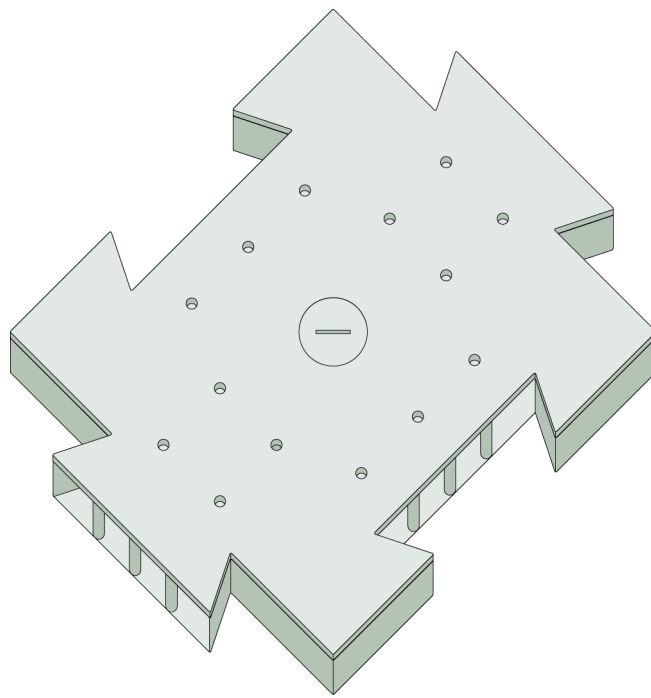


# PUZZLE PAVEMENT

A competition project for better streetscapes in unpaved informal settlements



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Master's thesis for the Landscape Architecture Programme

EX0504 Degree Project in Landscape Architecture, 30 HEC

Level: Advanced A2E

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Title in Swedish: Puzzle pavement - Ett tävlingsprojekt för bättre gaturum i informella bosättningar utan markbeläggning

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# Prologue

Early 2017, we stood before the choice of choosing a subject for our master's thesis. Since we wanted to compare ourselves to other landscape architects and designers, it made sense to enter a competition focusing on design. During our education we have come across design competitions, but never entered one due to lack of time. The master thesis course gave us a full semester to do whatever we wanted, an opportunity to enter a design competition ourselves. But what competition should we enter? As we scouted the range of current competitions we found several possibilities. The subjects were rather different, ranging from designing a moon base to a pedestrian bridge in Warsaw. After evaluating the possibilities we chose the competition DENCITY 2017. The suitable time-frame and its limits in constraints was reasons for choosing this competition.

The competition targeted informal settlements. This subject made us realize that we could contribute to help people and that this thesis could inspire others to involve in the subject. Thereby possibly making the lives of the 860 million residents in informal settlements slightly better.

We would like to thank our course mates for your valuable revisions and input to this work it has been highly appreciated. We would also like to thank our supervisor professor Thomas Oles for your inspiring manners, encouraging us to challenge ourselves and believing in ourselves, our education and our profession.



Photo 1. © Agnes Djurberg





## Abstract

The developing world's population is becoming more and more urbanized in a very rapid pace. The urbanization combined with a too normative city planning and use of inefficient approaches from governments has in many cases led to the formation of informal settlements, where 860 million people lived in the year of 2013.

Public space in informal settlements is often limited and of poor quality. This is also the case of the streetscapes, where many informal settlements lack proper paving, which leads to problems concerning transportation and health. By improving the streetscapes a number of problems can be solved. Furthermore it can also consolidate the informal settlement and integrate it with the surrounding formal city.

Our purpose with this master thesis is to engage in how design can contribute to better streetscapes in informal settlements. This thesis aims to inspire landscape architects and other designers to involve in this matter. Our intention is to create a general design concept and through a small intervention improve the streetscapes of informal settlements. In order to explore this subject we formulated the following questions:

How can we design a concept concerning streetscapes in informal settlements within the framework of the idea competition DENCITY 2017?

What aspects need to be considered when landscape architects involve in the issues of informal settlements?

To reach the answer of these questions we used three methods. We studied literature to relate our project to facts and to explore the subject of informal settlements. By analysing previous entries in the competition DENCITY we gained inspiration to how to approach this competition. Design as a method was used to create a concept to submit to the competition.

The competition DENCITY 2017 states that entries can either be site-specific or be designed as a general concept. We have developed a general concept where a product is developed. The way towards our product is explained in a design process explaining decisions and approaches. The submission presented in this thesis is called puzzle pavement. Puzzle pavement is a product in form of a plastic slab, aiming to supply informal settlements with a pavement, replacing the current dirt roads. Some of the key features of puzzle pavement is to manage rainwater, prevent the spread of airborne dust and to facilitate transport. The production of the puzzle pavement is also presented in this thesis. The puzzle pavement is produced using recycled plastic and the production phase involves the residents in the informal settlement. In this thesis we have discovered that the lack of planning and bureaucracy in informal settlements leaves a creative gap which can be filled with the wide range of knowledge that landscape architects hold.



# Sammandrag

Den urbana utvecklingen sker snabbt, från år 2000 till 2010, ökade utvecklingsländernas befolkning med 1,2 miljarder invånare per vecka (UN-Habitat 2012a p. 28). År 2014 levde 54 procent av världens befolkning i städer, en siffra som beräknas stiga till 66 procent år 2050 (UN 2014 p. 1). Det urbana livet är associerat med hög standard gällande hälsa, ekonomi och tjänster, men när tillväxten sker oplanerat och infrastruktur förbises är det svårt att behålla en hållbar urbanisering (UN 2014 p. 3). På grund av den snabba tillväxten har städer svårt att tillhandahålla planerade fastigheter, vilket har lett till en hastig ökning av informella bostättningar (Kileki Mrema 2008 p. 6). År 2013 levde 860 miljarder människor i informella bostättningar världen över (UN-Habitat 2012b).

Bristfällig tillgång till vatten, sanitet och infrastruktur, dålig kvalitet på byggnader, överbefolkning och osäker bostadsstatus är de fem definierade faktorerna av informell bostättningar (UN-Habitat 2012b. NP). När definitionen av informella bostättningar jämförs med FNs deklaration av mänskliga rättigheter blir det tydligt att standarden inom informella bostättningar måste förbättras. Attityden mot informella bostättningar har under de senaste 50 åren gått från att röja undan de informella bostäderna till att rusta upp dem (Kileki Mrema 2008 p. 8). Trots att det finns tydliga fördelar med att rusta upp informella bostättningar, tenderar vissa städer fortfarande att avhysa de boende (Davis 2007 p. 115).

Ett sätt att engagera folk i upprustningen av informella bostättningar är via designtävlingar. DENCITY är en årlig designtävling som lanseras av organisationen Shelter Global. År 2017 lanserade Shelter sin tredje tävling med målet att förbättra informella bostättningar genom design (Shelter Global 2017 a). Det är genom denna tävling som vi kommit i kontakt med problematiken som finns med informella bostättningar. Syftet med tävlingen är:

“[...] The intent of this competition is to foster new conceptual ideas about how to better handle the growing density of unplanned cities. Contestants should consider how design can empower communities and allow for a self-sufficient future.

For this years competition, the focus will be on improving living conditions in urban settings. There are no restrictions in regards to site, program, or size. Projects can be based on a specific urban location or a general concept. The object is to limit constraints and give participants the freedom to think in the most creative way possible [...]”

(Shelter Global 2017 a. NP)

## Avsikt

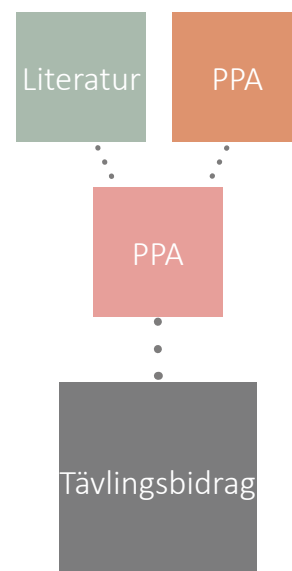
Syftet är att undersöka och ge förslag på hur design kan bidra till bättre gaturum i informella bostättningar. Vidare avser arbetet att inspirera landskapsarkitekter och andra inom kåren till att engagera sig i dessa frågor. Vår avsikt är att skapa ett generellt designkoncept, som med ett litet tillägg förbättrar gaturum i informella bostättningar. För att vidare utforska ämnet har vi formulerat följande frågor:

Hur kan vi utforma ett koncept gällande gaturum i informella bostättningar inom ramen för idétävlingen DENCITY 2017?

Vilka aspekter måste landskapsarkitekter ta hänsyn till vid involvering i problematiken gällande informella bostättningar?

## Metod

Arbetet genomfördes med hjälp av tre olika metoder; litteratur, analys av tidigare tävlingsprojekt och design. Litteraturen innefattade både skrivna källor och dokumentärer och användes för att ge en introduktion till ämnet, avgränsa arbetsområdet och fungerade som substitut till en platsanalys. Genom att analysera tidigare tävlingsbidrag, kunde vi hitta idéer, tillvägagångssätt och inspiration till vårt eget tävlingsbidrag. Design användes för att utforska frågeställningen och för att nå vårt tävlingsbidrag. Genom en designprocess kunde vi undersöka, skissa och testa olika idéer för att slutligen komma fram till ett slutresultat. I vår designprocess försöker vi på ett tydligt och transparent sätt redovisa hela processen genom att relatera vår process till teorin Research through designing.



Figur som illustrerar de tre olika metoderna som vårt arbete bestod av.

# Utforskning av ämnet

## Offentliga platser i informella bosättningar

Offentliga platser refereras ibland till den fattiges vardagsrum och fyller flera funktioner i en stad (UN-Habitat 2015 p. vii). En typisk egenskap för informella bosättningar är bristen på offentliga platser (UN-Habitat 2015 p. 32). Det finns en stor efterfrågan på yttre ingripande eftersom de offentliga platserna ofta bortses från i informella bosättningar (Werhmann 2009 p. 35). Fördelarna med att investera i offentliga platser är många, det kan leda till bättre hälsa, säkerhet och ekonomi (UN-Habitat 2015 p. 6). Samtidigt kan en och samma yta användas till flera olika aktiviteter, vilket stärker behovet av fungerande offentliga platser (Kileki Mrema 2008 p. 18).

## Risksatta områden

Många informella bosättningar befinner sig i riskområden där exempelvis erosion och översvämning är vanligt (Davis 2007 p. 140). I det här arbetet har vi avgränsat oss till att undersöka problemen och riskerna med gator som saknar markbeläggning i informella bosättningar, något som är vanligt förekommande i utvecklingsländer (Gonzalez-Navarro & Quintana-Domeque 2010 p. 254). Transport och tillgänglighet försvåras utan markbeläggning vilket skapar dagliga problem för de boende (Sytse de Maat 2010). Den stora mängden smuts och luftburen damm som sprids är också ett stort problem (Sytse de Maat 2010). Förutom att dammet hamnar överallt påverkas även hälsan hos invånarna negativt (WHO 2005 p. 59).

## Arbetsprocesser inom informella bosättningar

Att utveckla ett nätverk av gator med markbeläggning har flera positiva effekter på ekonomin samtidigt som det underlättar transport (UN-Habitat 2012a p. 52). Gator och offentliga platser är viktiga för att länka informella bosättningar till den omgivande staden (UN-Habitat 2014 p. vii). Genom att uppgradera och integrera informella bosättningar med den omgivande staden, går det att undvika framtida informella bosättningar (UN-Habitat 2014 p. vii). Informella bosättningar har utvecklats dynamiskt och när uppgraderingar ska göras är det viktigt att de sker succesivt (Kileki Mrema 2008 p. 10), det är även bra ur en ekonomisk synpunkt (UN-Habitat 2014 p. viii).

## PPA

Från de analyserade tävlingsprojekten fann vi nio tillvägagångssätt som visat sig vara lyckade.

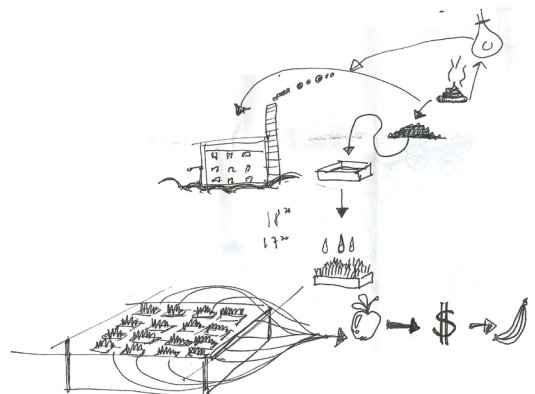
- Användning av lågteknologiska lösningar
- Återvinning
- Användning av lokala resurser
- Involvera invånarna
- Lösa vardagliga problem
- Arbeta i faser
- Respekt för det befintliga
- Skapa identitet
- Förbättra offentliga platser

## Designprocess

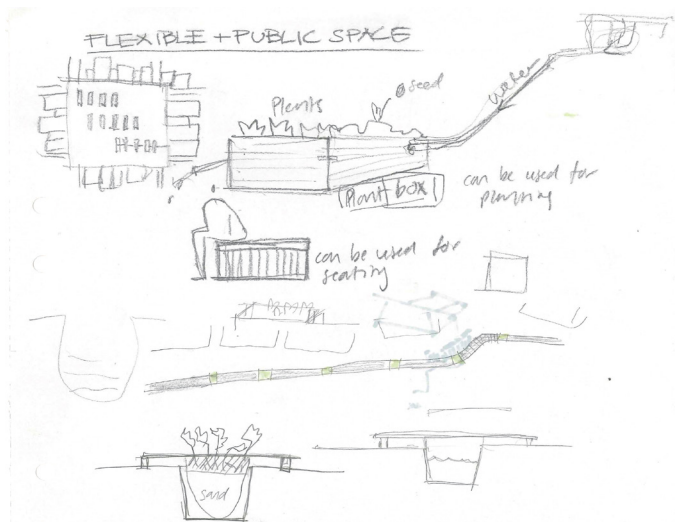
Tidigt i arbetet insåg vi att övergripande problem som sanitet eller ekonomi var för komplexa för att lösa genom ett litet designgrepp. Genom att studera litteratur och tidigare projekt, avgränsade vi vårt arbetsområde till offentliga platser. Även detta ämnesområde var för stort, vilket ledde oss till att fokusera på gaturum. Vi tog fram följande designprogram och sa att vår design ska:

## Designprogram

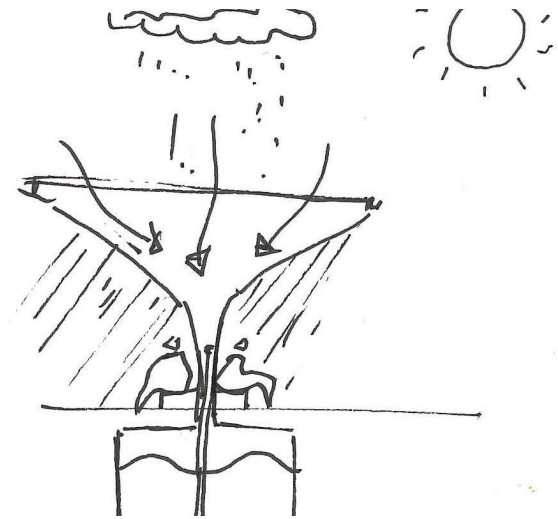
- Lösa vardagliga problem genom att förbättra gaturummet i informella bosättningar
- Sträva efter minsta möjliga ekonomiska och ekologiska fotavtryck
- Involvera den lokala befolkningen för att skapa en känsla av ägande, identitet och för att reducera risken att störa de existerande strukturerna
- Syfta till att skapa en flexibel lösning genom att arbeta i olika faser



Tidig skiss i designprocessen där övergripande problem som i detta fall sanitet försökte lösas genom att omvandla avföring till näringsrik jord.



Skiss där planteringsytor användes i kombination med sittmoduler i offentliga platser.

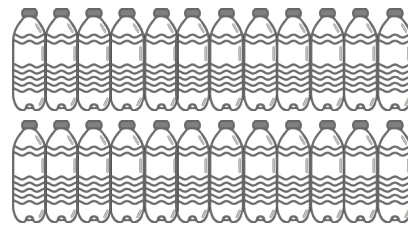


En av de sex olika idéerna utifrån designprogrammet. Att utnyttja regnvattnet var en aspekt som togs med i den slutgiltiga idén.

Från designprogrammet tog vi fram sex idéer, av dem valde vi en. Vi hämtade inspiration från de andra idéerna och adderade till vår slutgiltiga: puzzle pavement. Genom att skissa och testa idéer tog vi fram en produkt, en markplatta med fokus på att förbättra transport, luftkvalitet och hantering av regnvatten. Vi bestämde att produkten puzzle pavement skulle uppnå tolv viktiga funktioner som förbättrar levnadsstandarden i informella bosättningar.

