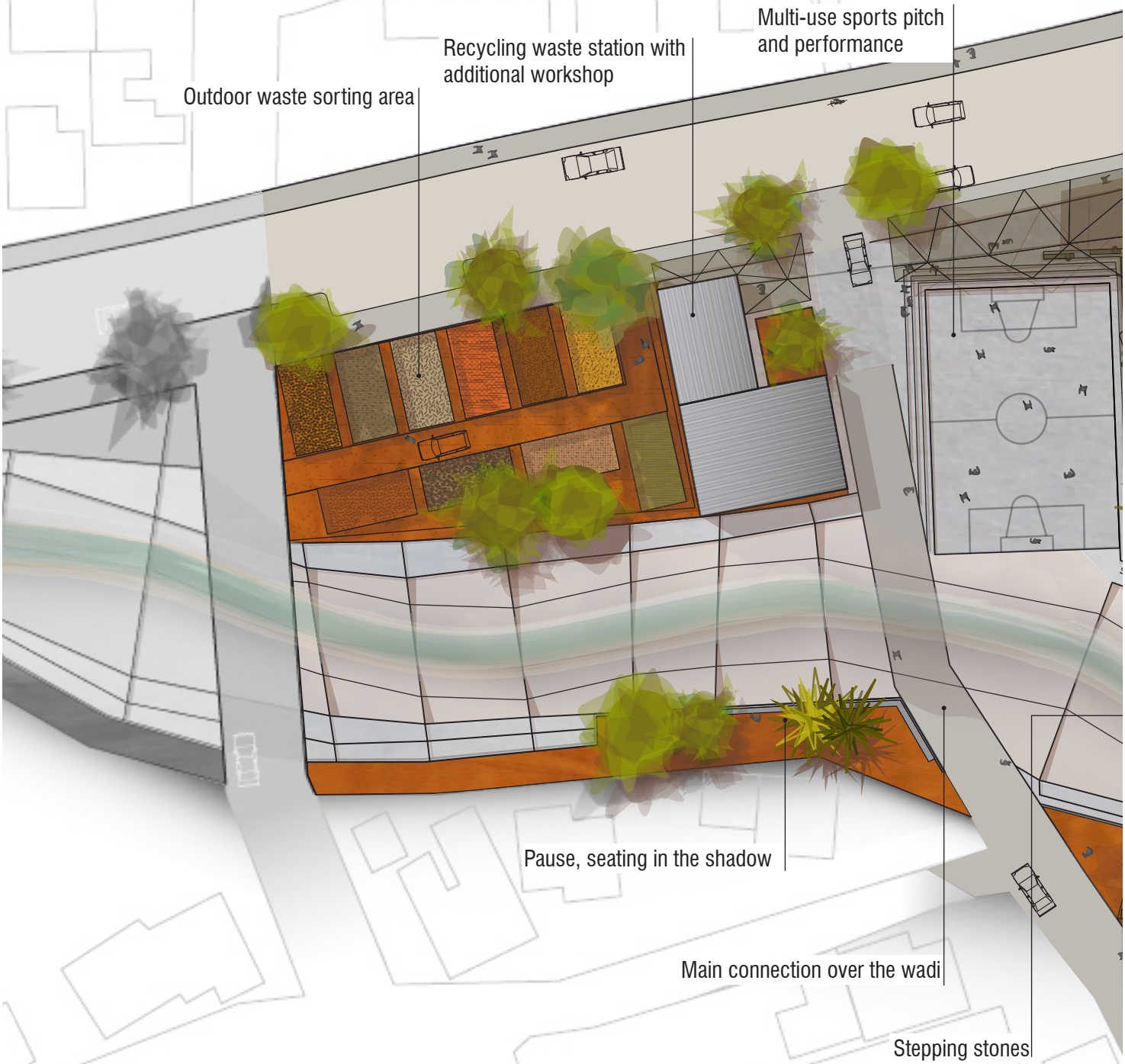


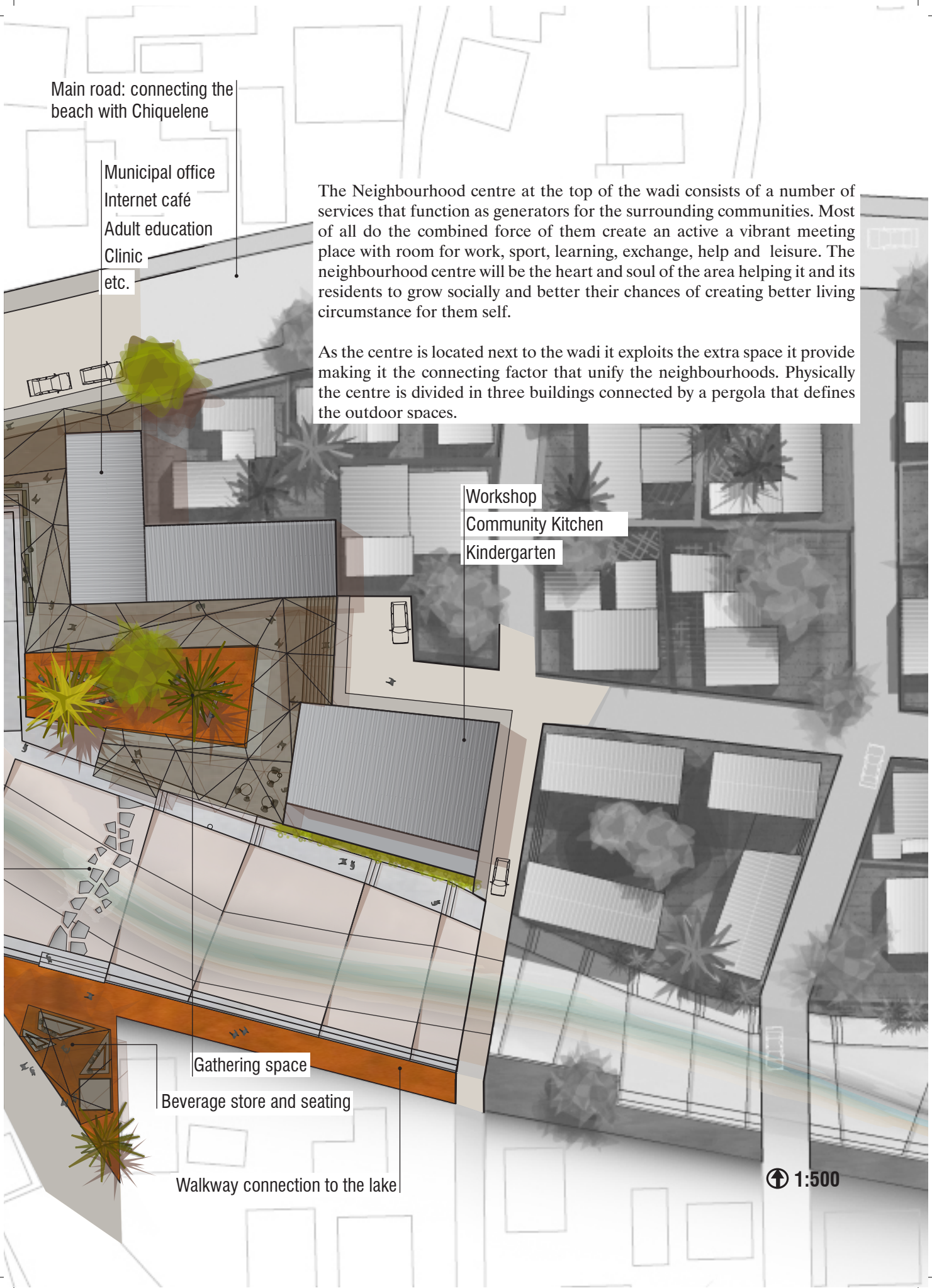
VISUAL CONNECTIONS AND LANDMARKS

The physical shape of the wadi makes it a vertical landmark in the landscape. It is visual from the golf course and it leads the eyes up the hill to the new neighbourhood centre marking its important presence in the neighbourhood. When travelling the other way from west to east on the new main road the wadi creates a open visual connection over viewing the lake, the Costa do Sol and in the distance the beach before the road turns and continue downhill.

1:1200

NEIGHBOURHOOD CENTRE





The Neighbourhood centre at the top of the wadi consists of a number of services that function as generators for the surrounding communities. Most of all do the combined force of them create an active a vibrant meeting place with room for work, sport, learning, exchange, help and leisure. The neighbourhood centre will be the heart and soul of the area helping it and its residents to grow socially and better their chances of creating better living circumstance for them self.