## Billigt material

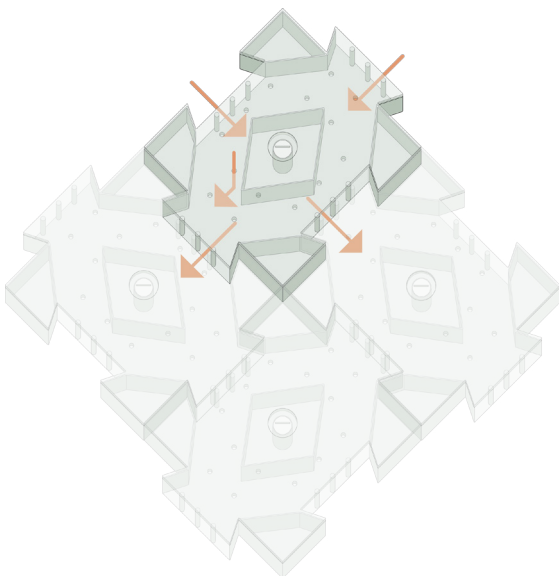
Plast är ett lättillgängligt material som är lätt att återvinna och omforma. För att tillverka en markplatta krävs det cirka 24 plastflaskor.



För att producera en platta krävs 24 plastflaskor

## Hantera vatten

Puzzle pavement skapar ett nätverk av interna kanaler där regnvatten kan transporteras. Vattnet kan antingen samlas upp i cisterner eller ledas direkt till planteringsytor. Ovansidan är perforerad med hål som leder in regnvatten.



Vattnet transporteras inuti plattorna.



Vatten kan ledas till planteringsytor.



## Hållbar

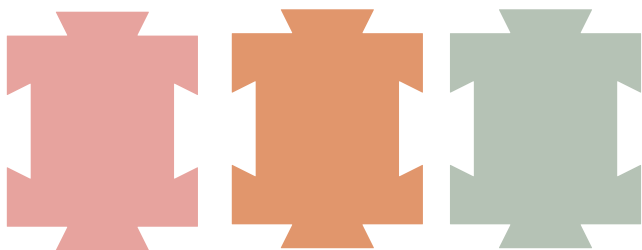
Den inbyggda konstruktionen är försedd med ett fackverk för att jämna ut trycket från både fotgängare och lättare fordon.

## Lätt att montera

Den fyrkantiga formen och med en storlek på 400mm x 400mm gör plattan lätthanterlig. Plattan monteras ovanifrån för att låsas ihop med de andra plattorna. För underlättad produktionen är plattan uppdelad i en överdel och en underdel, samt en jordskruv som förankrar plattan. När plattan konstrueras behövs därför tre olika former.

## Olika utseende

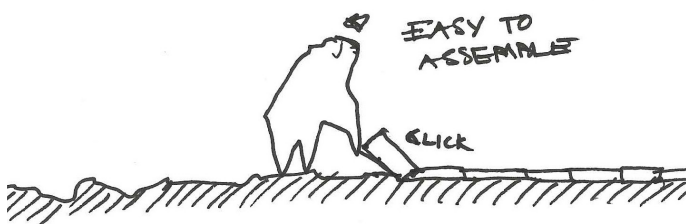
Genom att sortera plast efter färg får plattorna olika utseende. På så sätt kan gator färgkodas vilket skulle kunna leda till ökad orienterbarhet.



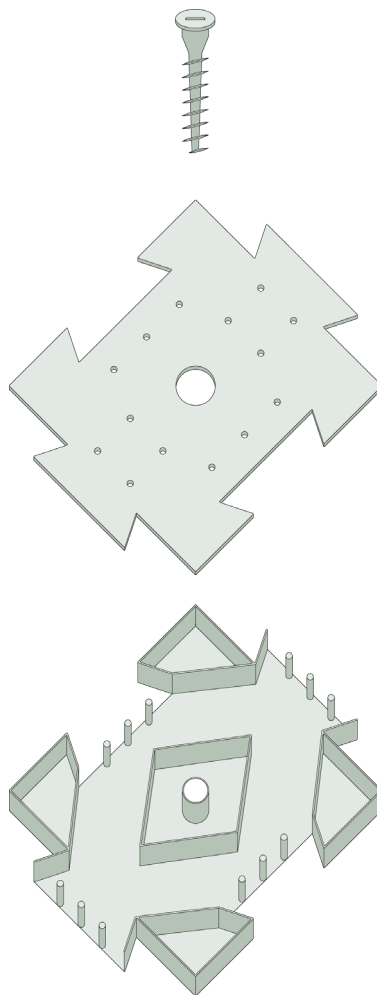
*Olika färger kan underlätta orientering.*

## Placeras var som helst

Flexibilitet är en stark identitet i informella bosättningar. Fördelen med puzzle pavement är att den kan placeras nästan var som helst, även på trånga gator dit större maskiner inte når.



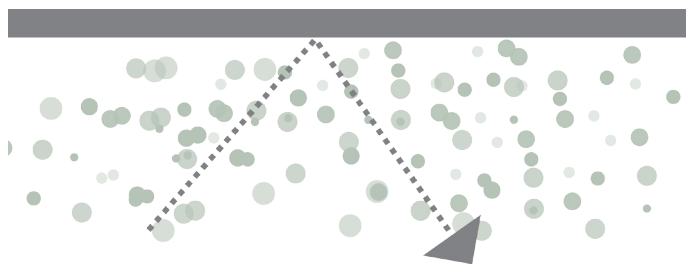
*Plattorna kan placeras på trånga gator.*



*Bilden visar hur plattans tre olika delar monteras. I underdelen syns ramens konstruktion.*

## Förebygga luftburet damm

Den undre delen av plattan hindrar damm från att spridas i luften vilket ger en bättre luftkvalitet.



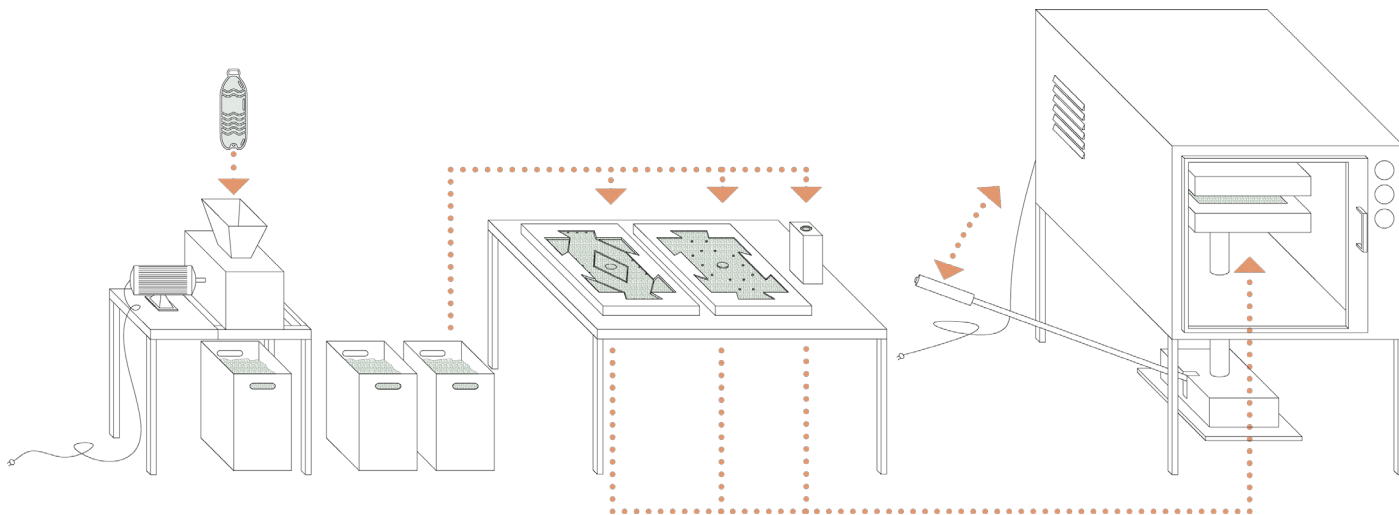
*Plattan skapar ett skyddande lock som hindrar spridningen av damm.*

## Produceras lokalt

En lokal produktion minimerar material- och transportkostnader, samtidigt som invånarna kan engagera sig i produktionen. Invånarna kan kompenseras för att hjälpa till med insamling av plast och montering av plattorna, vilket kan öka känslan av ägande. Produktionen äger rum i en enkel verkstad, där plast mals ner till granulät som sedan smälts och formas i en ugn.



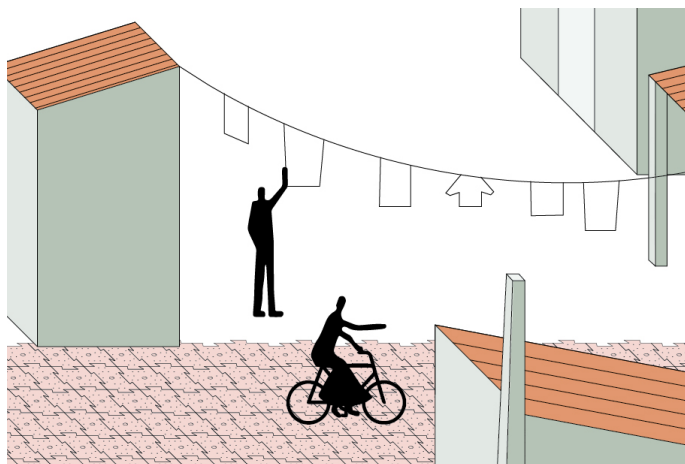
*Produktion och genomförande sker med hjälp av invånarna.*



*Produktionsfasens olika steg från plastflaska till puzzle pavement*

## Underlätta transport

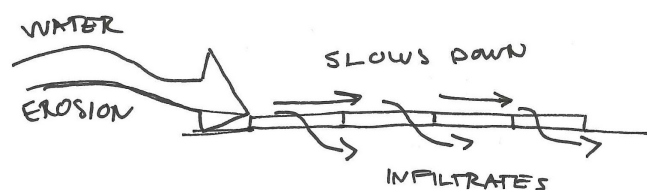
När plattorna är utlagda skapas en platt yta som underlättar transport och framkomlighet.



*Den plana ytan underlättar transport.*

## Hindra erosion

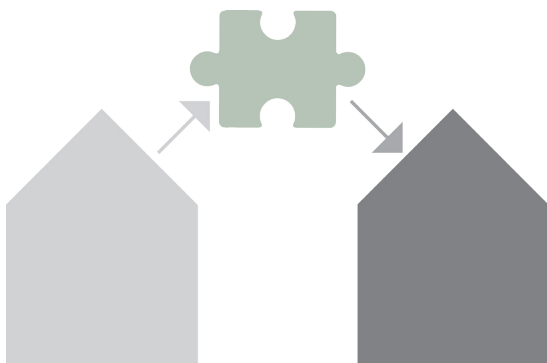
Eftersom vatten leds inuti plastplattorna minskar risken att regnvatten eroderar den underliggande marken.



*Vattnet transporteras inuti plattorna och minskar risken för erosion.*

## Möjlighet till omplacering

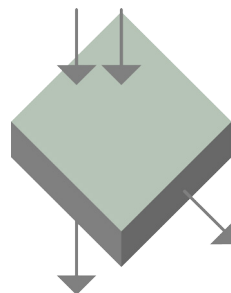
Puzzle pavement behöver inte vara en permanent lösning. Vår förhoppning är att gränsen mellan den formella staden och informell suddas ut. Om investering görs i form av ny infrastruktur kan plattorna och verkstaden flyttas till en ny informell bosättning där behovet är större. Denna flexibilitet är också viktig om mindre tillägg sker i gaturummen, då delar av puzzle pavement kan flyttas.



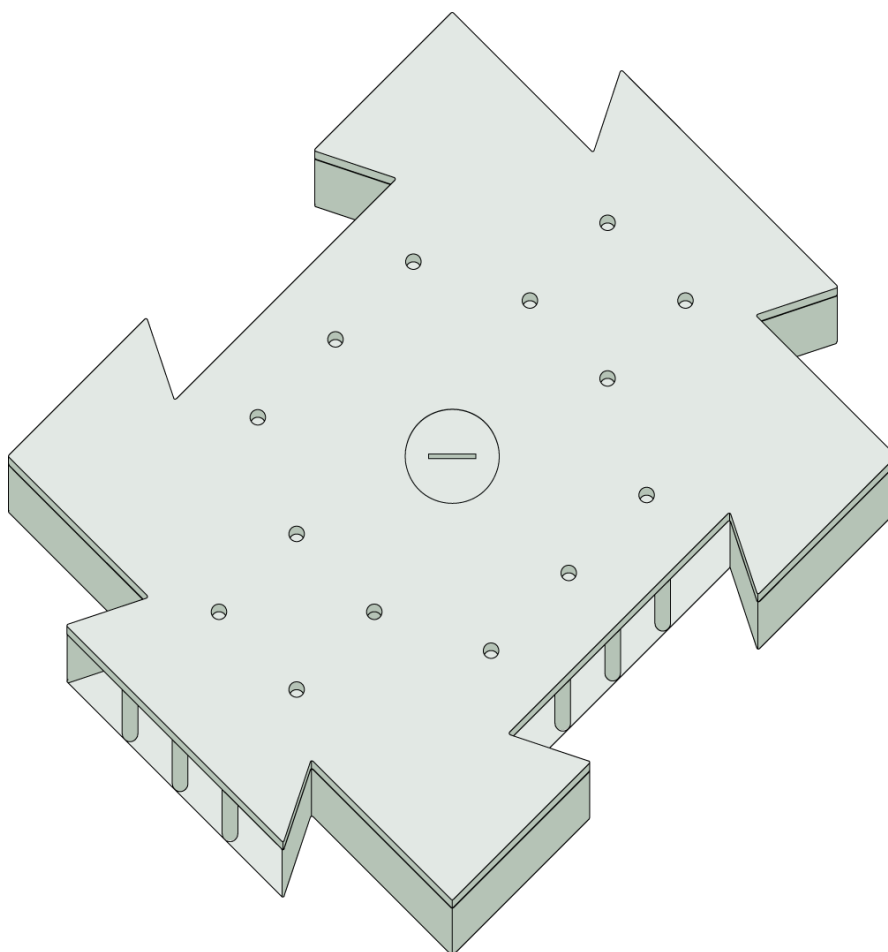
*Puzzle pavement kan enkelt flyttas.*

## Permeabel

En del av regnvattnet rinner genom skarvarna mellan plattorna, vilket fuktar den underliggande jorden och minskar risken för spridning av mer damm.



*En del vatten återgår till marken, vilket minskar spridning av damm.*



*De tre olika delar hopfogade till en platta.*



# Diskussion

Genom att arbeta med ett generellt koncept, har vi tagit fram en produkt som förbättrar förhållanden och det dagliga livet i informella bosättningar. Några aspekter som förbättras genom förslaget är att det hindrar spridning av damm, förbättrar vattenhanteringen och underlättar transport och orientering inom de informella bosättningarna. Om produkten puzzle pavement skulle användas på riktigt behöver den vidareutvecklas och anpassas. En förutsättning för genomförandet är även att invånarna i den informella bosättningen är engagerade och positiva till projektet.

Under processen har vi insett att avsaknaden av statligt engagemang och planering i informella bosättningar skapar en kreativ lucka som kan fyllas med den breda kunskapsbas landskapsarkitekter bär på. När landskapsarkitekter angriper de problem som finns i informella bosättningar är det dock viktigt att vara lyhörd och se till invånarnas behov, för att inte förbise existerande kvaliteter och fungerande strukturer.

Slutligen hoppas vi att vi genom detta arbete inspirerat landskapsarkitekter och andra inom kåren till att engagera sig i hur design kan skapa bättre förutsättningar för de boende i informella bosättningar.



Photo 3. © Agnes Djurberg

# Disposition

This thesis is divided into four different parts to simplify reader understanding of the work process leading to this document.

## Part 1

Introduction

The first part presents a background to the subject which targets the big picture regarding informal settlements. The purpose chapter of this thesis together with the research question and demarcations are also included in this part.

## Part 2

Methods

This part presents and explains what methods have been used to explore our research question.

## Part 3

Exploration of the subject

In this part we explore the subject by studying literature, by studying previous projects and by design. The literature combined with the previous project analysis forms a design program in which the design method takes its stand. The design method leads to a design process aimed at producing a competition submission.

## Part 4

Discussion

The last part is where discussions, reflections and further research are raised. In this part a critical review of our competition submission is carried out.

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# Part 1

## Introduction

The first part presents a background to the subject which targets the big picture regarding informal settlements. The purpose chapter of this thesis together with the research question and demarcations are also included in this part.



# Background

The world is becoming more and more urban. In 2014, 54 percent of the world's population lived in cities (UN 2014 p. 1). It is estimated that by the year of 2050, cities will come to house 66 percent of the world's population (UN 2014 p. 1). Almost two thirds of the world's population growth since 1950, have ended up in cities (Davis 2007 p. 11). From year 2000 to 2010, the developing world's urban population grew with 1.2 million inhabitants every week (UN-Habitat 2012a p. 28).