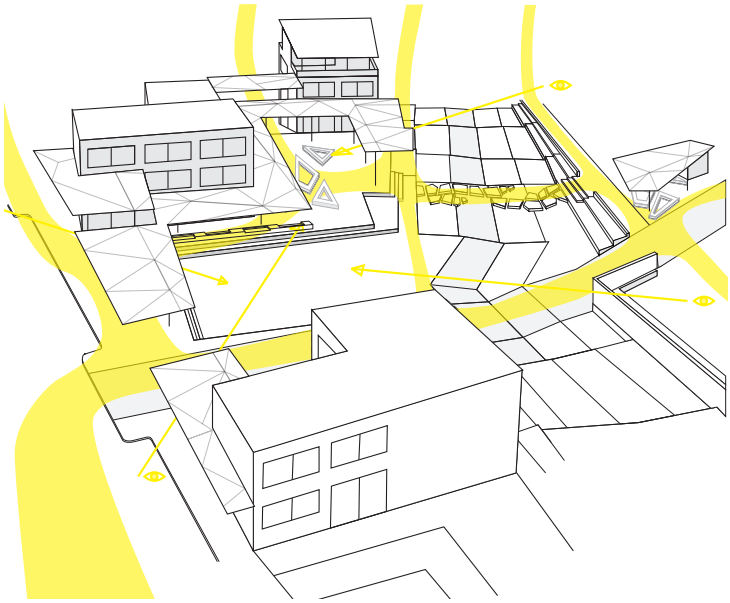
As the centre is located next to the wadi it exploits the extra space it provide making it the connecting factor that unify the neighbourhoods. Physically the centre is divided in three buildings connected by a pergola that defines the outdoor spaces.

RELATION TO THE SURROUNDINGS AND HEIGHT

The neighbourhood centre is located on the edge of the wadi where the water space and the public space meet. The location means that the centre is lifted up 1 meter, as the wadi is naturally placed lower than the buildings. The difference in elevation creates a plateau stretched out between the buildings, which creates a unity of the indoor and outdoor spaces, and define the public space. Additionally, the plateau creates a connection to the other side of the wadi, as the plateau continues on the other side. The buildings are in three stories and are remarkably different then the existing build environment. The height of the buildings creates a natural landmark and orientation point in the landscape, as it can be located from a distance.


SONIA

ORIENTATION AND ROLE



The location of the neighbourhood centre has determined its shape. The new and re-established infrastructural connections in the surroundings, has created new flow patterns, which has been deciding for the buildings shapes. Moreover, the centre is located so it visually relates to its surroundings, especially towards the main road that will bring many people by the centre.

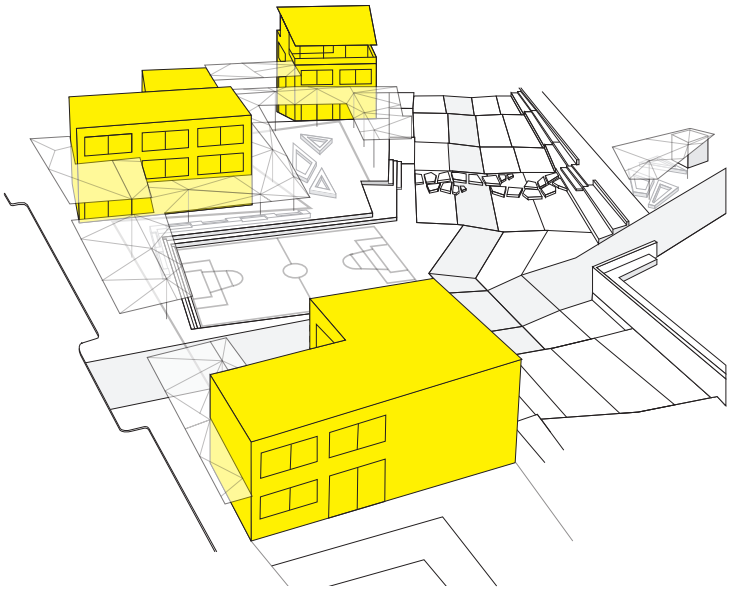
The location of the community centre at the wadi's top gives it a central location in the build environment and therefore it has a strong connection to the surroundings. Furthermore, is it located just where there used to be an important connection across the former trench. This is where the road crosses the wadi now and connecting the two sides. In that way the design strengthens the transition from what was before to the new development.

The role of the community centre is to be a generator for the surrounding communities, in both economical and social ways. The simple fact that social interaction between different people is taking place can bring development, but in most cases more has to happen. The generating factor is the different activities and services taking place in and around the centre. Here workshop facilities can be the setoff for smaller businesses, and adult education facilities can become the gateway for new job opportunities.

A nother project of similar character is the Beckham Library in London, where a communal facilities and a library is combined to service the surrounding area. Its role is among others to distribute knowledge, and help locals to find jobs to generate development. Or a community in a more similar context the centre structure in the Favela Bairro program in Rio de Janeiro in Brazil. Here it functions also as a social meeting hub; with sports facilities and at the same time it is a landmark in the area.

Fig. 9.6
Community center, Favela Barrio program, Rio de Janeiro Brazil; Peckham library, London by Alsop Architects

FACADE EXPRESSION

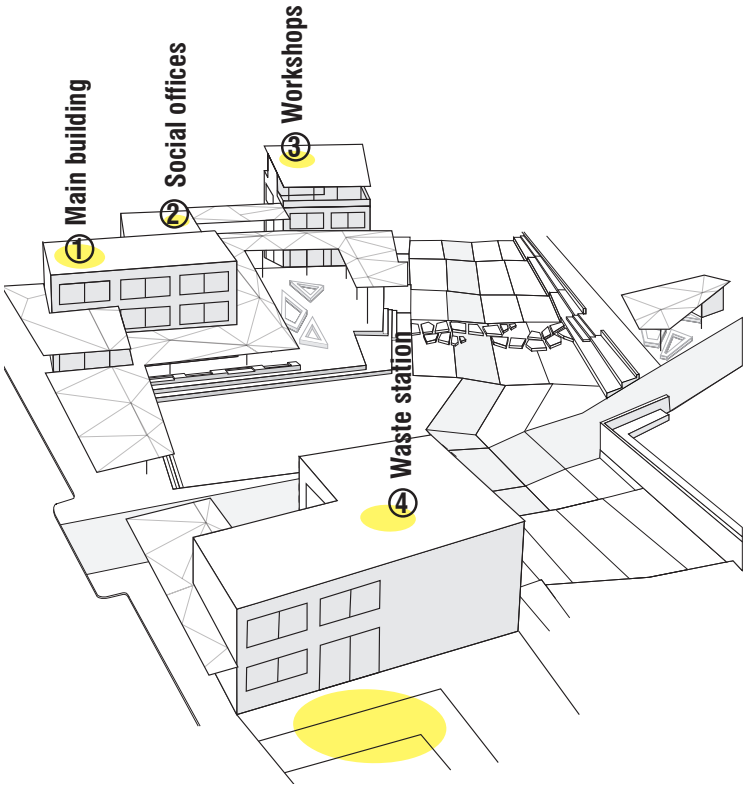


The architecture of the neighbourhood centre is to be kept simple and adjusted to the hot climate. In this way we work towards a more sustainable development, by using minimum funding on the buildings, as they are only the shell for the activities. The buildings can be constructed in prefabricated modules (see fig. 9.8) and build by the local materials – concrete bricks with a plastered surface (see fig. 9.7). It is however important to work with sun protection of the windows, especially to the north where it is strongest.

Fig. 9.7
Exampels of facade: Gideon and Guyer Architects

Fig. 9.8 Exampels of facades: San Lucas School, Chile
Francisco Izquierdo and Maria Jose Architects

SERVICES AS GENERATORS



The purpose of the services is to activate and inspire the local population to work and improve their standard of living. We are suggesting both workshops for men and women and day-care facility which can make it easier for the women to work some hours a day.

① 1. The main building is where the most official and divers facilities are located. At the bottom floor the municipal office, the internet café and the beverage store are located. They facilitate customers that come and go during the day. At the second and third floor you will find the class rooms for the adult education, and shared facilities for youth clubs, and sports clubs. It is possible to borrow the room if you would like to start a new activity or association.

② The second part of the main building is drawn back from the main road, which is also reflected in the character of the services. It is more private services, like AIDS and HIV care, Health clinic and Law consultation.

③ The third building bordering the wadi is three stories towards the centre of the neighbourhood centre, and four stories towards the back. The building house mostly workshops of different kinds, that relates to the local skills, interests and needs. These could be as mentioned. Besides the workshops a kindergarten is located at the top of the building. It has its outdoor space under the pent roof and indoor space on the floor below. In the bottom of the building just towards the centre, a common community kitchen is located. It is thought to be a space where the many people having their daily rhythm in and around the centre can eat the ‘prato do dia’(plate of the day).

④ The waste station is however different that the other two buildings. It is where the waste manager has his office, but next to it the blacksmith workshop is located in a double high garage. Here the cars used to transport the waste can be repaired.