One example of the rapid urbanisation in the developing world can be seen in Lagos, Nigeria. Lagos had a population of about 300.000 in 1950 and in 2007 the population had increased to 13.5 million (Davis 2007 p. 16). This particular case of extreme urbanization is due to the expansion of multiple smaller cities into one large (Davis 2007 p. 16). Lagos is now a mega city, defined by UN as a city with more than 10 million inhabitants (United Nations 2014). Urbanization is often associated with mega cities around the world (Davis 2007 p. 17). The urbanisation trend affect all cities including the smaller ones (Davis 2007 p. 17). City growth is not only due to people moving to the city (Davis 2007 p. 17). As cities expand in area, they come to include adjacent towns and villages which leads to an even larger increase of city size and population (Davis 2007 p. 17). Life in urban settings is associated with higher standard of life, concerning, health, economics and services (UN 2014 p. 3). However, if the growth is unplanned and infrastructure is overlooked a sustainable urbanization is hard to reach (UN 2014 p. 3).

An example of the effects regarding rapid urbanization can be seen in the city of Dar es Salaam in Tanzania (Kileki Mrema 2008 p. 6). The inability to provide sufficient amount of surveyed and planned plots has caused a rapid increase in informal settlements (Kileki Mrema 2008 p. 6). Because of this rapid increase, the government has left high tolerance to the informal settlements during the last 40 years (Kileki Mrema 2008 p. 6). This shows how the informal settlements are in some cases becoming a regular and accepted phenomenon, even by their own government (Kileki Mrema 2008 p. 6).

Despite the acceptance of informal settlements, the opportunities to occupy land in closeness to cities has been reduced since 1990 (Davis 2007 p. 104). One reason is that speculative land investments in adjacent city areas has been a tremendously good investment and the interest in land investment is now higher for that reason (Davis 2007 Pp. 105). This blocks the opportunity for land occupation which is a common way of commencing a new informal settlement or expanding the surface of an already existing one (Davis 2007 Pp. 105). As the population increases at a higher rate than the area of the settlements, the problem concerning overcrowding increases (Davis 2007 Pp. 105).

Informal settlements can also occur because the formal options are so few for the poor and that city planning in many cases is too normative (UN-Habitat 2014 p. 6). City planners aim to satisfy the need for as many as possible and the biggest class of citizens is often the middle class (UN-Habitat 2014 p. 6). There is far more engagement of city planners in projects of an exclusive character than in projects for poor people. This distorted and unequal way of planning cities and housing has led to the rapid increase of informal settlements (UN-Habitat 2014 p. 6). There is data revealing that not all dwellers of informal settlements are poor, they are just not addressed by the city planning (UN-Habitat 2014 p. 6). Ultimately this means that more people than necessary need to live in informal settlements (UN-Habitat 2014 p. 6). 860 million people lived in informal settlements worldwide in the year of 2013 (UN-Habitat 2012b. NP). This number was acquired implementing UN-Habitats definition of a slum. According to this definition there are five parameters defining if an area is to be regarded as what they call a slum, these are;

- "1. Inadequate access to safe water
  2. Inadequate access to sanitation and infrastructure
  3. Poor structural quality of housing
  4. Overcrowding
  5. Insecure residential status"
- (UN-Habitat 2012b. NP)

To clarify the need for improvement in informal settlements one can compare the definition of slums stated by the UN-Habitat with the Universal Declaration of Human Rights (UN 1948). When comparing the documents, conflicts occurs. This means residents in slums to some extent lack human rights. For example article 21 (2) states "Everyone has the right to equal access to public service in his country." (UN 1948 p. 6). This contrasts to the definitions regarding the different availability to water, sanitation and infrastructure in slums relative to elsewhere in the country. Article 25 (1) states "Everyone has the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age or other lack of livelihood in circumstances beyond his control." (UN 1948 p. 7) This article directly and indirectly contrasts to parameter number one, two and three in the definition of a slum area as these are in fact parameters which affects the livelihood and are controlled by a secondary part. This comparison verifies the need of improvement in informal settlements.



The word slum is a vague term and is often associated with dismissal (UN-Habitat 2003 p. 9). The word has many secondary meanings and is in some cases seen as a political incorrect (UN-Habitat 2003 p. 9). The meaning can vary depending on what part of the world it is used in, and even in the same city the word can differ (UN-Habitat 2003 p. 9). In this thesis we use the term informal settlements instead of the term slum. This because of the many different associations and vagueness of the term.

We interpret that the attitude towards informal settlements programs have gone from clearance and resettlement programs to upgrading programs. The Government of Tanzania used clearing projects to handle the problem with informal settlements in Dar es Salaam (Kileki Mrema 2008 p. 8). The informal settlements were removed and new housings for the residents were built (Kileki Mrema 2008 p. 8). These projects were later abandoned in the late 60s, since it became apparent that the problem regarding the informal settlements was only relocated (Kileki Mrema 2008 p. 8). The new housing addressed at the dwellers of the informal settlement were too expensive for the people with low income (Kileki Mrema 2008 p. 8). After this failed program, the government replaced the slum clearance policy with upgrading programs (Kileki Mrema 2008 p. 8). The argument that clearing projects only leads to relocation of informal settlements is also present in the documentary *Slums: Cities of Tomorrow* (2013). During a visit to Raba, Morocco, no upgrading strategies were adopted which lead to a constant relocation of dwellers (*Slums: Cities of tomorrow* 2013). The new housings did not allow the residents to earn money through services within their homes, which immediately affected the informal economy and their ability to pay for rent (*Slums: Cities of tomorrow* 2013). Because of this, few people could afford to live in these buildings and were forced to move (*Slums: Cities of tomorrow* 2013). The World Bank (2008 p. 22) also argues for upgrading strategies. Investments should be aimed to enable residents of the informal settlements to help themselves to a better quality of life (World Bank 2008 p. 22).

Even though most agree on the success of upgrading strategies, some cities still have a tendency to evict residents of informal settlements by concealing slum clearance under the slogan of city improvement (Davis 2007 p. 115). An example of this is the green structure plan of Dheli (Davis 2007 p. 117). The government built a boardwalk and tourist attractions while simultaneously clearing the Yamuna Pushta slum (Davis 2007 p. 117). Even though a large amount of poor people were evicted and forced to move, the city board were applauded for their city improvements (Davis 2007 p. 117). An example of this is also highlighted in the documentary *Slumming it* (McCloud 2010). A new masterplan proposes clearing the area of Dharavi and replacing it with skyscrapers (McCloud 2010). A resident of the informal settlement, is asked what she thinks of the new masterplan and her response is that she and the majority of the residents prefer Dharavi the way it is, the only thing they lack is proper water and sewerage infrastructure (McCloud 2010).

One way of achieving upgrading in informal settlements is through idea competitions. These are often hosted by some sort of organization. Shelter Global is one of these organizations and they annually host the competition called DENCITY. The formation of this document takes stand in this competition. Shelter Global describe themselves as an "interdisciplinary not-for-profit organization focused on providing safe, clean living conditions for everyone." (Shelter Global 2017 b). In 2017 Shelter hosted their third annual DENCITY competition, with the goal set to improve slums through design (Shelter Global 2017 a). The instructions for the competition are stated in the competition brief which read as follows;

"[...] The intent of this competition is to foster new conceptual ideas about how to better handle the growing density of unplanned cities. Contestants should consider how design can empower communities and allow for a self-sufficient future.

For this years competition, the focus will be on improving living conditions in urban settings. There are no restrictions in regards to site, program, or size. Projects can be based on a specific urban location or a general concept. The object is to limit constraints and give participants the freedom to think in the most creative way possible [...]"

(Shelter Global 2017 a. NP)



## Intentions

Our purpose with this master thesis is to engage in how design can contribute to better streetscapes in informal settlements. This thesis aims to inspire landscape architects and other designers to involve in this matter. Our intention is to create a general design concept and through a small intervention improve the streetscapes of informal settlements. In order to explore this subject we formulated the following questions:

How can we design a concept concerning streetscapes in informal settlements within the framework of the idea competition DENCITY 2017?

What aspects need to be considered when landscape architects involve in the issues of informal settlements?

This thesis focuses on designing a general concept in an informal settlement and is therefore not tied to a specific geographic location. The geographic demarcation is rather a result of the possible implementation of our general concept.

The submission require one design proposal. The finished design proposal is presented in Appendix 1. Formalities limits the competition submission to be presented on two boards, it should also include one text document containing between 750 and 1000 words and a team biography.

# Part 2

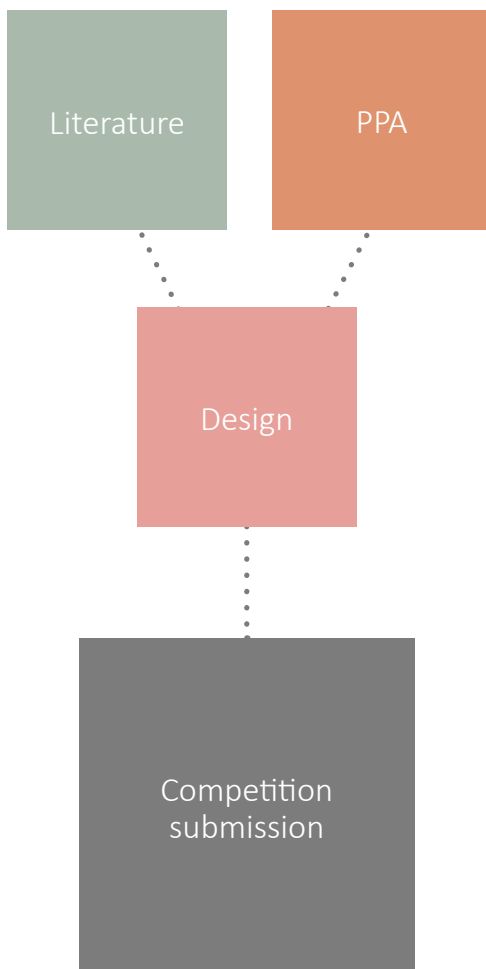
## Methods

This part presents and explains what methods have been used to explore our research question.



## Choice of methods

In this chapter, we describe the methods used to conduct this thesis and to reach a competition submission for DENCITY 2017. The methods were chosen in a pragmatic way. The methods were not determined in the beginning of this project, they were chosen and specified when needed. In our opinion design projects like this needs to develop over time, and therefore selecting suitable methods in advance is difficult.



*The figure illustrates the three methods used to reach a competition submission.*

## Literature and other media

The literature has served as a substitute for a place inventory and has provided a brief introduction to the subject of informal settlements. Literature was also used to contextualize our project in a bigger picture. The problem with studying literature instead of visiting a place is that it may result in generalizations, which can be problematic. What is a considerable aspect in some places may not be considerable in others. Studying literature instead of a physical place or a series of places may on the other hand improve our project in terms of the evidential basis it provides. Place inventories tend to be subjective as a single person to some extent interprets the real world from own experiences. The literature has often gone through a number of peer reviews meaning it is often more objective. The objective view is something that suits our project since the project goal is to design a general solution.

The literature helped canalize our project. Initially it was used to grasp the phenomenon of informal settlements. Multiple sources proved public space to be an important subject to address in informal settlements. Our literature study was therefore canalized to the subject of public space and streetscapes in particular. Our literature was not selected by any pre-defined criteria, other than it should help lead the project forward. Selection of literature was made from both personal judgement and recommendations. Different books, reports and written works were searched for and read when needed. When choosing literature in this way we do not make the claim of having done a full literature study. There are probably important written works which we have missed.

Apart from written work we have also studied documentaries. This has helped us get closer to the everyday life in different informal settlements. They have also showed examples of problems and aspects occurring in the presented informal settlements. Studying documentaries was used as supplement for interviews and site visits in informal settlements. We viewed documentaries of different characters. Some dealt with the phenomenon of informal settlements in general, showcasing different types of informal settlements worldwide. Other specialised in one particular informal settlement.

## Previous projects analysis (PPA)

Because our aim was to create a general concept, investigating previous projects from multiple locations constituted a tool to help us gather information on problem solving in different informal settlements. The PPA was also an insight to what made a successful competition submission. By studying the previous top three submissions of the competitions DENCITY 2015 (Shelter Global 2017c) and DENCITY 2016 (Shelter Global 2017d) we could extract ideas, approaches and inspiration on what type of intervention to use. Using several reference projects could be a way of revealing a common denominator. Since these proposals have been deemed promising by a jury, we expected them to be of high quality. The projects analysed might not be conducted with landscape architecture in focus, but could still supply valuable information.

To get a structure of our PPA and ensure that each project was analysed in the same way we formulated a template. The template contains five different questions which we seek answer by studying the previous projects.

### *What is the theme?*

Identifying the main theme could provide an overview of the project.

### *What is the target group?*

This question revealed what group of people the project saw as most important to aid.

### *What is the main problem?*

To understand how well the project solved the problem, the problem needed to be well presented.

### *A brief project summary.*

This is the part which showed the solution to the problem. It provided an insight to the idea and presented a summary of the project. This was necessary to fully understand the project.

### *What problem spaces, solutions, approaches and inspiration could be used in our competition submission?*

Points taken may improve our design program and therefore also our competition submission.

By finding recurring themes in the answers from the question "What problem spaces, solutions, approaches and inspiration can be used in our competition submission?" a number of categories could be identified. The PPA does not supply scientific facts as these analysed projects are part of a competition that does not require fact based entries. Instead this method is to be seen as a source of inspiration. The categories are presented in part 3, chapter PPA, table 1.

## Design as a method

In this work design was used as a method to explore our research questions. In the assignment stated in DENCITY 2017 the method is pre-determined as design. The method relates to and derives from both the literature and the PPA. Design as a method allowed us to find new ideas throughout the project. It also allowed us to evaluate the ideas by discussing, sketching, testing and brainstorming. The intention of using design as a method was not to reach a universal solution. The purpose of this exploration was to reach a possible design for a competition submission and to explore the subject of informal settlements. A design process seems to not follow any logical order which makes it difficult to explain and present to someone not involved. A design process is impossible to present before conducting it, therefore it will be further explained in part 3, exploration of the subject. However, we will now present our way of conducting this method in general.

Our first intention with this method was to create a good looking design. But since we participated in this particular competition, we discovered that design was not to be used to reach only aesthetic values. Because of this our way of using design as a method changed into focus on how to solve issues.

We were eager to use design as a way of solving problems but we realized that our first ideas were very difficult to implement in a real life case since they were based on our assumptions and prejudice. To be feasible, the ideas needed to be based on facts. According to research through designing, this stage relates to the constructivist approach.

To acquire the facts needed we used the literature method parallel to the design method. We focused our research in the literature to highlight problems concerning informal settlements. However these problems were often too comprehensive to tackle with one single design.

Since it was required in the competition to supply one design, we had to choose one problem space to address. We chose public space as our problem to address after we have found incentive for its importance in the literature. The literature tended to lead us to the advocacy/participatory approach of research through designing, since we were enlightened on the issues concerning informal settlements and trying to change them with the well-being of the residents in mind.



Public space was still too broad of a subject to take stand in to develop one design. Therefore we further channelized our problem space through literature studies to address streetscapes. Streetscapes would constitute our problem space but we needed to specify what work our intervention should do. Therefore we formulated a design program. The design program is derived from the results of the literature study and previous projects analysis. The design program summarizes our research in the form of bullet points to simplify implementation in our own competition submission. After the construction of the design program ideas relate to the positivist approach of research through designing. The ideas would be seen as hypotheses that could either correlate to the design program or not.

The many early ideas were categorized and funnelled into six different ideas which represented six different problem spaces. We took a decision to develop one of these ideas into our final competition submission. However we also tried to include as many aspects as possible from the other five. Puzzle pavement was the idea chosen for submission development.

In search of being scientific and aiming to explain as much as possible of the design process conducted in this thesis, we related our design process to the theories of Research through designing as stated by Sandra Lenzholzer, Ingrid Duchhart and Jusuck Koh (2013). This provides a scientific review of the design process set out to explain and make our personal and non-linear design process more transparent. Research through designing also provided a formal template to which we could relate our design process.

As there has been few formal templates for design projects to be academically feasible it has been hard to argue that design, and the design process is an academic method (Lenzholzer, Duchhart & Koh 2013). Research through designing is based on a literature analysis, trying to specify the different types of design methods commonly used in landscape architecture (Lenzholzer, Duchhart & Koh 2013). There are four characteristic approaches to design (Lenzholzer, Duchhart & Koh 2013), which are presented on the next page. In this project we have recognized ourselves in all four approaches, but they have been present at different times of our design process.



## Positivist

The positivist approach to design is a method that is classically scientific in the meaning that it aims to prove or dismiss a question or hypothesis (Lenzholzer, Duchhart & Koh 2013). An example of a positivist way of working with a landscape architect project may be asking questions such as: what is the optimum width of a bike path? The result is quantifiable and generalizable, however the result is not a full solution as it is not site specific (Lenzholzer, Duchhart & Koh 2013).

## Constructivist

The constructivist in research through designing strives towards creating something new (Lenzholzer, Duchhart & Koh 2013). It aims to make sense of a situation or phenomenon and the research is limited to one specific site (Lenzholzer, Duchhart & Koh 2013). The landscape architect's role is to be both the finder of the problem and the creator of the solution (Lenzholzer, Duchhart & Koh 2013). The solution is non-generalizable and the design process can be self-reflecting (Lenzholzer, Duchhart & Koh 2013). This approach is commonly used in architectural competitions and solutions developed by constructivism tend not to be 100% technically functional, as this is not the focus (Lenzholzer, Duchhart & Koh 2013). Focus is rather creating something unseen and new (Lenzholzer, Duchhart & Koh 2013).

## Advocacy/Participatory

Advocacy/Participatory research approach often aims for change (Lenzholzer, Duchhart & Koh 2013). The community or the users play a big role in this approach since they state the problem and define the framework for the design (Lenzholzer, Duchhart & Koh 2013). The landscape architect is an advisor rather than the ultimate designer in this case and the design outcome should often benefit the community (Lenzholzer, Duchhart & Koh 2013). Bottom-Up processes are common in Advocacy/Participatory research through designing (Lenzholzer, Duchhart & Koh 2013).

## Pragmatic

The pragmatic approach is when landscape architects do not decide on one of these research approaches (Lenzholzer, Duchhart & Koh 2013). Using all of the above stated approaches of research through designing, the pragmatic approach simply seeks what will work (Lenzholzer, Duchhart & Koh 2013). The pragmatic approach is not mere random mixing of the other approaches but implies that some projects may demand for the landscape architect to work with the methods parallel or sequential (Lenzholzer, Duchhart & Koh 2013).

# Part 3

## Exploration of the subject

In this part we explore the subject by studying literature, by studying previous projects and by design. The literature combined with the previous project analysis forms a design program in which the design method takes its stand. The design method leads to a design process aimed at producing a competition submission.



# Public space in informal settlements

Public space in informal settlements is the space that remains after the construction of homes (Kileki Mrema 2008 p. 24). The fact that an informal settlement is per UN-Habitat's definition overcrowded (UN-Habitat 2012b) and that most space is covered by houses gives reason to believe that the area of public space is very limited. UN-Habitat identifies the lack of public space as a typical characteristic for informal settlements (UN-Habitat 2015 p. 32). Because the land is often occupied either by housing for the residents or private use, there is little room left for public space and services (UN-Habitat 2015 p. 32). Even though the spaces are few, the existing public spaces are crowded and include a variety of different use (UN-Habitat 2015 p. 32).

UN-Habitat lists three categories of public space (UN-Habitat 2015 p. 27). The first category is called streets. Streets are not only roads and sidewalks, even if they are included in this category (UN-Habitat 2015 p. 27). This category also includes boulevards, avenues, squares, plazas, pavements, passages, galleries and bike paths (UN-Habitat 2015 p. 27). The second category is called public open spaces, they are defined as spaces that are not designed for transport (UN-Habitat 2015 p. 27). This category includes parks, gardens, playgrounds, public beaches, riverbanks and waterfronts (UN-Habitat 2015 p. 27). The third category is called public urban facilities, these are the buildings which the community owns together (UN-Habitat 2015 p. 27). Examples of this sort of facilities are, libraries, community centres, markets and sport facilities (UN-Habitat 2015 p. 27).

Regardless of category, public space is at its best when intended for everyone's use (UN-Habitat 2015 p. 15). Investing in public space means investing in the wealth of not a person or group but the community as a whole. This is because the public space belongs to all residents. This means everyone should be able to benefit from the investment (UN-Habitat 2015 p. 15).

Public space is sometimes referred to as the poor man's living room (UN-Habitat 2015 p. vii). We interpret that this probably relates to the limited living space in the actual indoor living room and its quality typically being very poor, the social activities are therefore moved. The streets are where social interaction, business and other daily essentials take place (UN-Habitat 2015 p. 32). Public space is important not only for transportation but also as a catalyst for socioeconomic development in informal settlements (UN-Habitat 2014 p. viii). Public spaces can therefore have an important role in informal settlements.

A properly designed public space can improve the neighbourhood life (UN-Habitat 2015 p. 32). Public space can also become a symbol of engagement in civic questions and pose as an important place for upgrading interventions (UN-Habitat 2015 p. 32).

Through developing and improving the public space, multiple benefits in a neighbourhood can be achieved (UN-Habitat 2015 p. 6). Better public health, higher democracy involvement, greater sense of safety and better economy are examples of benefits that can be reached (UN-Habitat 2015 p. 6).

Public space can serve as a substitute for formal shops and businesses (UN-Habitat 2015 p. 16). It can also provide a platform for informal economies (UN-Habitat 2015 p. 16). This is particularly important in informal settlements as small businesses and shops are often a part of an informal economy (UN-Habitat 2015 p. 16). This informal economy is sometimes required for poor people's income (UN-Habitat 2015 p. 16). In interviews with shop keepers close to public spaces, the public realm can become beneficial for people owning shops in the adjacent area (Kileki Mrema 2008 p. 71).

Public space in informal settlements supply a large variety of everyday activities, the same surface can be used for business, recreation, socializing, et cetera (Kileki Mrema 2008 p. 18). Due to the multi functionality of the public space in informal settlements, the public space proves to be an important factor in the everyday life of the dwellers (Kileki Mrema 2008 p. 25). Public space contributes with, health- and environmental benefits and social cohesion (Kileki Mrema 2008 p. 25). Therefore, there is a keen interest in upgrading the public space (Kileki Mrema 2008 p. 25).

Christian Werthmann (2009) also argues for the importance of involvement in public space in informal settlements. Public space is in high demand for outside intervention as it is often less developed compared to the surrounding built environment (Werthmann 2009 p. 35). As an example Werthmann describes that the dwellers living in favelas in Sao Paulo build their own houses, but are less keen to form the public space outside of their homes (Werthmann 2009 p. 35). He further argues that there is living proof of how landscape architecture can improve life in informal settlements (Werthmann 2009 p. 35). Giving public space the attention it needs through constructions of spaces such as plazas, sport fields and playgrounds, community life does develop in these new outdoor areas (Werthmann 2009 p. 35).



# Hazardous conditions

To avoid eviction and high rent due to speculation in land values, many informal settlements are located in hazardous areas, such as landfills, on soil exposed to erosion, flooding areas and so forth (Davis 2007 p. 140). When a natural disaster strikes, it is often the poorest people who suffer the most (Davis 2007 p. 143-144). Not only are their houses often located in the most exposed places, their houses are often those of the lowest standards, making them more vulnerable (Davis 2007 p. 143-144). We realize that not all informal settlements are located in hazardous areas. However, the fact that some are, provides a problem space for our further research. We have therefore studied the hazards and complication of not having paved streets in more detail. This is because streets are a part of the public space.

Road infrastructure is better in the developed world than in the developing world (UN-Habitat 2012a p. 52). Roads are important for transportation and connectivity in the city, but also constitutes the basis for other infrastructure such as sewerage and water supply (UN-Habitat 2012a p. 52). The development grade of the road network also has a positive effect on the entire economic system in a city, facilitating people and goods movement (UN-Habitat 2012a p. 52).

Paved streets in urban areas provide several services such as facilitating movement, providing better access and allowing for deliveries of commercial goods (Gonzalez-Navarro & Quintana-Domeque 2010 p. 256). There is often lack of paved roads in poor neighbourhoods in developing countries (Gonzalez-Navarro & Quintana-Domeque 2010 p. 254). The authors present an experiment in their report where several surveys were made in an unpaved informal settlement in Acayucan, Mexico (Gonzalez-Navarro & Quintana-Domeque 2010 p. 254). The location was then given proper paved roads and new surveys were given to the residents. The result concludes that by providing paved roads, several benefits can be achieved (Gonzalez-Navarro & Quintana-Domeque 2010 p. 256). An increase in property value and home improvements are some examples of observed positive effects (Gonzalez-Navarro & Quintana-Domeque 2010 p. 262-263). By providing public infrastructure in an informal settlement, material poverty can be reduced in an urban situation (Gonzalez-Navarro & Quintana-Domeque 2010 p. 255)

Sytse de Maat (2010) also argues for the negative effects of partially or non-paved roads in the informal settlement of Dharavi, Mumbai, India. Both traffic and other means of transportation are compromised and access to local shops are blocked, causing problems for the resident's daily routines (Sytse de Maat 2010). The author further claims that one of the big issues with unpaved roads are

the large amount of dirt and loose sand (Sytse de Maat 2010). During the nine months between the monsoon, dirt and sand is accumulated and everything in the informal settlements stays covered by a layer of dirty dust until it is washed away by the rain (Sytse de Maat 2010). A positive aspect of unpaved streets is that the soil manage to absorb great amounts of water during the monsoon season and therefore refilling the ground water levels, avoiding flooding of drains which is common in the paved city (Sytse de Maat 2010).

Dirt is not the only problem with unpaved streets, it also affects the health of the residents. The World Health Organization highlights this as a problem concerning air pollution in the developing world (WHO 2005 p. 59). Road dust is a factor in the problem regarding air pollution in the developing world (WHO 2005 p. 59). The re-swirling of road dust is dependent on the road surface, traffic load, wind and humidity (WHO 2005 p. 59). Another example where health issues related to dust is presented in the report *The Challenge of Slums- Global Report on Human Settlements* by UN-Habitat (2003). The report presents a case concerning an informal settlement in Nairobi where dust is pointed out as one of the problems (UN-Habitat 2003 p. 154). The situation is worst for women and children since they are in greater extent bound to the informal settlement in their daily lives (UN-Habitat 2003 p. 154).

## Landscape Architecture in informal settlements

Despite the fact that informal settlements are a problem that need to be addressed, few design professions take part in these questions or have knowledge of working with these issues (Werhmann 2009 p.35). The modern design education has not prepared today's generation of design students for designing in urban informal settlements (Werhmann 2009 p.35). This is a perception shared by Liberatus Kileki Mrema who argues that local architect students share little concern of architecture in the informal settlements. The main reason for this is that there are little or no work opportunities in these settlements (Kileki Mrema 2008 p. 16).

The architecture in informal settlements is a statement of what the residents want and need, and what they can achieve on their own (Kileki Mrema 2008 p. 36). What has not been addressed in the architecture is a proof of what the residents cannot deal with themselves, for these problems interventions from outside the area is needed (Kileki Mrema 2008 p. 36).

In the documentary *Slumming It*, Kevin McCloud (2010) visits Dharavi, Mumbai in India. A number of positive aspects about informal settlements is mentioned. The overcrowding does not only mean inconvenience but also provides a great platform for social interaction and a strong community feeling (McCloud 2010). Due to the informal economy, shops and small business are abundant (McCloud 2010). The architecture in the area is recognized by its flexibility and space efficiency, especially in public space (McCloud 2010). In a conversation about the redevelopment plan of Dharavi, one of the residents argues that the only thing this particular informal settlement needs is working and accessible sanitation and water infrastructure (McCloud 2010).

## Work processes within informal settlements

Streets and public space are important to link informal settlements to the surrounding city, rather than seeing them as isolated island of poverty and misery (UN-Habitat 2014 p. vii). By both upgrading and integrating the informal settlement with the surrounding city, future informal settlements can be avoided (UN-Habitat 2014 p. 2).

UN-Habitat (2014) proposes a way of improving the streetscapes in informal settlements through a strategy. This strategy is suitable for a step-by-step approach, with several different phases, instead of suggesting an already finished single phased plan (UN-Habitat 2014 p. 37.). The report suggests that by working in a phased manner, enhancement can be made gradually and thus keeping up with the capacity of the local government (UN-Habitat 2014 p. viii).

The high flexibility in informal settlements poses as one of the strongest characteristics (Kileki Mrema 2008 p. 10). Being able to adjust over time, in line with people's physical demands and social desires makes informal settlements into a dynamic and non-predetermined place (Kileki Mrema 2008 p. 10). These statement therefore strengthens the idea of working in a phased manner.

This is a summary of the results obtained from the method literature and other media.

- Importance of public space in general and streetscapes in particular

The literature has highlighted the importance of public space in informal settlements. The public space is often very limited but extensively used for many purposes which affects the entire neighbourhood.

- Importance of designer involvement

Since the architecture in informal settlements is a statement of what the residents need and what they can achieve on their own. What is desired but not in already in place is interventions that need outside designer involvement.

- Upgrading in step-by-step approach

Informal settlements has developed organically and high flexibility therefore poses as one of its characteristics. By implementing the upgrading intervention in a similar step-by-step manner the intervention can develop alongside the settlement and the capacity of the local government.

- Unpaved streets can be a problem

The literature highlighted that unpaved streets affects more than transportation. An upgrade of the streets can therefore have several secondary benefits.

- Documentaries

The documentaries highlighted that the overcrowding in informal settlements can be a positive aspect, since it provides a platform for social interaction. Some residents like to live in informal settlements, but upgrading is still needed to provide these people with decent services.



## Previous project analysis

This section presents the results obtained when applying the question template to the six chosen projects. The PPA is summarized in a table describing what approaches we found could contribute to our own competition submission. The table also reveals which project used which approach.

### Urukundo; Slum Factory, DENCITY 2015

*What is the theme?*

Infrastructure and service.

*What is the target group?*

The Urukundo original habitants.

*What is the main problem?*

Today there is a large pressure on “cleaning up” the area, instead of upgrading it.

Fragmented service and infrastructure.

The cultural heritage of the inhabitants are at risk.

*A brief project summary*

The team have taken their starting point in the existing clay cooperative, aiming to develop it. The goal is to expand it to a factory producing construction materials that can be used to build various element for the project. They divide their project into three different stages:

- Improve the clay cooperative, and build a training centre.
- Rebuild and improve the main road between the factory and the settlements. Collect the water runoff, filter it and use it for irrigation and other public services. Use metal gabions filled with waste material from the factory to build terraces. Provide new activity and service points along the main road to activate the street.
- Through education and work knowledge the techniques and materials from the factory will spread to be used in the personal dwellings of the residents. The factory can now also be used to produce other marketable products. This leads to new employments in secondary productions.

*What problem spaces, solutions, approaches and inspiration could be used in our competition submission?*

In this project, they aim at improving the main road.

By doing this they are working with public space as a condition for a successful project. They are using recycling and low-tech sustainability, e.g. waste materials in gabions. They are focusing on using local resources. Creating work opportunities through the project. The designers state that the project was based on daily problems of the inhabitants. The project is divided into multiple stages.

### Rio De Janero; Mapping, DENCITY 2015

*What is the theme?*

Mapping informal settlements and identifying location.

*What is the target group?*

People living in the informal settlements in Rio de Janeiro, land and building owners, the bureaucrats and visitors.

*What is the main problem?*

People of the informal settlements in Rio de Janeiro are not placed on the map and lack a physical address. Difficult to apply for loans or work. Difficult to direct emergency services to the right place.

*A brief project summary*

By using camera equipped kites, scanning painted barcodes on the ground of the informal settlements in Rio De Janeiro, the area is mapped, both physically and digitally. The produced maps work as a tool for locating and addressing other problems, such as drainage and sanitation. The maps allow residents to associate themselves with a location (address), becoming part of an online social network. Having an address help people with issues that have been problematic for the residents, such as paying bills, applying for jobs and bank loans.

*What problem spaces, solutions, approaches and inspiration could be used in our competition submission?*

Identity is an important factor to be able to feel that you belong. Giving streets and public places an identity, help with orientation, not only for the residents but also for people outside of the informal settlements. The project aims to simplify the daily life of the residents.

## Agua Común-ity: Common Water, DENCITY 2015

*What is the theme?*

Water management and strengthening resident identity

*What is the target group?*

The residents of Manchay

*What is the main problem?*

They state three different issues:

- Water distribution – Each house access water by a water truck that makes multiple stops in difficult terrain. Water is only delivered weekly. The water is then stored in tanks on the backside of the house.
- Water security – Since water is stored on the backside of the house, water theft is an issue during nights.
- Lack of water recycling – Grey water is not recycled or reused.

*A brief project summary*

Water supply has become a class issue. It separates the residents in to two groups; those who can only afford to use water for nutritional needs and those who can also use it for irrigation. This particular ethnic group was forced to move from the green landscape of the Andes, to the desert like landscape of Manchay. The people have been deprived of their history and their economic situation decides whether they can grow their own plants near their house. The team proposes a water plant at the top of the hill on which the village is located. The water truck can now deliver water to one location. From the water plant, main pipes are vertically drawn down the hill and secondary pipes are horizontal, delivering water to each house. Grey water ends up in a sand filtration module built from the old water tanks. The filtered water is then led to a newly built roof on the house below. This allows cooling for the house and finally the water drips down on a planting box.

*What problem spaces, solutions, approaches and inspiration could be used in our competition submission?*

The team shows great respect for the existing physical environment. The team implements engineering through architecture in a simple way. The use of gravity offers free work and can be seen as a take on low-tech sustainability.