① Main building

Municipal office
Adult education
Meeting facilities
Youth club facilities
Internet café
Information board
Beverage store



② Social offices

Aids and HIV care
Health clinic
Law consultation

③ Workshops

Community kitchen
Kindergarten

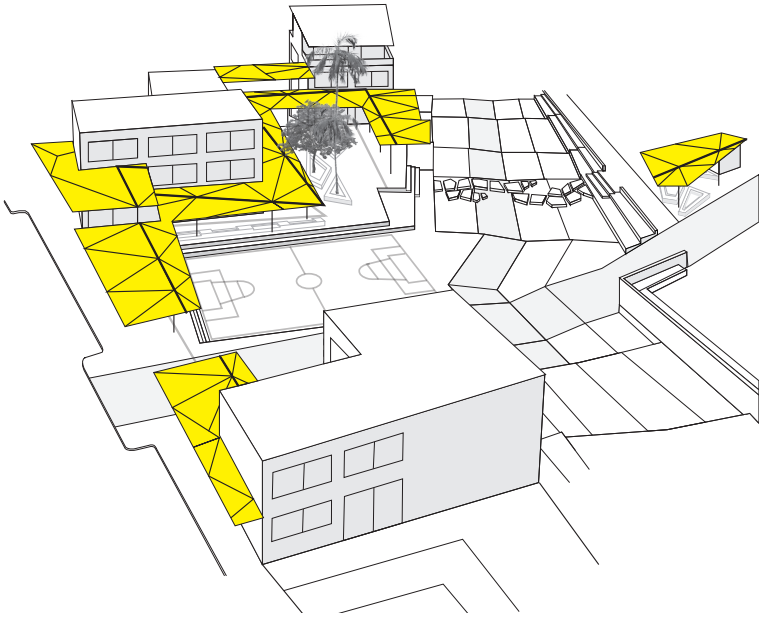
Workshops:
Wood
Bike repair
Wicker
Sewing


④ Waste station

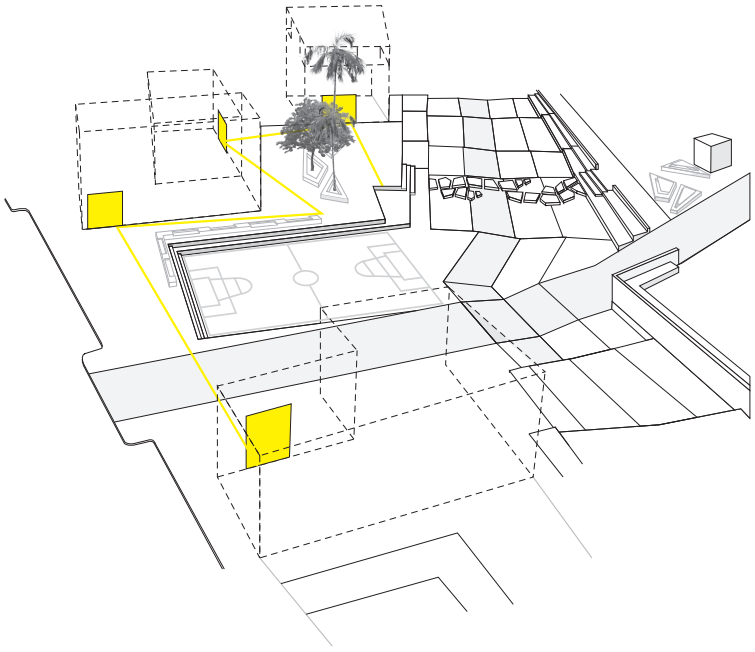
Blacksmith
Waste sorting


ARCHITECTURAL CONNECTION

Connection in the cover



Connection in the pavement



The flow patterns, which have been decisive for the location of the buildings, have also meant that the centre is divided in three separated buildings and the distribution of the services within these buildings is adding to the segregation. We did however want the centre to be a unified building structure which we created by making an outdoor architectonical connection in the shape of a cover roof running along the side of the building and connecting the entrances and defining the flow and the outdoor areas. The cover has a higher level of detailing than the buildings and will therefore be the visual focus. The inspiration to the structure is taking from a tree because the role of a tree in the local area is a gathering point as it provides shadow. It symbolise social activity, as it brings people together. The cover is raised up two places to mark the entrances underneath. The most important is the main entrance towards the street. The cover lifts up 7 meters from the ground, to make the entrance easy to see and locate and to open up the neighbourhood centre space towards the road. It breaks in to point one where the related distribution road runs through the centre the other where it meets the wadi. In both cases does it continue on the other side as an entrance to a new building and as a pavilion on the south side of the wadi.

The cover has bearing beam that runs through it marking the flow between the buildings beneath it. The entrances are all located towards the public space, and to further illustrate the connection between them another paving type is laid down in the same path as the beam above it showing that a clear direction is combining entrances.

MATERIALS

The pergola is made out of rough wooden poles and corrugated iron as the two only materials. They are known from the area as what the locals use for their houses, but here the materials are used in a new and inspiring way.

The pavement is made of concrete, and the connection strip is made of black concrete. This is simply done by colouring the concrete in the casting process.

Fig. 9.10
Exampels of a pergola inspired by a tree

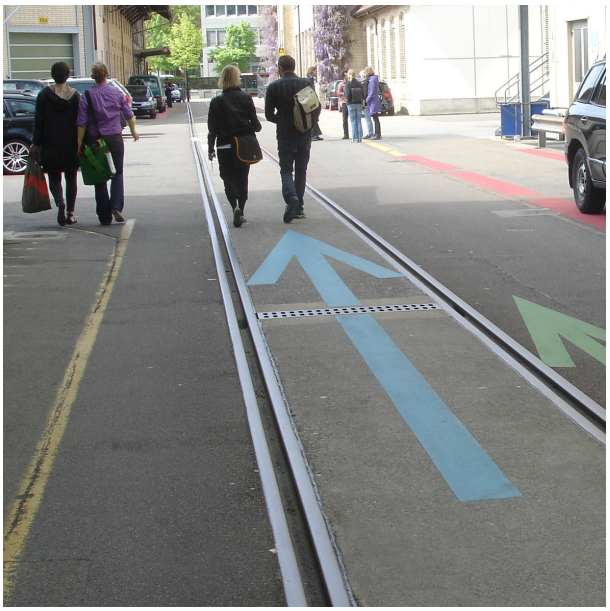
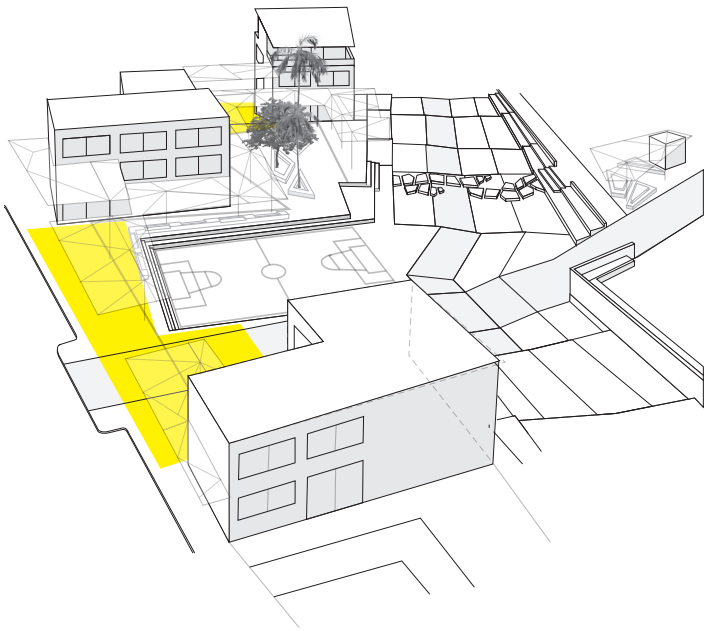


Fig. 9.9
Example of how marks in the pavement is used to make a connection

OUTDOOR PUBLIC SPACES

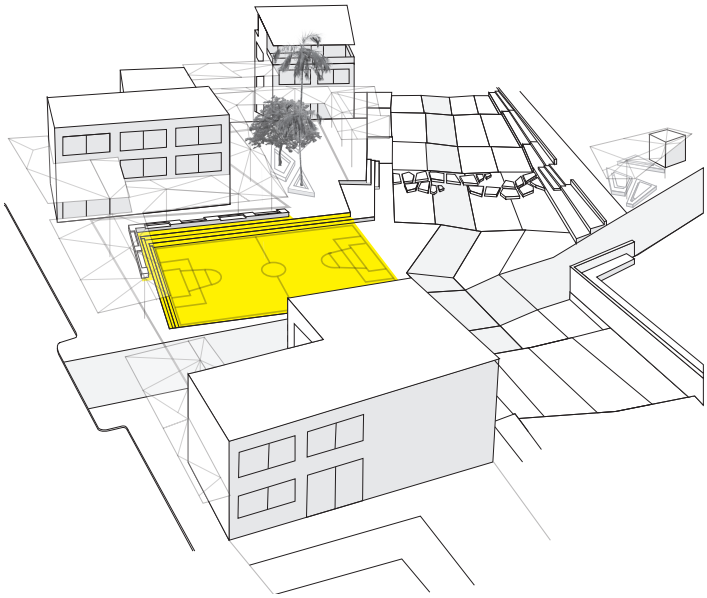
Entrance areas



The Neighbourhood centre has two main entrance areas marked by the cover that stretches between the different buildings. The official entrance is the one that stretches between the waste station and the main building. It is at the same level as the sidewalk enrolling it in the entrance area of the centre, illustrating the easy access and invites people further into the space.

The 'back entrance' of the area is the one located to the west between the social offices and the workshop. The path leading to it is narrow but the location on top of the hill makes it visible all the way from the bottom. When coming from this side one has to walk up a 1,5 meter stairs before entering on the plateau directly under the cover in and in front of the seating area in the courtyard.

Sport and performance



Right in front of the main building and directly related to the wadi is a multiuse sports pitch and performance area located to specially activate the many children and teenager in the area. It is one of the spaces along the wadi that get flooded once in a while and it is therefore located lower than the rest of the neighbourhood centre plateau. This creates stairs along the pitch that can be used for spectator. Bordering the pitch and the hallway benches are located providing extra seating in the shadow and defining the different uses of the space.

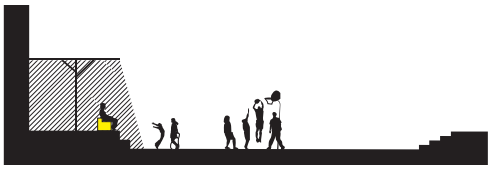


Fig. 9.11 Section through the sport pitch and surrounding stairs

Leisure and gathering

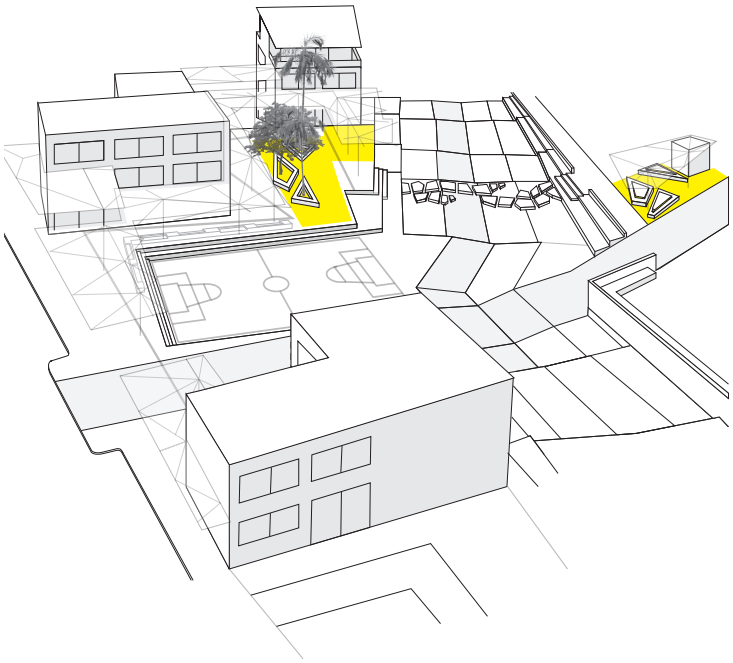


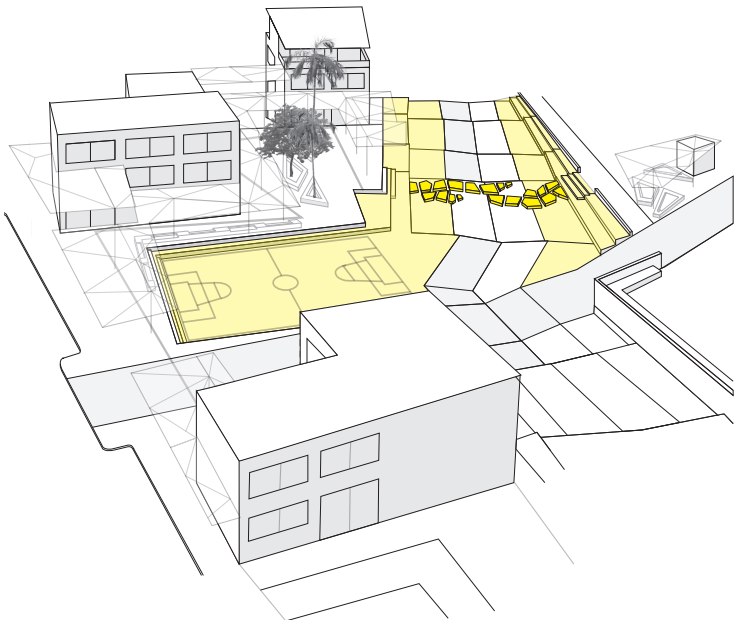
Fig. 9.12
Section through the courtyard

Fig. 9.13
Section through the pavilion

Overlooking the sports pitch and performance area is a small courtyard defined by the workshop and the social offices and the roof cover. It has a soil base and in it are planted three large trees providing shadow for the benches located beneath. The atmosphere is quiet and without any activities other than the ones the people bring along with them. Here the locals meet, relax and exchange ideas and experiences.
At the south side of the wadi a small pavilion and beverage stand provide the settings for a similar environment. Here the benches have small tables and the locals may use them for when eating, drinking and playing games. The pavilion is visually connected to the rest of the neighbourhood centre illustrating the connection over the wadi and between the two neighbourhoods.

Fig. 9.14 'Flame of the Forest' - the tree in the courtyard

Water space



The neighbourhood centre is created around the wadi and when this is not flooded it is used for other activities. The most permanent of them is the sports pitch. A more passive one being a series of stepping stones connecting the neighbourhood centre and the pavilion.
The character of the wadi contributes to the space of the neighbourhood centre with its shifting character. Its location next to the centre make people relate to it and by watching it fill up with water they understand the purpose of it and will therefore take care of it.

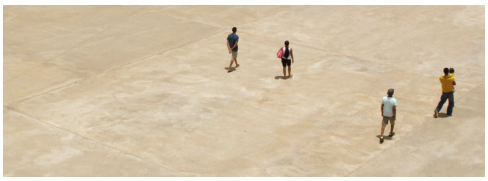
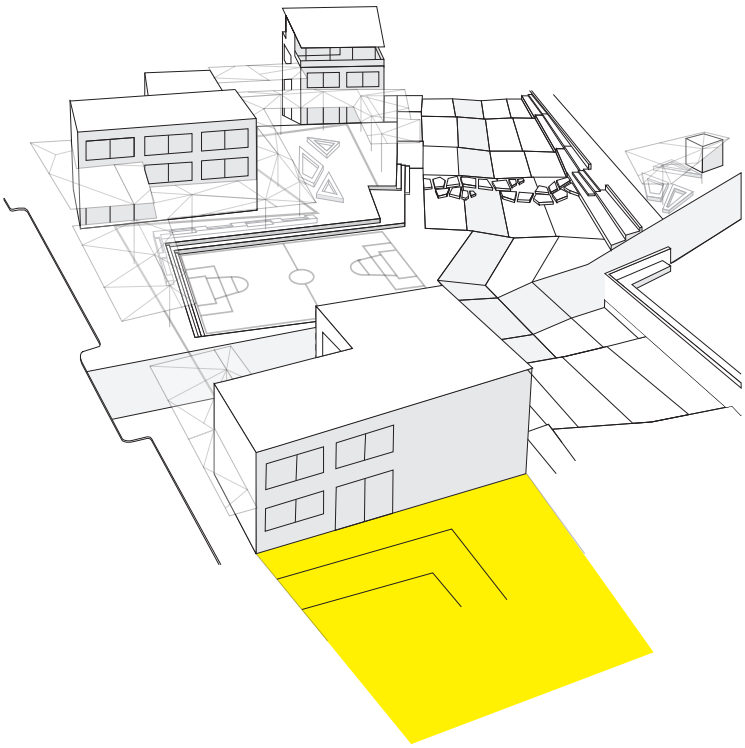


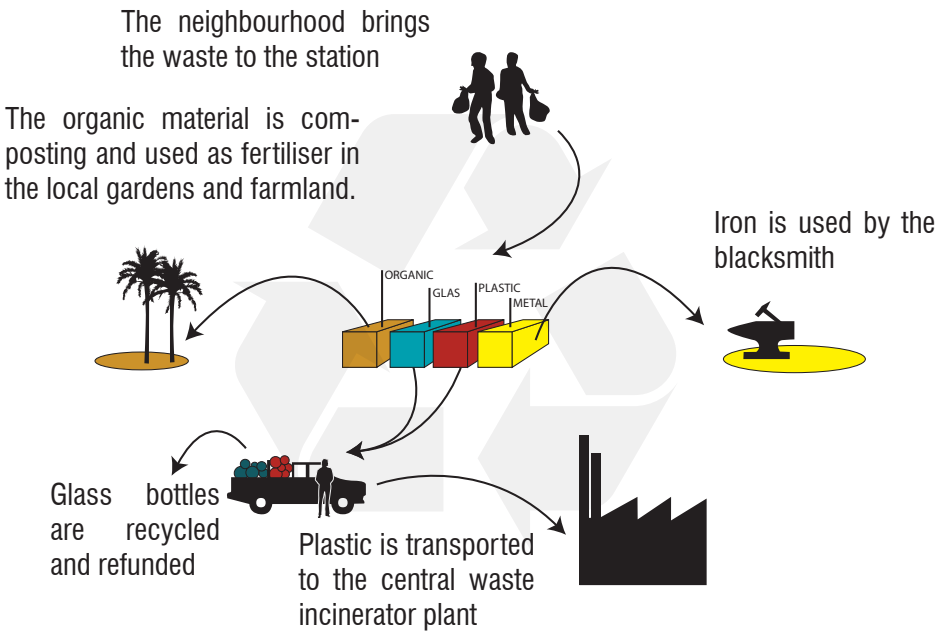
Fig. 9.15 The concrete material of the wadi