## Versova Koliwada, DENCITY 2016

*What is the theme?*

Aquaculture

*What is the target group?*

The Versova village residents and surrounding city.

*What is the main problem?*

Pollution, mainly from plastic debris in the Oshiwara river. Decrease in fish population, affecting the villagers business. Loss of heritage knowledge.

*A brief project summary*

The team have divided the project into four different phases;

Phase one – Knowledge and training centre that tackles the problem of lost knowledge in constructing fishing nets. Knowledge of the net weavers are used to build a water filter system. The water filter system collects plastic and part of the debris is used to build floating rafts, the rest is sent to recycling.

Phase two- Larger floating fishing farming pods are also created with plastic waste and fishnet. These are used to increase the production of fish.

Phase tree – Using rainwater management, they aim to recharge dried out wells and also filling an inland aquaculture. In this phase a fish market is built to expand the business and is a first step towards integrating Versova with the rest of Mumbai.

Phase four – Introduces a fish processing unit, aiming to sell products instead of unprocessed products. This includes a restaurant, aquarium and information centre. The last phase aims to further integrate Versova with Mumbai.

*What problem spaces, solutions, approaches and inspiration could be used in our competition submission?*

Structure project in different phases and show development over time. Reusing and recycling waste material. Integrate the informal settlement to the surrounding town. Use and spread available knowledge.

## Incremental Alex, DENCITY 2016

*What is the theme?*

Housing and infrastructure strategies.

*What is the target group?*

Residents of Alexandra, people currently awaiting housing.

*What is the main problem?*

The Reconstruction and development program, RDP, (The governmental strategy) has not worked, it has led to construction and secondary rent of shacks in-between the formal houses. This because the RDP houses are too expensive.

*A brief project summary*

The first proposed step is to reallocate the existing funds, instead of building houses the money should be used for infrastructure. When the infrastructure is in place, the team proposes a new incremental modular housing system. The team suggests setting up the basic walls, containing the infrastructure. The house can then be developed at any time by the residents using any material of choice. The creation of a building development manual for the residents helps the residents to understand how they can further build their homes. The final step is to limit the expansion of housing in the area, not set to rise above 75%, leaving 25% of the area as public space.

*What problem spaces, solutions, approaches and inspiration could be used in our competition submission?*

This project is based on incremental stages, not only in the housebuilding itself but also in the fact that they address the need for infrastructure as a first step. They leave the actual work to be done by the people living in the area. This is the most economical solution as no one needs to be hired for the work. The fact that the houses are built by the residents themselves would also generate a sense of ownership, making people more aware and conscious of their homes and the area.

## Allometric sake, DENCITY 2016

*What is the theme?*

Ventilation and thermal comfort.

*What is the target group?*

Slum dwellers in Cairo, Egypt.

*What is the main problem?*

Thermal comfort is a problem in the hot climate of Cairo, especially in the denseness of the slum areas, as the air here is more likely to be still. The ventilation today is inefficient.

*A brief project summary*

By applying three types of thermodynamic relations, the team has come up with three types of ventilation strategies for three types of buildings. The software SAKE helps dwellers to construct a suitable solution for their home.

*What problem spaces, solutions, approaches and inspiration could be used in our competition submission?*

They have used local building techniques and materials.

The result of the previous project analysis is presented in the table below.

	Urukundo: Slum- factory	Rio de Janeiro: Mapping	Agua Común- ity: Common Water	Versova Koliwada	Incremental Alex	Allometric Sake
Low-tech sustainability	X			X		
Recycling	X			X		
Use of local resources	X			X	X	X
Residential involvement	X	X		X	X	X
Solving daily problems	X	X	X			X
Multistage	X			X	X	
Respect for the existing			X			
Identity creating		X		X		
Improving public space	X	X		X		

Table 1. This table summarizes what of the previous projects can be implemented in our design.

From the previous project analysis we concluded nine approaches which has been successful in the competitions DENCITY 2015 and DENCITY 2016.

- Low tech sustainability  
Reaching sustainable processes without needing advanced technological equipment. This approach supply inexpensive solutions and easy implementation.
- Recycling  
Reuse of existing materials keeps costs down and contributes with a clean-up process.
- Use of local resources  
Using existing resources to greatest extent possible mitigates costs and transports.
- Residential involvement  
Might strengthen the community engagement. Residents holds great knowledge of the area.
- Solving daily problems  
Interventions which targets often occurring problems can contribute to a positive change in the daily life of the residents.
- Multistage  
By dividing the intervention into different stages solutions acquire more flexibility.
- Respect for the existing  
Accepting and using the existing structures often leads to a better holistic solution.
- Identity creating  
Can strengthen the community feeling.
- Improving public space  
Public space interventions has the ability to improve the whole surrounding society.

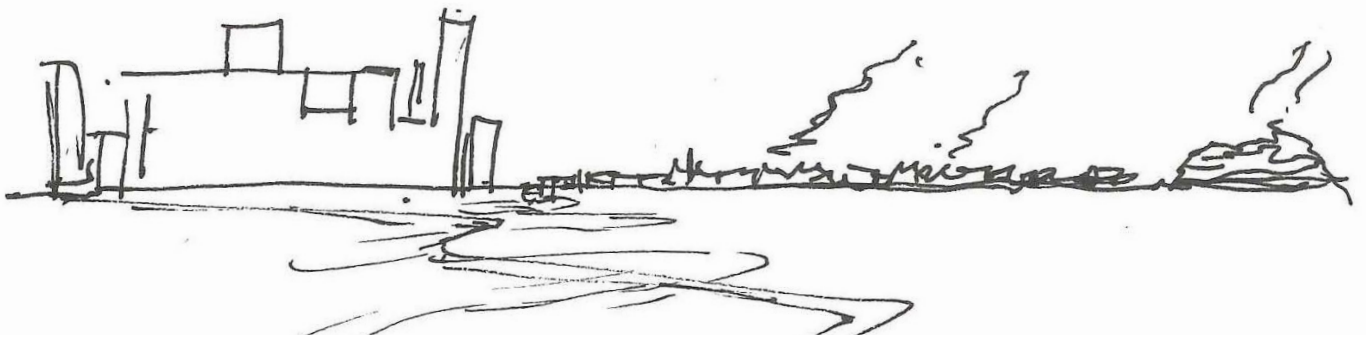
# Design

This chapter reveals the results of our design method and how different decisions have evolved to a final competition submission. By relating our design method to the theory of research through designing, we can refer to what type of design approach occurred at what stage. First we describe our process in chronological order and present how our focus has changed during time. Secondly, after finding our final idea, we thematically present how we constructed our final design for our competition submission. The full competition submission is presented in appendix 1.

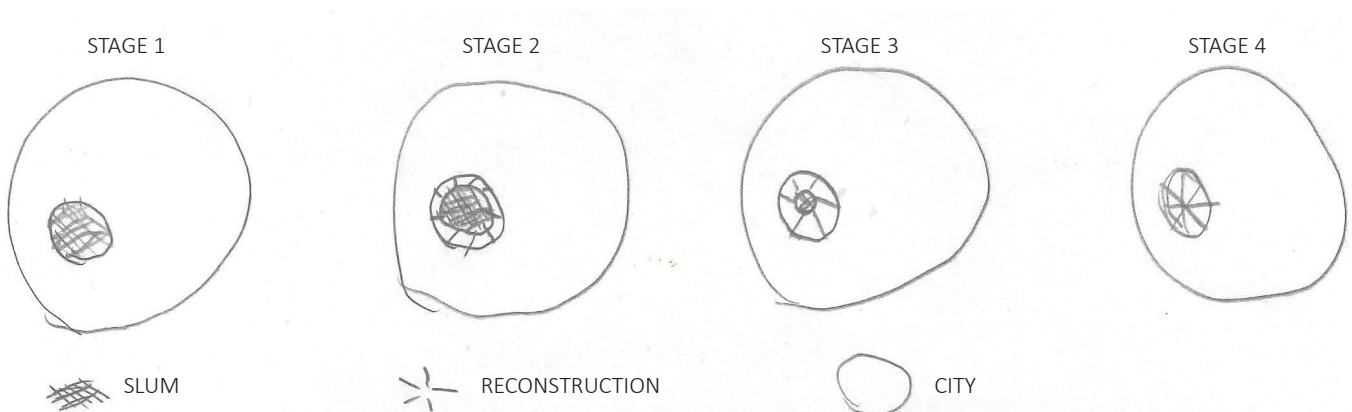
## Early sketches

When we entered the competition DENCITY 2017, we immediately started thinking of possible problems and solutions related to informal settlements. We did not limit ourselves at this stage but instead tried to develop as many ideas as possible, a few of them are presented here. Most of these early ideas were created using our assumptions and prejudice of informal settlement and in many cases they did not relate to facts. They were therefore irrelevant and discarded. As we began studying literature we noticed the literature often emphasised big structural problems such as lack of safe water, sanitation, economics, housing, eviction, crime, resident safety, governmental attitudes and so forth. Therefore we focused on solving these big issues.

During this phase of the project our idea of an informal settlement was that it would be located adjacent, or in direct closeness to a larger formal city, as seen in sketch 1. This was a conception that remained when we developed further ideas, it was also a requirement stated in the competition that the submissions should focus on urban informal settlements. One of the issues that needed to be solved to reach an upgrading of the informal settlement was how the border between the informal settlement and the city could be erased. A concept aimed towards this is presented in sketch 2, where the informal settlement would be included in the city in four steps. The informal settlement would be economically supported and through reconstruction it would become a part of the city. The question that needed to be answered was how this would be carried out and how design could contribute. This particular idea was not developed any further but the concept of upgrading in different steps, and integrating the informal parts with the formal parts of a city influenced our later ideas.



*Sketch 1. This sketch shows our interpretation of a typical urban informal settlement adjacent to a larger city. This conception remained important in our following design process.*

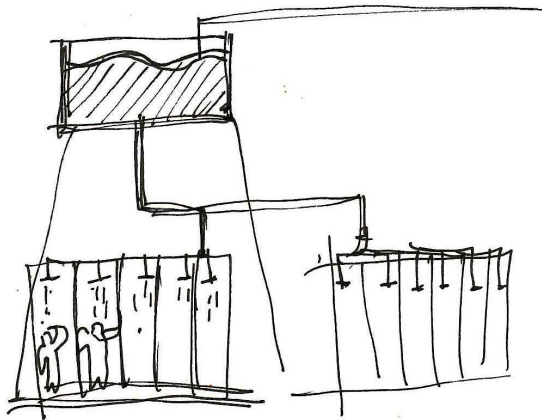


*Sketch 2. A concept in four steps where an informal settlement gradually is economically supported and included in the adjacent city.*



Most of our early ideas relates to the constructivist approach in the theories of research through designing. The fact that we stated both the problem and the solution, and that many of the ideas were not technically feasible invokes this approach. We discovered that these big problems, lack of safe water, sanitation, economics, housing, eviction, crime, resident safety, governmental attitudes and so forth, were beyond our control and would require both political and financial involvement. This meant we could not develop these ideas into a competition submission, these issues are hard to address by design and the predetermined method to be used in the competition was design.

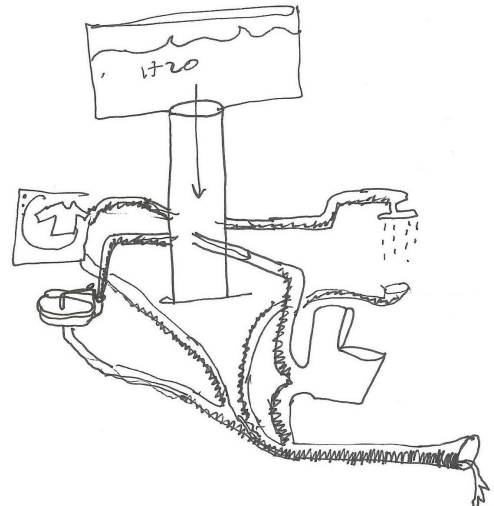
Our focus changed to finding one main problem. But it was not clear at this time what this one problem might be. At this stage our focus aimed to change things for the residents to the better. Being advisors rather than designing landscape architects. Therefore this part relates to the advocacy/participatory approach of research through designing.



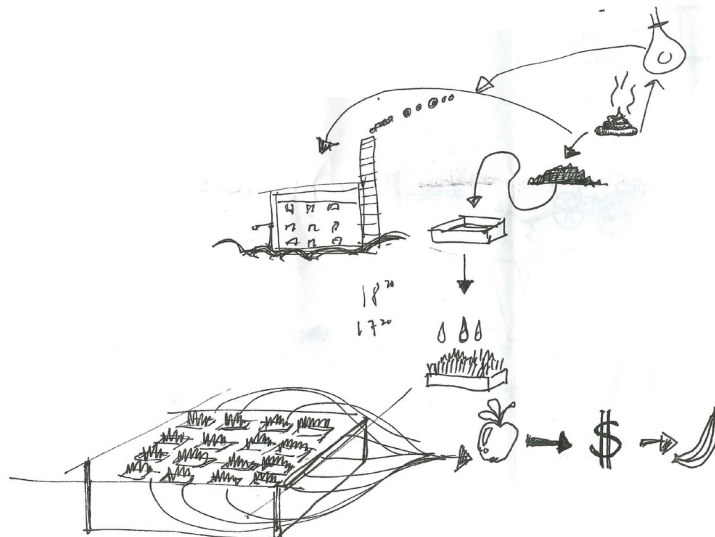
Sketch 3. Describing an idea where collected rainwater could be reused in showers.

One early idea was to collect and use rainwater to supply a multifunctional sanitary module. Rainwater would be collected and used for showers, laundry and restrooms, shown in sketch 3 and 4. This was an idea we did not further develop since focus would probably have been on how to solve all the technical features of the module and therefore be a case for an engineer rather than a landscape architect. We also found it difficult to develop into a design related to landscape architecture. However, the idea of dealing with the issues of water and reusing rainwater was something that affected our final design.

Another idea we had in an early stage was to try to handle the issues of sanitation. This is described in sketch 5, where excrement would be collected and transformed into nutrient rich soil. The idea was that this soil would be used as fertilizer allowing for cultivation. The fruits and vegetables grown here could be used for peoples own consumption or be sold, allowing residents to make a profit. This idea turned out to be more of a principle but the idea of developing this into a design remained.



Sketch 4. An other example of a multifunctional sanitary module where several different services would be supplied by rainwater. Collecting rainwater was an idea that continued in our design process.

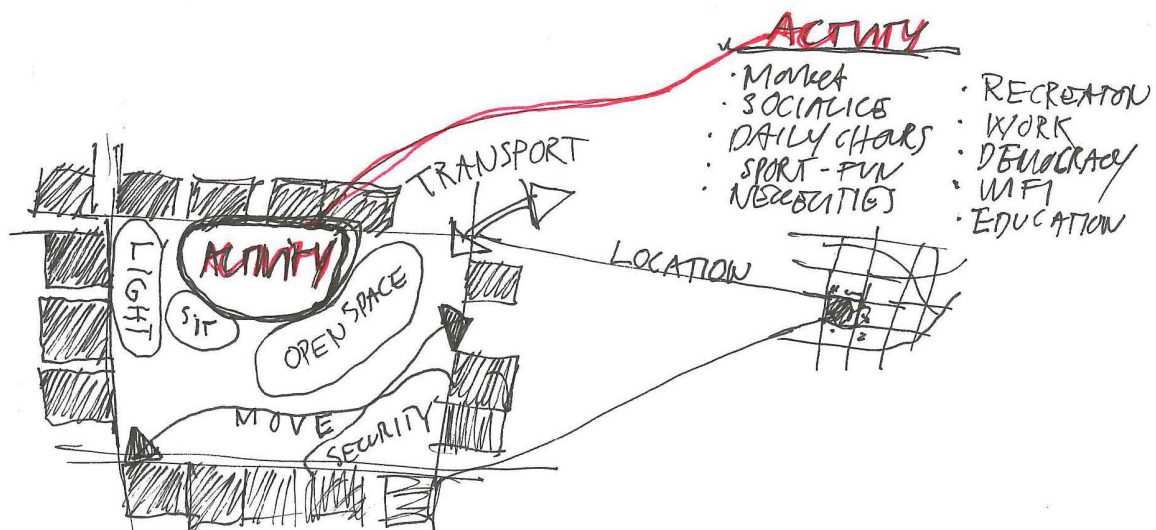


Sketch 5. Depicting a process where excrements could be used as fertilizer, allowing for cultivation and the possibility for residents to earn money. This idea was further developed in to one of the six final ideas.