WASTE STATION



The new waste station is going to take care of what the trench did before. With the wadi there is no longer space for waste dumping and this provides an alternative. In other parts of the city there is a well functioning waste collecting system, but because this area has been inaccessible and poor it has not been an option. Even though the system has been well functioning in parts of Maputo, it is doubtful if there are resources enough to cover the whole city. Instead we are developing the concept from Mafalala, where central waste stations are set up and where waste can be delivered. This saves both time and co2 to do so, and create local workplaces as waste sorters.

In Curitiba they have a similar system where the waste is collected in central stations, but where the population get a little for delivering the waste. For example they get a school book or food tickets. We imagine something similar can work here.




SONIA

Chapter 10 CONCLUDING REMARKS

Even though Mozambique has developed enormously since its independence and particularly after the civil war ended in 1992, it still ranks as number 99 out of 163 of the poorest counties in the world with 54% of the population living in extreme poverty. Moreover, there are numerous pressing issues: the country is presently one of the most corrupt in the world, the literacy rate is 46,4 % and 99 % of the urban poor live in informal slum areas.

In addition to these, the capital, Maputo, is currently faced with two major issues: climate change and uncontrolled urban growth. These issues are especially apparent in North-eastern Maputo. This 900ha low-lying coastal area suffers from both inland run-off issues and tide-floods issues along the coast. Climate change will amplify the run-off issues due to increased rainfall as well as the tide-floods due to sea-level rise. At the same time, North-eastern Maputo is a very attractive residential area as it is located near the beach and is close to the centre of Maputo; therefore it receives a great deal of the annual 3,5-5 % urbanisation. Most inhabitants live in informal unplanned settlements of one-story houses marbled by a maze of small roads and paths. Moreover, nearly all new urban development still happens in this uncontrolled manner. In other words, these compounding issues make North-eastern Maputo extremely vulnerable and strategic-planning-action has to taken to meet these challenges.

The first product of this report is a ‘strategy process and action plan’ for North-eastern Maputo. Theoretically, this stands on the shoulders of UN-habitat (2009), who advocate for another type of planning approach in third world cities, and Sennett (2008), who argues for integrating uncertainties in the planning processes. Planning on this basis means being strategic, flexible, action-oriented and focused on the planning process. Our plan purposes four milestone years in the planning process: 2025, 2050, 2075 and 2100. It focuses on how single projects all related to a backbone structure consisting of ‘infrastructure’, ‘barriers’ and ‘landscape modification’, can control informal urban growth without dictating details about how and when it should happen, and at the same time tackle the issues from climate change. It ensures a gradual and coherent development through single projects and will help improving the living standards in North-eastern Maputo.

The 2025 milestone addresses the immediate issues regarding run-off from the neighbouring areas, accessibility issues in North-eastern Maputo and to surrounding areas, and issues of urban development in vulnerable and unsuited areas. The second product of this report is a design proposal for a zoom-in area with run-off and accessibility issues. This area is concentrated around an erosion trench along the hill bordering

North-eastern Maputo and where a new main infrastructural connection is going to be located. The design of this infrastructure is based on an analysis of the local area and integrates positive characteristics and needs of surrounding neighbourhoods. The design contains a constructed wadi coupled with a water magazine (lake) that ensures stable water conditions around the trench and at the bottom of the hillside along with a new infrastructural system that connects this area to the rest of Maputo. These large physical elements change the area dramatically in part by functioning as generators for improving a number of local urban concerns stressed in the analysis.

The wadi becomes a unifying element in the area eliminating the physical barrier of the erosion trench and creating space for new programs and activities. It connects spaces between the former trench edges; now roads can cross and reunite the two neighbourhoods creating better accessibility and allowing residents better possibilities for upgrading their houses and gaining official land tenure. The design also focuses on using this gained land for establishing new housing with a higher density thereby re-housing people whose houses where scarified for the project.

Where the wadi and the main road meet, a neighbourhood centre will be placed, creating a social meeting place and a generator for the surrounding communities. This will initiate development by providing different services and educational offers which can engender economic development, create workplaces and, in the end, help provide better living standards for locals.

The whole design of the space around the wadi, which is named 'water stairs', is regarded as a pilot project via presenting a physical example of how upgrading public spaces, densifications and water treatment can be handled in informal areas. Hopefully, this inspires both municipalities and locals by showing how climate change and unplanned urban growth can be tackled locally in informal slums.

Reflection

Reflection of the strategic process and action plan

North-eastern Maputo is a complex area with many internal insecurities and versatile challenges such as social segregation, land rights, vulnerable ecosystems and an unstable external economic and political context. We could have chosen several planning approaches to deal with urban development in these complex settings. However, we regard the largest challenge and contradiction in North-eastern Maputo to be uncontrolled urban growth in areas that, in s few years, may be unsuitable for living due of the effects of climate change.

The unpredictability of effects and extent of climate change in addition to the rate and character of an urban growth encourage us to invoke the notion of flexible strategic planning as the foundation of our process and action plan. There are however many ways of addressing the notion flexibility. We choose to translate the notion into action oriented interconnected projects that can be implemented individually at different times by different actors. Due to the poor state of the national economy and political administration level we see this as one of the only ways such a plan can be realised. The projects suggested in the plan all concern infrastructure, barriers and landscape moderation. We see the largest potentials in these because they all relate to the build environment and, to a great extent, can be pursued independently. These three elements are meant to affect without dictating urban development making it resilient to the shifting demands that certainly will occur through out the next 90 years. However, it is important to state that other elements could have been implemented as well; for instance, land use regulation. This would have resulted in a more comprehensive plan with a clearer subdivision of different areas with different identities. It would however also have resulted in a less resilient plan in relation to climate change not to mention a less cohesive plan in relation to development in informal areas.

The scale of the projects in the plan seems to be the largest obstacle for the realisation of even single components of it. The public construction jobs taking place in Maputo today are few, amounting to only minor improvements of roads and, in rare cases, construction of new ones. The execution of just one of the six wades, not to mention the dike along Av. Marginal, will be an enormous coordination challenge with many different actors involved, thus setting a high demand for public participation. For this reason, we choose to focus on single projects in the plan so that the burden of the projects can be divided.

However, the challenge is not entirely the construction of the projects. The administrative tasks behind the implementation of each single project in the different local environments are enormous. Because the foundation (climate change and urban development) of the process and action plan are elements that constantly change, the plan needs to be continuously evaluated and improved to utilize updated information and urban demands. This puts strong demands on the scientific base of the administration that is currently absent in Maputo. The extent of the project together with the extent of the rest of the pressing challenges of Maputo, such as poverty, political corruption and lack of providing basic services, make it absolute necessary for the projects in our plan to be approach holistically; in a way where the adaptations to climate change becomes a part of the general improvements of the city and meet the present and future needs of the inhabitant.

Reflections on the design

Regarding the zoom-in design solutions, we will discuss two perspectives; first the likelihood realization, and second, if our design lives up to the design strategy.

Realisation

In the strategic process and action plan, we suggest self-structured urban environments that are upgraded through a bottom up planning approach as in Klong Bang Bua and Mafalala. The development in these two cases were initiated by local authorities but carried out by local communities. We imagine that the upgrading in the area around the erosion trench could happen the same way.

However, in this project there are two main constructions, the wadi and the main road, which the municipality must be involved in implementing. Even so, the communities can contribute with labour and willpower, and the combination can lead to great changes so long as the authorities give the right initiatives. This does not mean that a good incisive is sufficient, the municipality or another organisation also has to be involved in assembling strong professional team supporting the locals through the design and upgrading process. Last but definitely not least, it is essential to establish an economical foundation on which the development can rely. The organisation Slum Dwellers International is currently establishing an ‘urban poor fund’ which will provide the poor with an opportunity to borrow money to upgrade their houses and pay it back over long time periods. This is also practiced in numerous bi-lateral programs. This creates a gateway for establishing better housing conditions and better quality of life in the long term. The idea is that small initiatives can result in larger transformation in the community and spread in ever-widening circles.

Design

Wadi and programming

To start out with, the strategy (rationale) of the wadi was to solve run-off and erosion issues that created an unstable environment along the trench and floods at the foot of the prominent hill. Moreover, the wadi was also supposed to integrate public spaces along it and function as a connecting space among them. As the design progressed, we experienced how complicated it was to fulfil our strategy because the trench is more than 300 meters long and because we did not want to eliminate houses for the sake of public programming nor did we want the trench to be a physical barrier.

Therefore, we compromised by making a rather wide wadi with no more than 50 cm tall edges with integrated walkways connecting the lake and the neighbourhood centre at the top. We concentrated the programmed public spaces at these two locations and distributed smaller pauses along the wadi edge with shade and seating options. As shown in the analysis, gathering spaces are always shaded and along roads. This is integrated in the design to make it more familiar, and easier to adapt to, for locals and at the same time provide direct relation with the nearby houses.

Flow and accessibility

The road between Chiquelene and the beach was already planned by the Portuguese but never constructed. There is a clear mark of where it had been anticipated. We therefore construct the road at this location in order to save the greatest number of houses as well as to create public space around the wadi without heavy traffic. The wadi, as a flow space, is meant to be safer for pedestrians, and especially children, than walking along the road.

We expect the space around the wadi to be most often used by locals living in the surrounding communities

and not as much by people passing by. The space is therefore designed as a local public space. As shown in the analysis, accessibility brings possibilities for upgrading and we implemented this in the plan by laying down distribution roads connecting the existing houses to the infrastructure network. The improved accessibility can however have the downside that the value of the land increases to an extent where people wish to sell their houses instead of upgrading them. This, of course, might change the character of a neighbourhood and could result in simply moving the problem to another part of town.

Neighbourhood centre

The main role of the new neighbourhood centre is as a generator for the community. A secondary role of the centre is as a common gathering space for local communities. It will form an identity point and a landmark in the area that is dramatically different from the immediate surroundings. Creating such a point for identity in the design may have been underestimated in the analysis and therefore has not been central in the design strategy. Nonetheless, it has been created through the neighbourhood centre and will be a visible gathering point for the surrounding communities.

Densification

The city of Maputo needs to densify in order to realistically provide its population with basic services. This is a substantial challenge to solve not only because it requires significant funding, but also because is requires cooperation between the public and the private sector in Maputo. In a broader perspective, solutions need to found at every scale, from large social housing compounds to smaller local initiatives. The model we proposed for establishing new housing in the area around the trench definitely belongs to the latter category in that we focused on flexibility and local engagement in the projects.

When transforming an area by proposing initiatives that increase living standard and possibilities in a curtain area, there is a good chance that it attracts people from elsewhere. In this way the proposed changes may not beneficial for people for whom they were intended.

As the analysis showed, people have strong connections to their areas and, on these grounds, we conclude that it would be preferable to keep and relocate as many of the people in the area as possible. If people are forced to move due to our solutions then we have not succeeded. However, doing nothing is worse and as the design is regarded as a pilot project to inspire other initiatives, one can hope that similar smaller and larger projects will take place around the city.

The project experience and design process

When everything has been said about the strategy and the design proposals a word has to be said about the project experience and design process. Working in an entirely unknown and very different context has broad large challenges with it and the short execution period of four months have been fare from enough to get the full perspective on both the situation in Maputo and the prospects and effect of climate change. We have handled a part of the material on these two subjects and the project reflects this. We are aware that there might be holes in our background knowledge however we do think that the project is representative and illustrate a possible design scenario in the given context. The Strategic process and action plan do have elements in it that seem too large to handle but in that case it is important to remember that the purpose (partly) was to illustrate the actions needed not the action possible.

The design process behind the project has been long and the design focus has shifted several times. The fact that the area, the culture and the context was new to us made it more difficult than usual to narrow down a focus. The challenge of working in a so radical different context have however been very rewarding and hopefully the end result of the project will be an inspiration on how one could work with climate change and urban growth in developing countries.

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Illustration list

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Fig. 1.2 www.flickr.com (Accessed: 23.04.10)
Fig. 1.3 http://images.travelpod.com (Accessed: 22.04.10)

Fig. 2.1 UNFCCC (n.d.) (United Nations Framework Convention on Climate Change) 'Climate change: impacts, vulnerabilities and adaptation in developing countries'
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Fig 3.7 Grimard, A. 'CITIES AND CLIMATE CHANGE Initial Lessons from UN-HABITAT' UN-Habitat
Fig 3.9 http://www.panoramio.com (Accessed: 27.04.10)
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Fig 3.11 Maputo Municipal (2008) 'Plano de Estrutura Urbana Do Município de Maputo, INTRODUÇÃO AO PEUMMSUAS RAZÕES E FILOSOFIA'. Maputo Municipal, 2008

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Fig. 5.1 Jørgen Eskemose

Fig. 7.3 Otelo Uetela
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Fig. 9.1 www.archdaily.com (Accessed: 31.05.10)
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APPENDIX 1

WHAT IS CLIMATE CHANGE?

The climate is constantly changing. Over periods of time that range from decades to million of years the climate has shifted radically for shorter or longer periods with enormous consequences for life on Earth. This is often referred to as a natural fluctuation. Furthermore, the amount of CO2 in the atmosphere has, at times, been greater then currently without human interference (Strahler, 2000).

However, the general consensus of the present situation among natural scientists is that the short- and long-term climate change, we now see, is a result of human emissions (IPCC, 2007a). In the western world the industrialisation has increased emissions of greenhouse gases into the atmosphere, due to the burning fossil fuels and changing land use. The increased amount of these gases (carbon dioxide CO2, methane CH4 and nitrogen dioxide N2O) in the atmosphere is preventing the radiation of heat from Earth back into space, coursing global warming through the greenhouse effect. Global warming courses the climate to change and to do so more rapidly the ever before. The effects are as alarming; melting ice caps and glaciers, reduced snow covers, increasing ocean temperatures and acidity and changes in cloud cover and precipitation (Dodman, 2009; Strahler, 2000).

UN's Intergovernmental Panel on Climate Change (IPCC) has in its Fourth Assessment Report (4AR) produced extensive global reviews on observations, scenarios and discussed the level of adaptation, mitigation and vulnerability (IPCC, 2007a). The latest years increased temperatures is the largest and fastest rising trend the scientists have ever been able to detect in the history of Earth. All observations estimate with high certainties that global warming will increase and even accelerate. 4AR estimate temperatures on Earth to increase from a minimum of 1,8 degrees Celsius to as much as 4 degrees Celsius by 2100 (Dodman, 2009).

Fig. 10.1
Flooded streeet

The consequence and effects of global warming

The IPCC predict and estimate the climate change and simulate the behaviour of the climate system based on fundamental laws of physics. The models do however, hold many assumptions due to lack of information on e.g. the haste of which the ice caps melt and how this affect the ocean circulation system. The IPCC models predict that thermal expansion of the oceans alone will make the sea-level rise between 0,18 and 0,59 meter before 2100 (Dodman, 2009). Other models trying to incorporate the melting ice caps predict that sea-level will rise between 0,30 and 5 meters (INGC, 2009). Three of the newest model predictions from England, Chi[illegible] and Denmark are based on the radiation balance of the sun and they estimate the sea-level will rise between 0,70 and 1,20 meters before 2100 (Aagaard, 2010).

Another consequence of the global warming is the change in type, frequency and intensity of extreme weather events such as cyclones, floods, droughts and heavy precipitation (Dodman, 2009). These changes are even harder to predict then the rising sea-level. Nevertheless one thing is clear, these events will have severe consequences for people all over the world. It is vital to get an agreement on how to tackle the common responsibility for the previous and present emissions of CO2 and start planning for how to meet the future challenges of climate change.