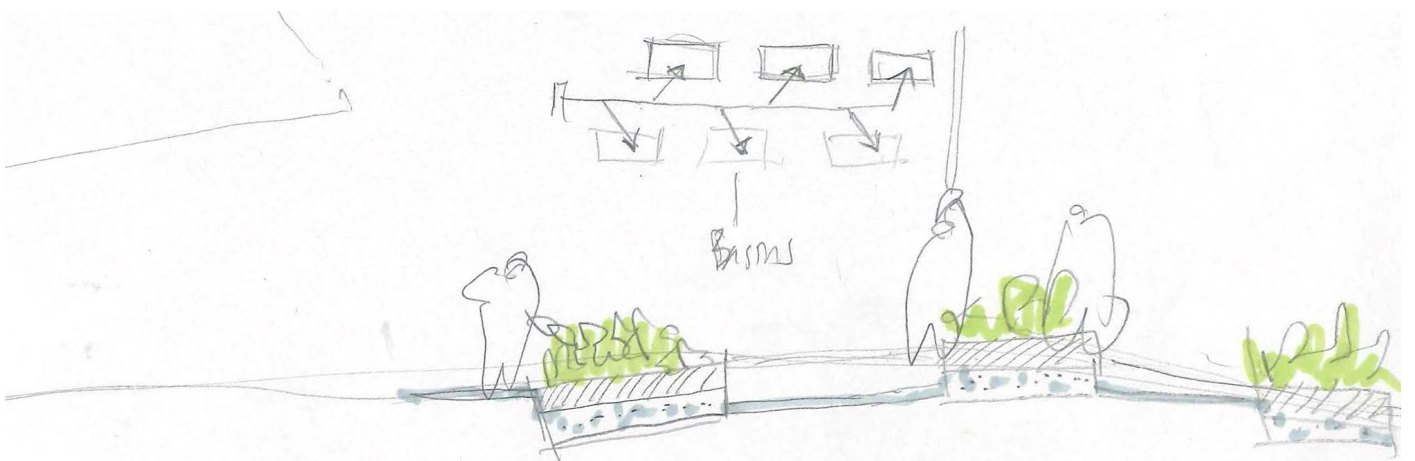
We realized most of our ideas was aimed at serving the entire community and that most of them were placed in the public realm. Therefore we found public space to be a subject that interested us, it was also a fields strongly related to landscape architecture. Research from our other methods also proved it to be an important aspect in informal settlement development. The idea of working with public space is something that we retained through our work and came to be the one main problem space we addressed.

The literature claimed that public space in informal settlements was multifunctional. To be able to understand the many activities that could be carried out in the public space in an informal settlement we created a simple sketch, sketch 6. This sketch provided us with ideas of what types of activities that could be carried out in the public space of informal settlements. It was also a way for us to understand that public space is a large subject including many different categories.

Influences from some of our earlier ideas of using rainwater can be seen in sketch 7, where planting boxes are placed in the public space. The rainwater would be led to irrigate the plants. By repeating this process the water could gradually be filtered. In the final stage, clean water could be extracted. Using plants that could produce vegetables and fruit also relates to some of our earlier described ideas. Locating the project in the public space created further questions. Who owns the plants? And who has the right to harvest the fruit?



Sketch 6. Proposal of different activities that could be carried out in the public realm of informal settlements.



Sketch 7. This sketch shows an idea of how water could be filtered and used for irrigation. The harvest from the plants could be used by the residents.

Even though we had settled on public space to be the main problem, our ideas differed very much from each other and it was therefore hard to choose a path for our future design work. To canalize our future design process we decided to formulate a design program. The design program is derived from the results of the literature study and previous projects analysis. It constitutes the foundation for our design process from this point on. The design program summarizes our research in the form of bullet points.

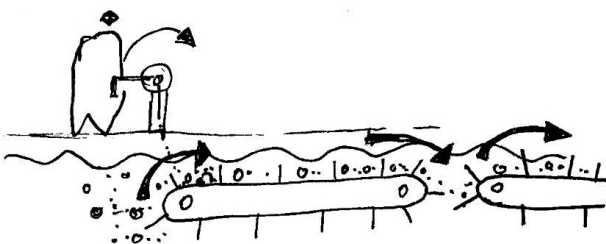
## Design program

- Solve daily problems by improving the streetscape in informal settlements.
- Strive for smallest possible economic and ecological footprint.
- Engage the local residents in order to create a sense of ownership, identity and reduce risk of interfering with existing structures.
- Aim to create a flexible solution through a multistage implementation.

## Six ideas

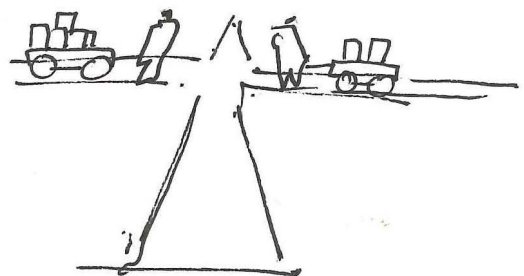
From our design program we developed six different ideas for a competition submission. The six different ideas represents six different approaches to answer to the design program. The ideas were chosen and developed by trying to compile our early sketches into possible concepts.

The first idea was called Open sewer travelator, depicted in sketch 8. The idea was to install manually operated travelators in the open sewers of the informal settlement. This would allow waste to be transported to one point where it later could be managed.



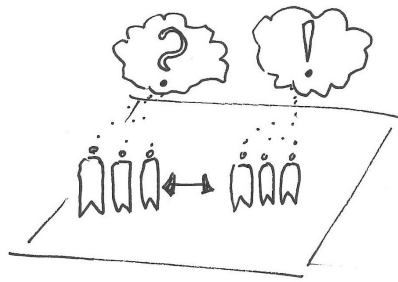
Sketch 8. Open sewer travelator. This was an idea with the goal to shovel the waste in the informal settlement to a predetermined point.

The second idea was called Making the slum roll depicted in sketch 9. The goal was to create better transportation routes within the informal settlement. This would be conducted by partially paving the roads using locally acquired materials. The idea would include a wagon facilitating transport of items and goods. The paved part of the road could have different colours for easier orientation.



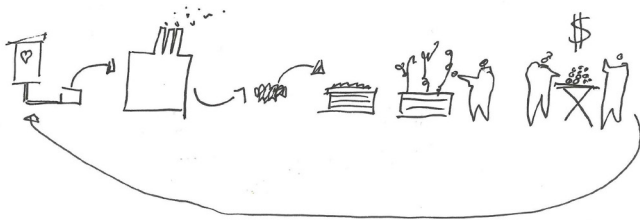
Sketch 9. Making the slum roll. The aim of this idea was to make transport more efficient in the informal settlement, using pavement and simple vehicles.

The third idea was Analogue linked in and can be seen in sketch . This idea aimed to create a public space where employers could meet potential employees, thereby creating work opportunities. This idea could also contribute to a local economy.



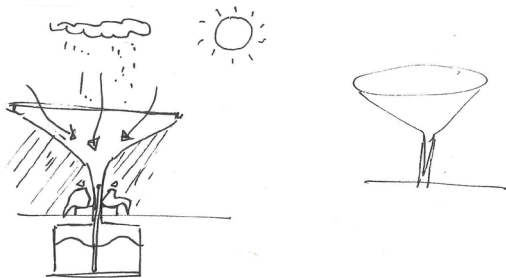
Sketch 10. Analogue linked-in. This idea aimed to connect employers with possible employees in public space.

The fourth idea was called Use excrement, grow plants. By transforming excrement into nutrient rich soil, crops could be grown within the informal settlement. The harvest could then be used for own consumption or sold. the chain of events included in this idea is depicted in sketch 11.



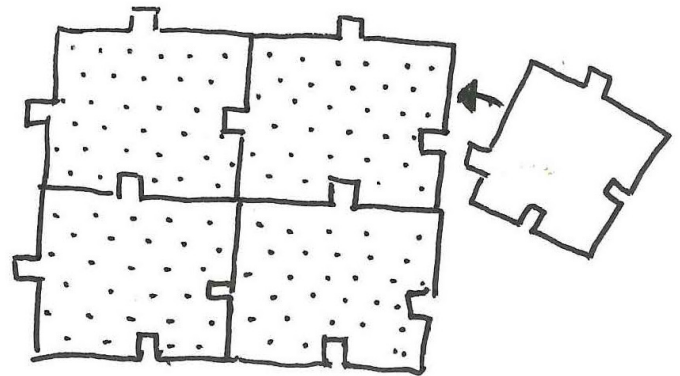
Sketch 11. Use excrements, grow plants. This idea used excrements which would be turned into nutrient rich soil. Plants grown in the soil could be sold or used for own consumption.

The fifth idea was Shade and water collecting cover seen in sketch 12. This idea aimed to create a module placed in public space, providing shade and collecting water.



Sketch 12. Shade and water collecting cover. This construction collects water and provides shade. The construction could be manually adjusted to different sizes.

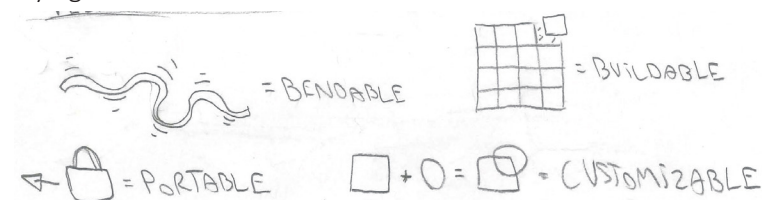
Our last idea was Puzzle pavement seen in sketch 13. This idea used a puzzle shaped slab to pave the streets in informal settlements. The slab would improve transport and air quality by reducing the amount of dust in the air. The slab should also be permeable, letting rain water drain through the slab.



Sketch 13. Puzzle pavement. This is a puzzle shaped slab used to pave the public space in informal settlements currently lacking pavement.

We decided to develop the Puzzle pavement idea to be our competition submission. But we also included aspects from the other five ideas. Examples of included aspects from the five other ideas were, residential involvement, water collection, better orientation using different colours of the streets, income opportunities and to create a sense of community. The decision of further developing puzzle pavement canalized our focus from public space to streetscapes. Our final purpose and research question was determined at this point.

The more familiar we got with the subject of streetscapes in informal settlements, the more we understood what our best contribution could be. Research regarding the problematics of unpaved roads in informal settlements also supported puzzle pavement. The decision to continue working with the puzzle pavement, combined with the fact that our project was non site specific lead us to work in a product development manner. We discovered that the ideas we preferred and were most suitable for implementation were those where we designed a product. By designing a product that was flexible and adaptable to various areas, we overcame the problem of not being site specific, an example of how to deal with this can be seen in sketch 14. The products functions would decide where the product could be implemented. This stage relates to the pragmatic approach of research through designing. We were simply trying to find what worked in the current situation.



Sketch 14. An initial sketch of how to work in a product development manner with flexible solutions, which has no need for a specific site.

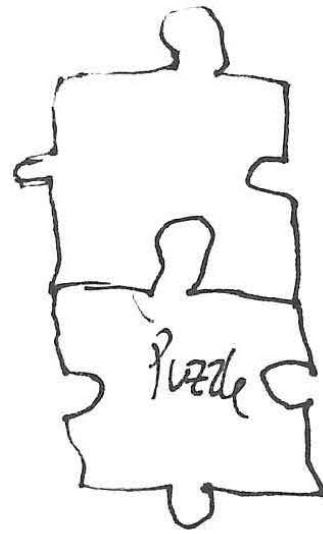


# Puzzle pavement

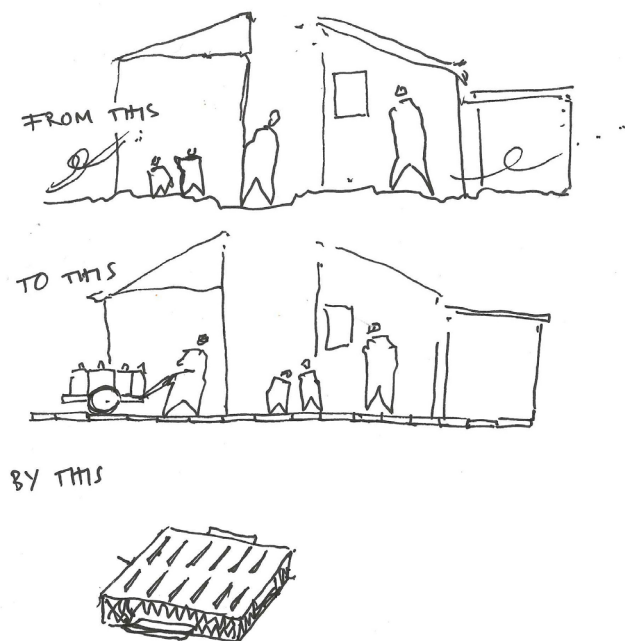
The idea was set out to improve the streetscapes in informal settlements currently lacking clean and functional streets. By studying literature we could also conclude that the product could address several other problems regarding streetscapes in informal settlements. Some of the problems which we addressed were erosion, air pollution from dust and water management.

From the point that our main concept was determined, our approach to designing remained mostly pragmatic since we worked parallel with the different approaches of research through designing. We were still trying to anchor some of our decisions based on research which relates to the positivist approach, this can be seen in sketch 17. We also aimed to change things for the residents therefore being advocacy/participatory, see sketch 15. We also wanted our product to be new and innovative, to make a good submission to the competition. We were therefore constructivistic, see sketch 16.

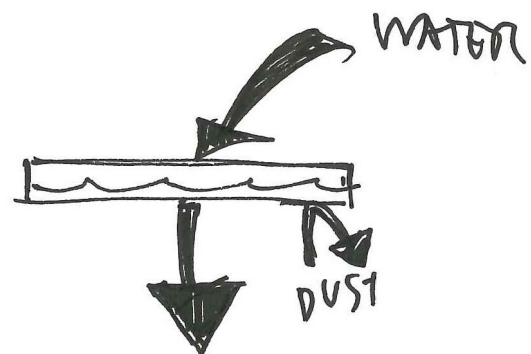
From now on the design process is no longer presented in chronological order. By thematically describing the design process we can present different features of puzzle pavement in a more comprehensible way.



Sketch 16. Puzzle pavement should make use of a puzzle in a new way, allowing for high flexibility and creativity.



Sketch 15. A sketch illustrating the positive effect on the residents when implementing the puzzle pavement in unpaved informal settlements.



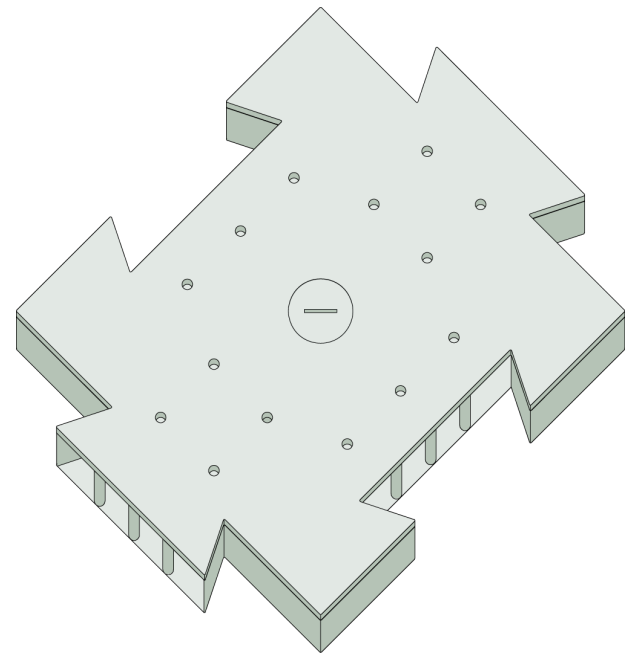
Sketch 17. The puzzle pavement would prevent dust spread and manage rain water. These are features directly derived from research which has shown that both water and dust can be a problem connected to unpaved streets.

To be able to better grasp what the puzzle pavement should achieve in the streetscape we defined key functions that should be incorporated into the construction. This would then work as boxes to tick when designing the product.