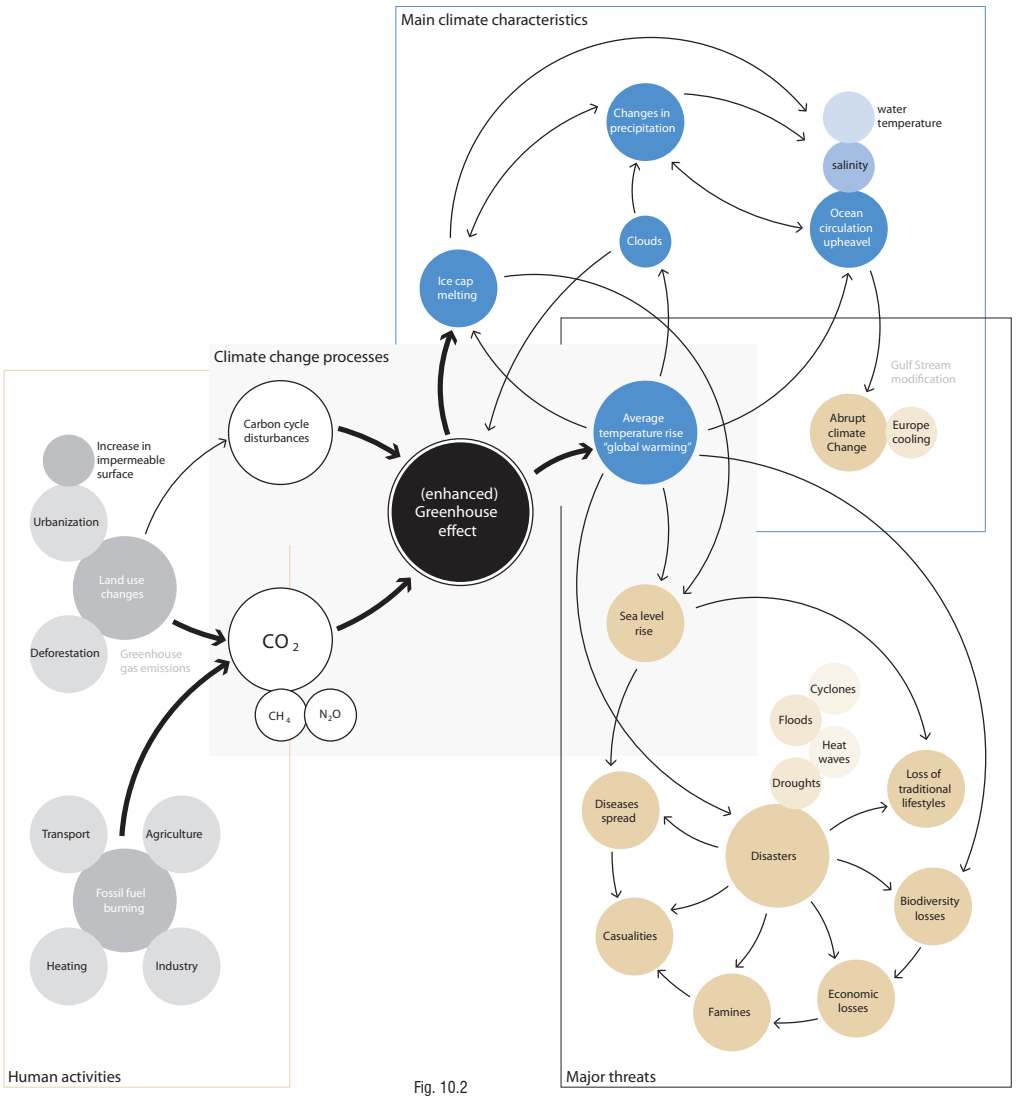

Fig. 10.2
Disaster diagram

APPENDIX 2

DIMENSIONING OF THE WADI

The erosion trench created at the hill side is caused by the runoff from a large area further up the hill. When there is heavy rain, the water flows into the streets and roads, which serve the area as drainage. At the brink of the hill the water has gathered on the roads, and when it runs over the soft earth on the brink it creates the erosion trenches.
As the project shows we have designed a Wadi which in the future will prevent the erosion from happening. To estimate the dimensions of the Wadi design, we are looking into hydrology based on a series of rain data. Unfortunately there is a general lack of registrations and rain data collection in Maputo. Therefore to approximate the dimensions of the wadi we have used data from Miami in Florida. In general it is possible to use data collected elsewhere as long as the climate is comparable, the annual precipitation and the elevation is the same. Miami has a location of 25°47'16 N, 80°13'27W, whereas Maputo has 25° 57' 55 S, 32° 35' 21 E. They are located on the same latitude on each side of equator which means they have similar weather conditions, just displaced rainy seasons.
It is difficult to find the exact matching data situation for two different locations and between Miami and Maputo there is a difference in the average annual rainfall of 300 mm. But if we look into the prospects of climate change, we know that Maputo will have heavier rainfalls. Therefore we will roughly say that will compensate for the higher average rain in Miami. This will correspond to an incensement of 35 percent. In comparison there to, the expected climate change in Denmark will have an annual increase in precipitation of 10-20%

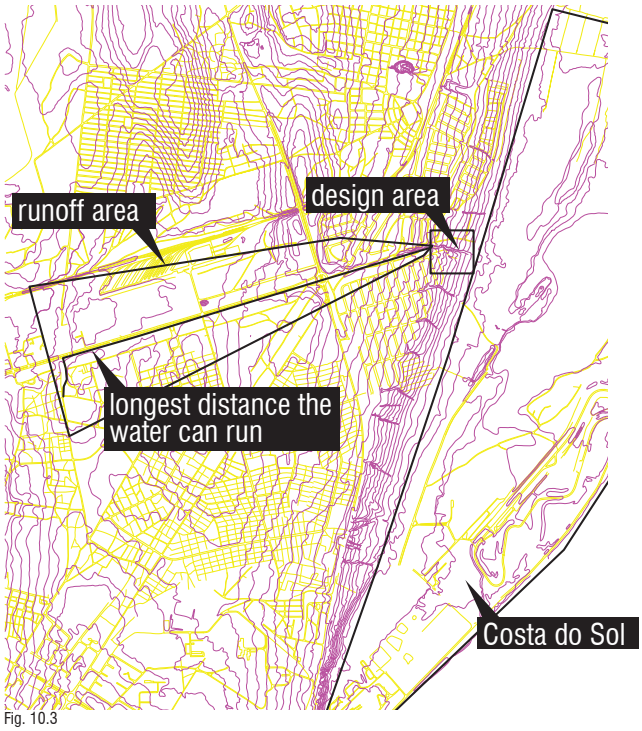

Fig. 10.3
Runoff area

The aim

We want to dimension the wadi for a 6 month rain, 1 year, 2 year, 5 year, 10 year and 100 year rain. The result will be a ratio between the heights of the sides and the length of the cross section. The different year rains will cause different levels in the design, and it is these levels that we want to find. We are aiming for a variety of the different expressions with the different amount of water, as shown in the design strategy.

Calculations

First we need to find the flow rate before we can find the proportions of the wadi. The flow rate tells us how many cubic meters of water will flow though the wadi pr. second. To find this we need to have the rain intensity and the reduced catchment area (see fig. 10.3). The reduced catchment area is the impervious area where the water will run off. About 30 percent of the water will evaporate or descent into the ground and will therefore have no influence on the wadi. The duration intensity is depending on the time of which it will take the water to run from the furthest point in the catchment area to estimate the maximum. The flow rate is also very depended on the surface on which the water runs. The surface has a resistance and a gradient. Therefore it runs off with a certain speed. In the catchment area the surface is mostly clay and tarmac and the landscape is descending 10 meters over a distance of 1km. We have therefore estimated the velocity of the water to 1 m/s. The flow rate Q tells us how many m3/s of water will come through the wadi, which is giving us an area to dimension.
Q [m3/s] = rainfall intensity [m/s] × the reduced area [m2]

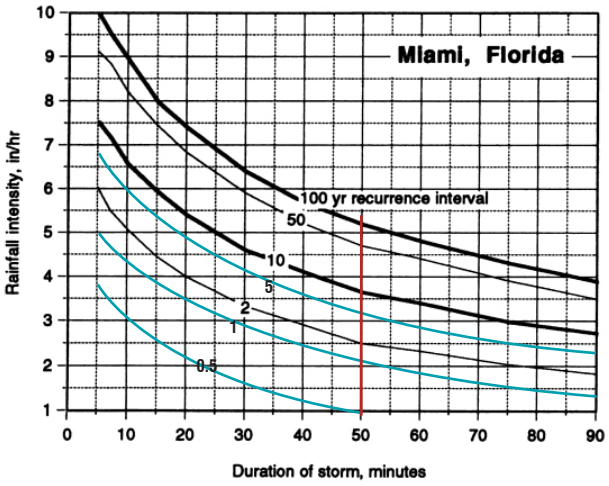

Fig. 10.4
Intensity Duration Frequency Curve, blue curves are self estimated

When the water reaches the wadi, the surface material and the slope change. This gives us another velocity.
We want to find out the dimensions for the wadi. For this we combine the continuity equation and the Manning formula.
Manning formula is describing the perimeters which determine the velocity of the water:
$V = M \times R \hat{} (2/3) \times I \hat{} (1/2)$
M (Manning roughness, is the material roughness which is determined by the material type),
R = hydraulic radius, which is R = A (area)/P (the wet perimeter P = width +2×height)
I (energy line gradient, the decrement over a distance)

We want to find the dimensions of the wadi which being the height and the width. Therefore we combine the Manning formula and the continuity equation.
$Q = A \times V => V = Q/A$
Combined with: $V = M \times R \hat{} (2/3) \times I \hat{} (1/2)$
$Q/A = M \times R \hat{} (2/3) \times I \hat{} (1/2) =>$
$Q = M \times R \hat{} (2/3) \times I \hat{} (1/2) \times A =>$
$Q = M \times (w/h)/(w+2 \times h) \hat{} (2/3) \times I \hat{} (1/2) \times w \times h$

We know the value of Q when the water comes into the wadi and therefore it is possible for us to try out different cross-sections of the wadi. On the appendix CD you will find an excel file* with the calculations for the different rain intensities. Beneath is an example of the calculation process which is illustrated in an excel column on the next page:

M: The roughness value is set to 30. This factor is determined by both the material but also its surface. Especially the roughness has a large influence on the water flow, the more resistance the water meets on its way the lower the roughness value. In 'Afløbsteknik' (Wither et al., 2006) p. 177 the estimations of the roughness from different types of surfaces can be found. This has been calculated for a roughness which is between the categories of: 'a rock jagged and irregular but carefully exploded' and 'stone cover in regular earth profile' respectively Manning's number of 27 and 34.

I: The ratio between the height and the distance. We are working with four different ratios of the slope in the wadi, which will give different dimensions to the wadi and a variety in the character of the streaming water.

This calculation is made with I = 0.05 for area A (her kommer der en illustration som viser at planen er delt op i fire områder med I: Område A= 0.18 B=0,075 C=0,05 D=0,4)
The Q value we have from the previous calculation of the flow rate of the water coming to the wadi. This we use to compare the height and width of the wadi to.
Q = 17,29 m3/s
$17{,}29 = 30 \times (w/h)/$
$(w+2 \times h) \hat{} (2/3) \times 0{,}05 \hat{} (1/2) \times w \times h$

If we set the height to 0.5 m and the width to 3.2 m it gives us a flow rate of 17.29 m3/s and an area of 1.6 m2. We calculate the area for all the rain intensity for 0.5 year, 1, 2, 5, 10 and 100 for each section. Below you can see the example of the data from area A. It is the area, which is interesting for the design.

*Name of excel file: Rainwater calculations.

Område A

0,5 år		1 år		2 år		5 år		10 år	
Q	10,1725 m3/s	Q	17,293 m3/s	Q	25,431 m3/s	Q	33,569 m3/s	Q	
I	0,05 m/m	I	0,05 m/m	I	0,05 m/m	I	0,05 m/m	I	
M	30 beton	M	30 beton	M	30 beton	M	30 beton	M	
b	3,2 m	b	8,8 m	b	12,6 m	b	16,5 m	b	
h	0,5 m	h	0,5 m	h	0,5 m	h	0,5 m	h	
R	0,380952381 m	R	0,44898 m	R	0,463235 m	R	0,471429 m	R	
A	1,6 m2	A	4,4 m2	A	6,3 m2	A	8,25 m2	A	
Qberegnet	5,640358403	Qberegnet	17,30653	Qberegnet	25,3016	Qberegnet	33,52258	Qberegnet	

Fig. 10.5
Example of calculations from the excel file on the appendix CD

Design of the wadi

The design of the wadi is determined by the calculated results. The wadi is build up by levels where the different rain intensities will fill up the different levels. We have estimate the minimum sizes for the 4 different zones A, B, C, D, all the calculated results can be seen on the appendix CD. We have here shown an example of how we have dimensioned the wadi.
The wadi consists of a drainage at the bottom and two wider basins (fig. 10.9). The levels are determined by the water heights, so the drainage at the bottom is designed from the 0.5 year return period, the size of the first basin holds 1 and 2 year return period, and the second basin holds the water for 5, 10, 100 year return period.
We try to make the vertical height for the basins no more than 0.5 meters, to make it possible for it to be used for other purposes, and for security reasons.

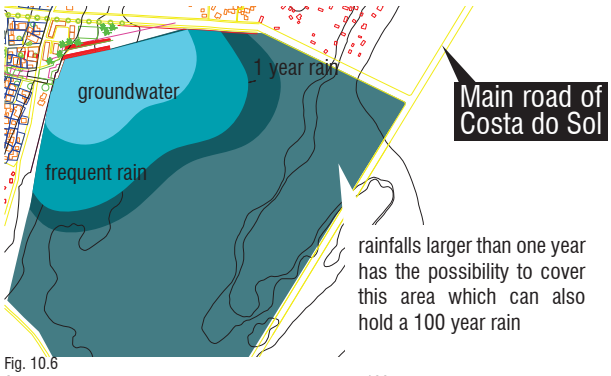

Fig. 10.6
Surface area of the three water levels and the scenario of a 100 year rain

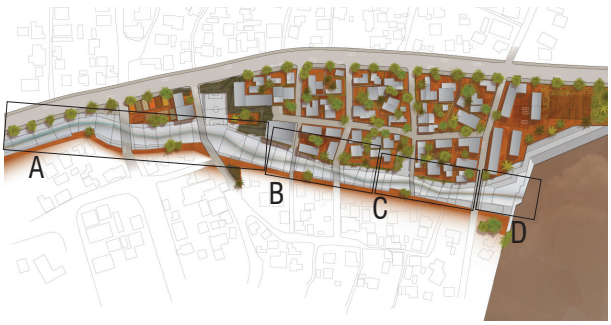

Fig. 10.7
Four zones with different slope coefficient

Fig. 10.10
The heights of the water levels with different rain intensity, as used in the design of the wadi

Fig. 10.8
Example of a lake with a edge descending gradually into the water

Fig. 10.9
Dimensions of the wadi

år		100 år	
	36,621 m3/s	Q	52,897 m3/s

	0,05 m/m	I	0,05 m/m
	30 beton	M	30 beton
	18 m	b	25,6 m
	0,5 m	h	0,5 m
	0,473684 m	R	0,481203 m
	9 m2	A	12,8 m2

eregnet	36,68665	Qberegnet	52,72725

Dimensioning of the lake

At the bottom of the wadi we have the lake to retain the water. The lake has this practical function but at the same time it also brings a recreational value to the lower part of the design area.
As the situation is now the water is running off from the agricultural area and the golf course with the danger of flooding the residential area in the lowlands. The lake and the new road structure will in the future ensure that this does not happen. The lake is dimensioned to hold a rain which happens 2-3 times pr. year, and in cases of heavier rainfalls the water will descend through drainage along the road and in cases of very heavy rains, the water can flood the golf course and run towards the drainage of the larger main road crossing Costa do Sol (se fig. 10.6). The location of the golf course means that a part of it will be turned into the permanent lake. This of cause reduces the useable area for playing, but the lake ensure on the other hand, a less frequent flooding of the playing field. In case of large floods, the roads functions as dikes and will prevent the water from flooding the low lying residential areas.
The lake consists of three different "layers", where the permanent water level is the second level which is caused by the frequent rainfalls and the third level is caused by the rain which happens 2-3 times a year (see fig. 10.11).
The edge of the lake is shaped with a soft slope (> 1:10), which makes it possible for the lake side to be used for other purposes when it is not needed for holding the water. It is also much safer for children to play along the edge when it descends gradually into the water, which is worth considering in this context.
The lake is going to be located at the foot of the hill, which means that the terrain is going to be shaped in order to hold the water. The lake will be excavated to reach the groundwater and earth will be pushed out to form an edge which can hold the 1 year rain. The terrain is sloping down towards the main road, and it is therefore necessary to create a boarder of the lake. The section of the lake shows the principle of the lake. The water will have a certain velocity when it enters the lake at the inlet and to ensure that the water is slowed down a barrier of large rocks is places. This insures that the water will not dig a hole in the lake and at the same time make a softer and safer descent into the water.

The dimensioning of the lake is done as shown in this example:
The water volume is calculated as: the rainfall [m] × the reduced catchment area [m2]. This gives us a volume which can then be divided with the desired depth of the lake.
In our design the levels of water has each a depth of one meter at the most. We want to dimension the surface area to estimate the size of the lake. The calculation of the areas is done simplistic with rectangular volumes, but in reality the terrain will increase much more gradually.

The rainfall which happens 2-3 times pr. year which is the largest volume the lake will hold is: 0.1 m (data from Maputo Meteorological Institute)
The reduced area: 1201480 m2 (120 ha)

The water volume is: 0.1 m × 1.201.480 m2 = 120.148m3. This volume is the inflow over an unknown time period. The lake will also have an outflow which is unknown. If we would dimension the lake to hold the total volume of a rain which happens 2-3 times a year, we would over dimension it, and it would take up a large area of the golf course. For this reason we have decided a volume for the lake, and drainage. The dimensions of the drainage will insure the desired water volume is obtained. The lake is therefore dimensioned to hold 80.098 m2 and which means we will have a permanent water mirror at contour 6, and occasionally 2- 3 times a year at contour 7.

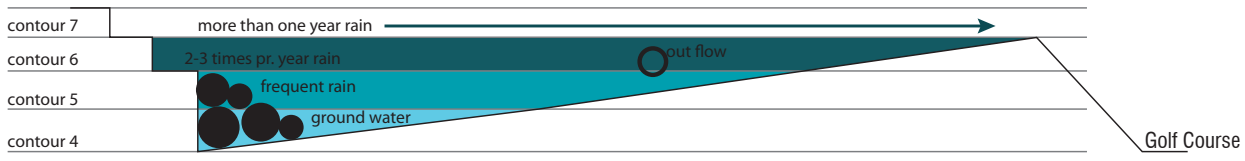

Fig. 10.11
Principle drawing of the section of the lake