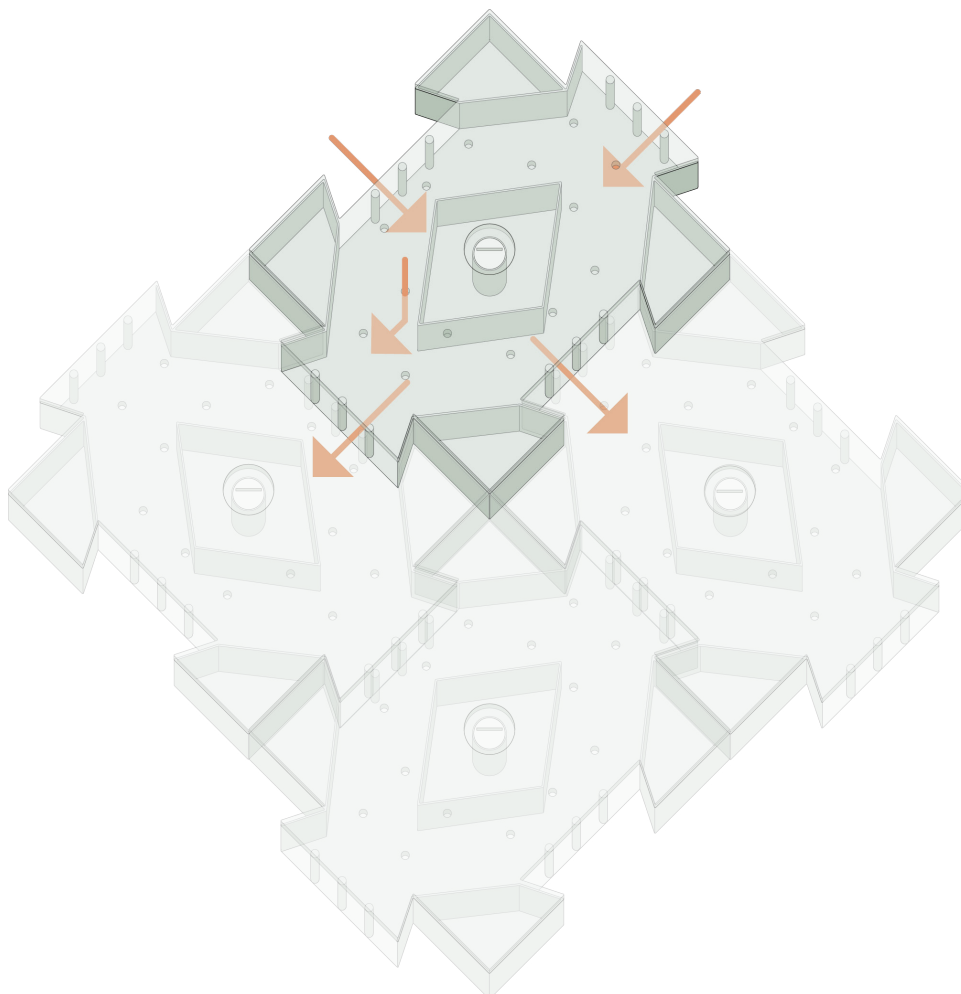
- Manage water – The pavement should be able to manage water runoff. This water could later be reused.
- Affordable material – The production of the pavement should be affordable. Preferably the material should also be made out of recycled or local materials.
- Durable – The pavement should be able to handle pressure from both pedestrians and lighter vehicles.
- Easy assembly – Simplicity when combining the different pieces with each other. The size and shape of the slab should be suitable for simple assembly and material efficiency.
- Different appearance – by using different colours of the pavement, streets could easily be recognized. This could provide better orientation and allow people to associate themselves with different areas.
- Prevent dust in air – By covering the existing exposed dirt roads, the pavement could mitigate the spread of dust into the air and help improve the air quality.
- Placed anywhere – The slabs should be able to be fitted almost anywhere.
- Locally produced – Producing the slabs locally minimize cost and generates work and income opportunities for people living in the informal settlements.
- Ease of transport – The pavement supplies a flat surface which facilitates and make transport safer.
- Slow down erosion – The slabs could slow down the speed of water during heavy rainfall and therefore reducing the risk of erosion on the existing dirt streets.
- Possible to relocate – One indirect goal for the puzzle pavement is to consolidate informal settlements in order to erase the border between informal and formal parts of one city. If this would happen the informal settlement could be paved with ordinary pavement, replacing the puzzle pavement. If this happens the puzzle slabs could be relocated to another informal settlement where it is needed.
- Be permeable – Apart from transporting water, part of the rainwater during rainfall would drain through the joints in to the underlying dirt. This would reduce the risk of over flooding and moisten the dirt, preventing airborne dust.

These functions consider the puzzle pavement itself, but more functions are needed in order to make it a good product. In our competition submission we would also need to formulate a way of implementing the puzzle pavement and therefore address social aspects and functions, who does what and when? Therefore we came to include a scenario where we present one way of how the puzzle pavement can reach its full potential. This addresses the social aspects and functions. The scenario is however only hopes and guesses, as we cannot know for sure how the puzzle pavement will be received and perceived by the residents. The scenario can be seen in the competition submission in appendix 1.

In illustration 1 and 2 you can see the final design of the puzzle pavement. But to know how we reached this design and how it fulfils the previously stated functions the following chapter describes how we reasoned and what descriptions were made to incorporate each function.



*Illustration 1. Our final design of the slab.*



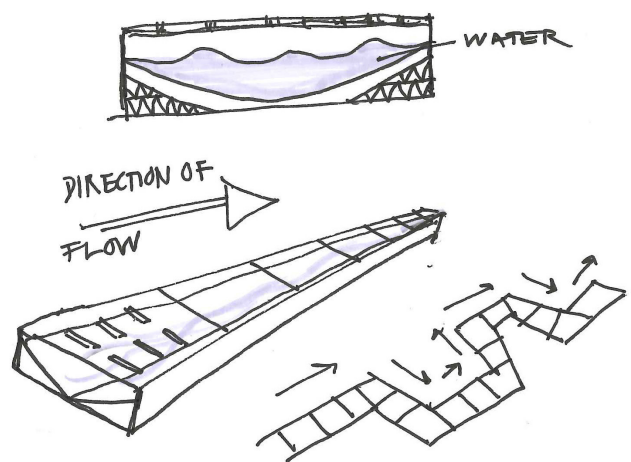
*Illustration 2. The connected slabs create a network of internal channels. Arrows indicate movement of water.*

## Manage Water

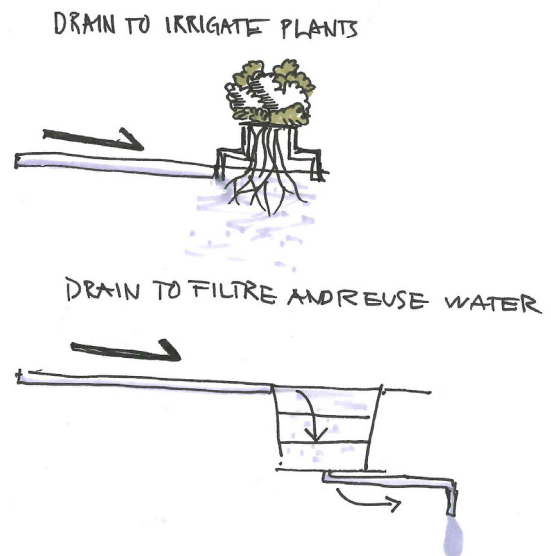
For the puzzle pavement to be able to manage rainwater, we explored ways of transporting water inside the puzzle slabs through sketching and digitally drawing one example of this can be seen in sketch 18. This resulted in a design with internal channels that would direct the water. By connecting the slabs, the channels would also connect, letting the water flow in the direction of the topography. The connected slabs create a network of channels. The water would need to be collected at some point. Cisterns underneath the ground, located low points could collect the water. How the water would be used after this point is for the residents to decide. Water could be lead to plants and provide immediate irrigation. Plants grown here could be used for harvesting fruit and vegetables. The use of the water is depicted in sketch 18.

For the water to enter the slabs and the water channel, holes needed to be placed in the top surface. We conducted an experiment to decide on the size and number of holes needed. One hole with the diameter of 10mm created a water flow of approximately 0,032l/s. Using 14 holes would therefore give the slab an ability to drain water at a rate of approximately 0,448l/s. This number is expected to be greater since some of the water will drain through the joints of the slab. Some of the water would also drain into the underlying soil. The measured results was obtained using a bucket with drilled holes  $\varnothing 10\text{mm}$ , measuring the time it took for one litre of water to drain. How much rain can infiltrate into the slab is dependent on the intensity of the rain. We reckon the slab would manage moderate rainfall good. Heavier rain might be a problem for infiltration.

DRAIN SLABS?



Sketch 18. Sketch depicting one of the options tested of how the slabs would direct water through internal channels.

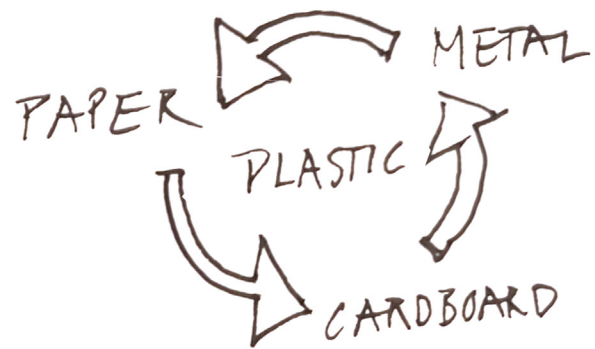


Sketch 18. Water could either be stored or used for immediate irrigation.



## Affordable material

When deciding on what type of material to use we looked back to our design program. One of our criteria stated is that we should strive for smallest possible economic and ecological footprint. At first we wanted to use whatever material that was available where implementation occurred. However, this proved to be more difficult since the choice of material would inevitably influence the design and construction. If the material was not specified, we could not continue with our design. We wanted our material to be recyclable, sketch 19 shows some of the materials considered.



Sketch 19. Different recyclable materials where considered when choosing material for the slab.

The material we finally chose was plastic. This would allow us to develop our design from the properties of plastic. From knowledge we had pre hand this project we knew plastic can be recycled and transformed into new shapes. Another reason to our choice was an observation made while studying documentaries included in our literature method, informal settlements often has a surplus of plastic waste . Recycling plastic material into slabs would therefore be beneficial both in economic and ecological point of views. This could also strengthen the use of low tech solutions.

To get an idea of how much material would be needed to create the puzzle pavement, we made some rough estimates. We calculated the total volume of one slab and could then by using the density of PET, polyethylene terephthalate plastic, as reference conclude that the total weight of one slab would be approximately 1 kilo. We divided the total weight with the weight of one plastic bottle. The results showed that to produce one slab you would need approximately 24 plastic bottles. The amount of plastic needed may vary since different types of plastic have different density and properties.

## Durable

The construction of each slab needed to be able to handle pressure from both pedestrians and lighter vehicles. Since the slab needed to be hollow for management, supports on the most exposed areas was needed. An internal framework placed on each corner of the slab and one in the middle was our solution and can be seen in illustration 1. We were aware that to guarantee durability, the slab would need further testing. The durability depend on thickness and type of plastic.

### INTERNAL CONSTRUCTION

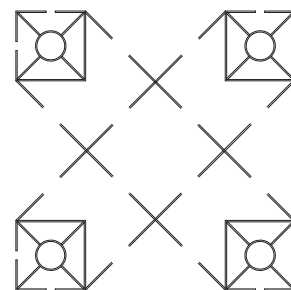


Illustration 3. An illustration showing a prototype for the internal construction of the slab.


## Easy assembly


When the decision of designing a slab was made we started exploring what shape it would take. By sketching seen in sketch 19, on different shapes we concluded that a square would be most appropriate, because of its simplicity. The square would not give uneven edges when laid out, which we found beneficial. We investigated different types of sizes. Too big and it would be difficult to handle and the production would need more space. Too small and it would need more material and would be less sturdy. By sketching in scale 1:1, we agreed on a square with the dimensions 400mmx400mm. However this might not be the best size. To reach the best size further testing and design would be needed. We chose this size and shape from own experience and comparison with commonly used slabs. Although the aim was to create a square slab, compromises ultimately affected the construction to facilitate water management and easy assembly.

When designing how the different slabs would fit together we tried several different solutions. Some were excluded since they would be difficult to mould. Others would require separate pieces of plastic. This idea was also rejected since they would make the assembly more difficult. The final solution was a shape that allowed the slab to be mounted from the top, securing it in an already placed slab.

For production facilitating reasons the slab was divided into two different pieces. One bottom piece which included the water channels and framework, and one top piece with holes for drainage. These two moulds and shapes were designed separately. The two pieces needed to be held together, which resulted in the design of an earth screw. The screw would keep the two pieces in place and also anchor the slab in the underlying ground. This design would therefore require three different moulds. One for the top piece, one for the lower piece and one for the earth screw.

What shapes work best?

○ ROUND. DURABLE BUT WILL LEAVE GAPS  
  
 ALSO NOT STRAIGHT EDGES.

□ SQUARE. WILL NOT LEAVE GAPS  
  
 ALSO WILL CREATE STRAIGHT EDGES

⬡ HEXAGON. STURDY AND SPACE-EFFICIENT  
 WILL LEAVE UNSTRAIGHT EDGES

△ TRIANGLE. STURDY.

⬠ WILL GIVE EDGES THAT ARE TILTED

Sketch 19. After the different tests, a square shape proved to be most suitable.

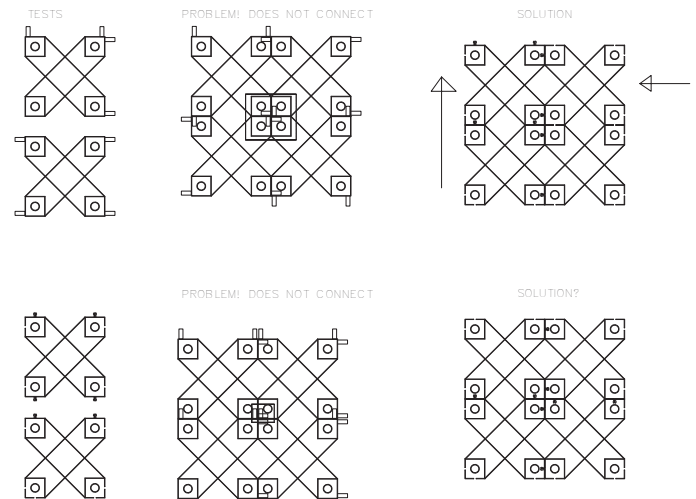


Illustration 4. Testing different types of connections of the slabs.

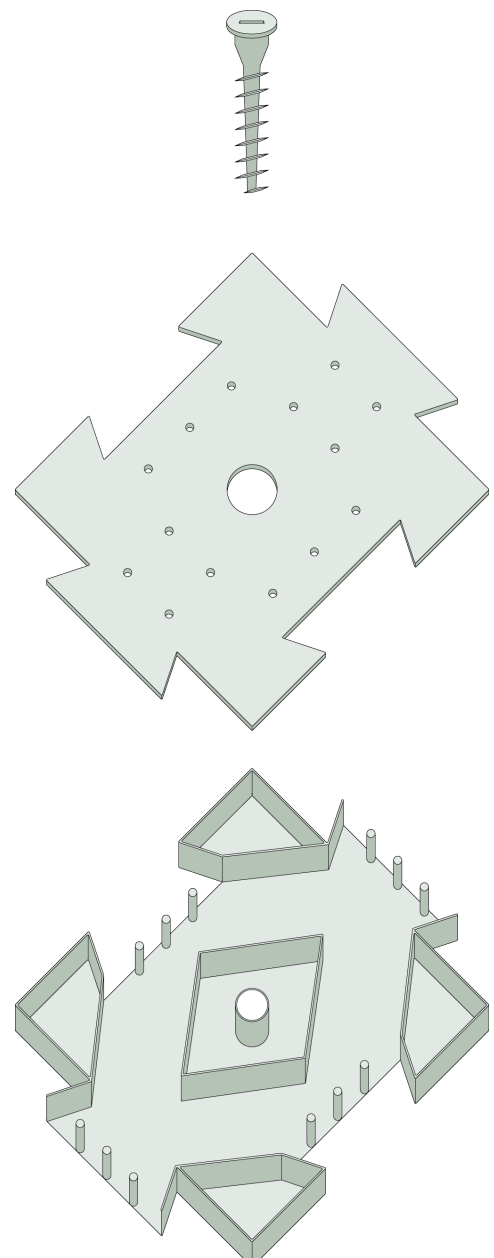


Illustration 5. Axonometric projection of the three different pieces needed to assemble one slab.

## Different appearance

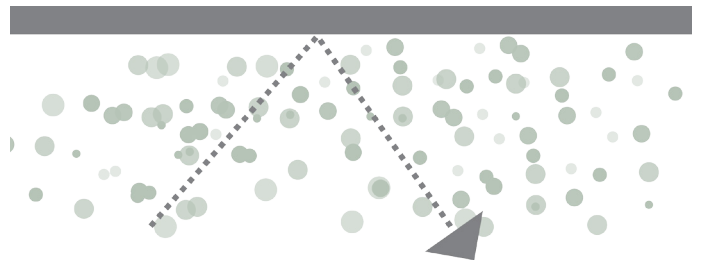
The colour of the plastic used for production would be visible in the produced slab. We tried to use this to our advantage. By sorting plastic in different colours, the layout could be arranged by colour. This could increase recognition in the informal settlement. Our hopes were that this would provide better orientation and allow people to associate themselves with different areas. This is solely hopes as it is for the resident's individual experience to decide. We chose to include this in our competition submission as it would strengthen our projects social functions.



*Illustration 6. Different coloured slabs facilitates orientation within the informal settlement.*

## Prevent dust particles

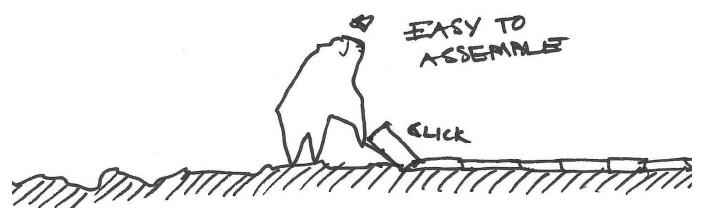
A function of the puzzle pavement was to prevent dust from re-swirling and thus polluting the air. The lower part of the slab will act as a dust barrier, counteracting the spread of airborne dust. Preventing the spread of dust was also a way for us to use our design to improve the daily life of the residents and their health.



*Illustration 7. Pictogram used in the competition to visualize the dust preventing function of puzzle pavement.*

## Placed anywhere

Since flexibility and space efficiency has proven to be strong characteristics of informal settlements we tried to create a flexible solution. The intention of the puzzle pavement was that it should be able to fit almost anywhere. It should be laid out by people so that no machines would be required, this meaning it could pave small tight streetscapes as well as big and wide. This would minimize the impact on the surrounding settlement by maintaining a respect for the existing structures.



*Sketch 20. Letting the people of the informal settlement both produce and assemble the puzzle pavement could generate income opportunities and strengthen the community.*

## Locally produced

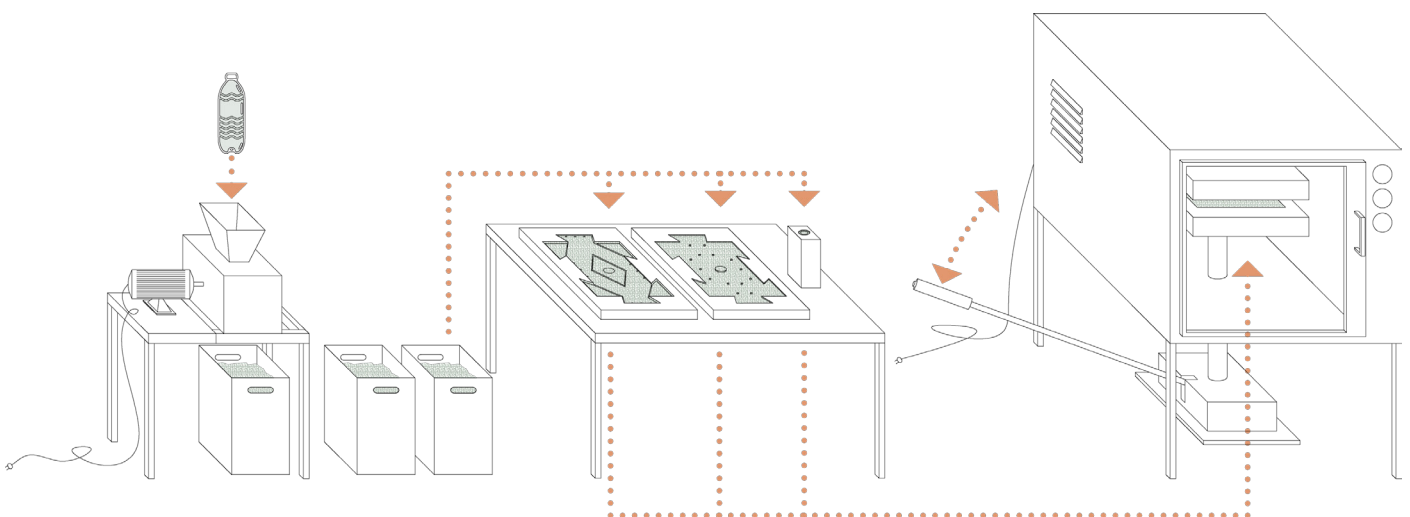
Producing the puzzle pavement locally would benefit several aspects, which is why we suggest keeping the production within the informal settlement. Firstly, it would minimize cost such as transportation of materials. Secondly, keeping the production in the area would allow for local residents to engage, which could generate income opportunities. If the residents were compensated for collecting plastic, producing and mounting the slabs, it could create a sense of ownership. This would also respond to the criteria in our design program, where our aim was to engage the local residents. For this to work the intervention demands interest from the residents. This is not something we can assure will occur. Nonetheless, we presented this idea in our submission since it answered to the bullet point in the PPA, stating the importance of residential involvement.

The production of puzzle pavement would start with residents collecting and delivering plastic to a shed-workshop. The workshop would be equipped with a plastic grinder, moulds and an oven. Plastic would be shredded into granulate and poured into a mould. The granulate-filled mould would be heated in the oven, causing the plastic to melt. By pressing the mould together with a jack-screw the plastic would obtain a new shape.

The production of the puzzle pavement would require electricity. We were aware of that some informal settlements lack proper power grids to power the machines needed. In these cases solar panels could be used, producing the power needed. This was something we did not further researched, instead we chose only to mention the different possibilities in our submission.



*Illustration 8. Part of an illustration used in the competition. Involving the residents in the production can create a sense of ownership.*



*Illustration 9. The production chain as presented in the competition.*



## Ease of transport

The puzzle pavement would create a level surface when laid out which would improve accessibility to local stores and other necessities. Transforming an uneven dirt street to a flat surface would facilitate means of transport. Moving about in the informal settlement would be easier and less hazardous. This would require the top surface of the slabs to provide a good grip, for this some sort of pattern would need to be incorporated into the mould of the top piece. The grip issue is something we discovered after submitting the competition and is therefore not included when presented in appendix 1.

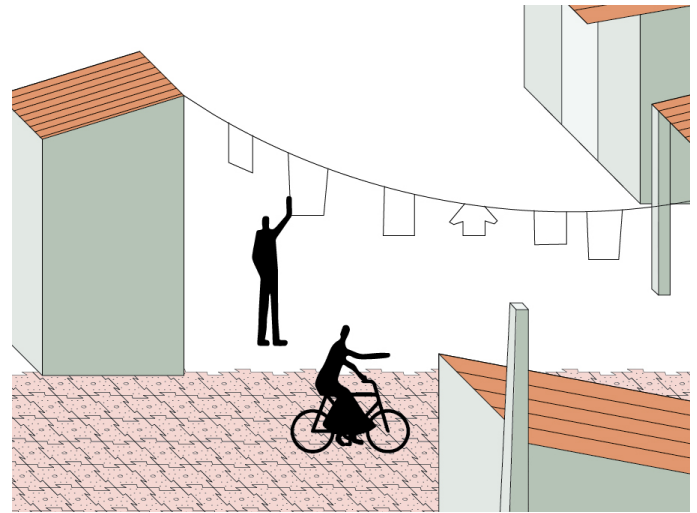
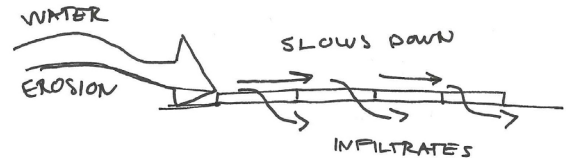


Illustration 10. Part of an illustration used in the competition. Puzzle pavement creates a flat surface, facilitating transportation.

## Slow down erosion

By directing rain water into the slabs, the amount of erosion on the underlying dirt streets would be reduced. This was a positive side effect of the water management feature that we discovered whilst designing the slab and further studying the literature.



Sketch 21. The slabs would cover the dirt road which slows down the erosion of unpaved streets.

## Possible to relocate

The puzzle pavement does not always have to be a permanent solution. Our hopes were that the processes of consolidation in the informal settlement would erase the border between formal and informal parts of the same city. This feature made us think of the mobility of the puzzle pavement. By designing a product that was easy to mount and dismount we could acquire this feature. This would also allow for changes in the streetscape. If something is to be added, it is easy to remove a couple of slabs. This strengthens the flexibility of the solution.

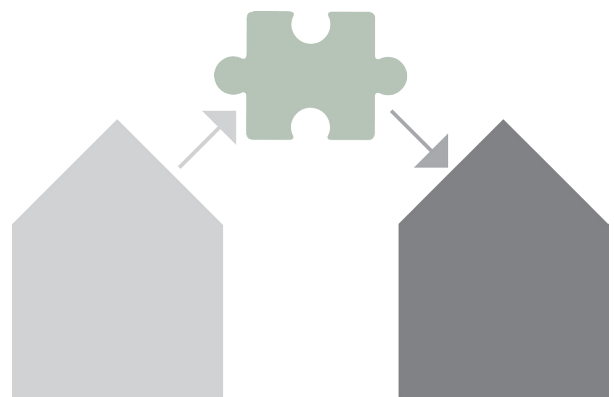


Illustration 11. A pictogram used in the competition, illustrating how the puzzle pavement can be relocated.

## Be permeable

Some of the water would drain through the joints between the puzzle slabs. This would reduce the risk of over flooding and moisten the dirt, preventing airborne dust.

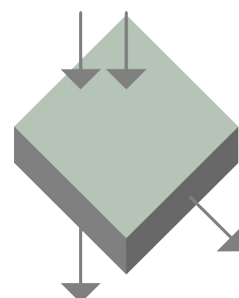
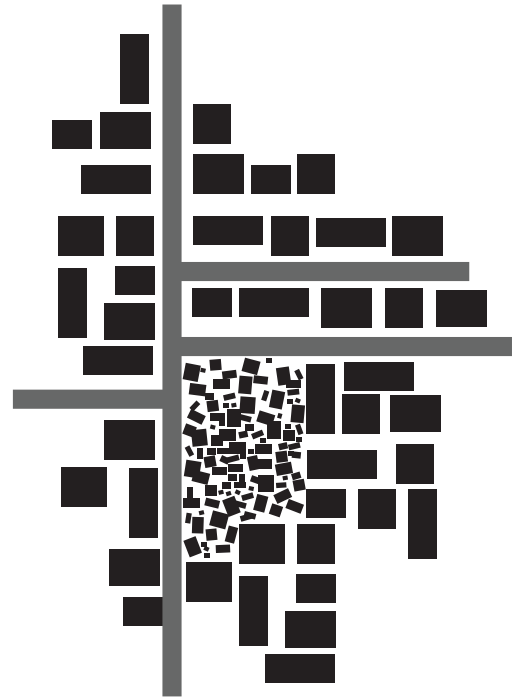


Illustration 12. A pictogram used in the competition to illustrate that some water would drain through the joints

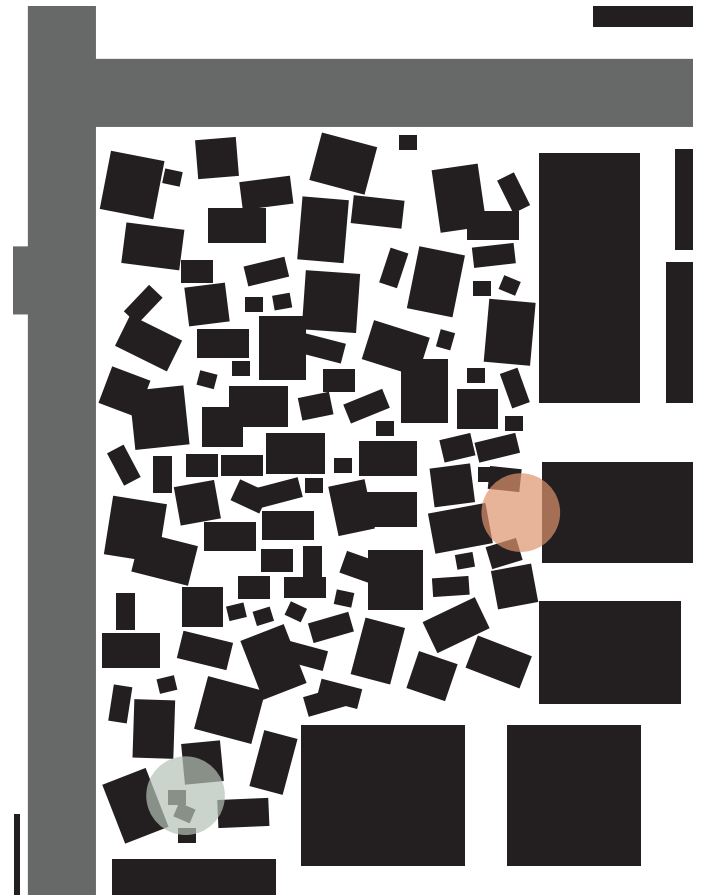
# How to use puzzle pavement

In order to explore the best way of using the puzzle pavement and what work it would do in an informal settlement we have created a scenario included in our competition submission. However this scenario represents the optimum scenario where the puzzle pavement can reach its full potential. In real life this would probably not happen, at least not in every case. This leaves questions regarding how to use puzzle pavement. Therefore we will now present a case where we try to implement the puzzle pavement in an informal settlement archetype. The archetype is placed in direct closeness to a larger formal city. The scale in the informal settlement is much smaller than in the surrounding city, and so is the scale of the public space and the streetscapes. The informal settlement is organically structured while the formal is ruled and planned. The archetype is depicted in illustration 13.

Where would be the best place to start laying out the puzzle pavement? As we see it there are two ways of dealing with this. The first being that the most vulnerable surfaces acquiring the biggest positive impact from the puzzle pavement is the best place to start. This would strengthen the informal settlement itself but would not contribute to the consolidation process we wish to see between the formal and the informal parts of the city. The second approach is to start at the borders between the formal and informal settlement. This would better contribute to the consolidation process, but may not upgrade the informal settlement in an equally good way. Examples of these two approaches are depicted in illustration 14.



*Illustration 13. The archetype of an informal settlement located in a city. The grey lines are main roads and the black rectangles represent blocks.*



*Illustration 14. This illustration shows two potential starting points for the puzzle pavement, dependent on what the wishes are about what the pavement should achieve. The orange circle may be a good place to start if one wishes to consolidate the city and the informal settlement, the green circle may be a good place to start since this could be where the puzzle pavement would be most beneficial to the informal settlement.*

Inside the informal settlement there are different types of streetscapes. There are streets of various length and width, there are open spaces, places with different usage etcetera. Which type of surfaces would be best suited to address with puzzle pavement first? In our opinion the type of places prioritized should match the problems that are significant in this particular informal settlement. If the main problems are connected to transportation the streets would probably be the best place to start.

What type of road to start with may also be an issue. Should the puzzle pavement first be placed along the main paths and then spread to the smaller ones or should it be the other way around? The positive side of starting on the main paths may be that this to greater extent makes transportation more efficient if most of the traffic is bound to these paths. The positive side of starting on the smaller paths may be that it gives the residents a chance to familiarize themselves with the concept of the new pavement. It may also affect the daily lives of the resident to a higher extent if the puzzle pavement is placed right outside their door.

Open spaces, squares and plazas may be the right place to start if there is potential for upgrading these places and make them into more vibrant and used places. For example, an open space may be very dusty because of a windy location, but it has the potential of housing a fruit market. However it is now unable to do this because of the dust. In this case it would be a good idea to pave this open space first and reach a potential economic and social upgrade of the nearby neighbourhood. The puzzle pavement can then spread from this open space.

In any implementation case it is very important to have a dialogue with the residents of where they think the puzzle pavement should be used. There may be places where the current unpaved road for some reason may be preferred over the puzzle pavement and should then be kept unpaved.

A way of approaching the implementation may also be to just supply the shed workshop and the tools needed for producing the puzzle pavement. In this case each of the residents could bring their own plastic, make their own slab and place it where the individual resident think that it is appropriate. This would still allow the informal settlement to develop organically. This could be the best solution but sets high demand for cooperation among the residents as the pavement needs to interlock and be seen as one system rather than individual solutions.



# Part 4

## Discussion

The last part is where discussions, reflections and further research are raised. In this part a critical review of our competition submission is carried out.



Photo 7. © Agnes Djurberg



# Inspiring other designers to engage in informal settlements

Our intent of this thesis was to engage in how design could contribute to better streetscapes in informal settlements. The aim was also to inspire landscape architects and other designers to involve in this matter. Our intention was to create a small intervention in the form of a general design concept, targeting the streetscape of informal settlements.

As we have conducted this project we have discovered how design can become a part of the solution towards many problems concerning informal settlements. Since the UN-Habitat's definition of a slum in many cases describe the lack of basic needs, additions can be made to create better living conditions. The absence of these basic needs are due to the special conditions which prevails in informal settlements, where planning and bureaucracy are partly or completely absent. The lack of planning and bureaucracy provides a creative gap and opportunities for designers to work within since standardized solutions often requires both formal planning and bureaucracy. This is where landscape architects wide range of knowledge can and should be used. Both Liberatus Kileki Mrema (2008) and Christian Werthman (2009) argues that design professions are not engaged enough in the problematics regarding informal settlements. Participating in an idea competition inspired us to engage in the subject. We believe that a competition can act as a tool to increase designer's interest in these issues.

Informal settlements could also be a generator for new ideas and challenge the conception of what we in the western world believe is the best solution. Kevin McCloud (2010) stated in the documentary *Slumming* It that informal settlements has much to offer and that developed countries can learn a lot from processes and solutions in informal settlements. We believe that more engagement in informal settlements is needed. When engagement does occur it often aims to change things in informal settlements. People in informal settlements develop their neighbourhood in the way they prefer. This puts high demands on the outside designer, who might not recognize the values without involving with the residents. Responsiveness becomes very important in these locations, to set aside personal preferences is essential to really understand which interventions are needed and which are not. In the background we mentioned that in the documentary *Slumming* it (McCloud 2010), a woman was asked what she thought of the clearing and the new master plan for Dharavi,

Mumbai, India. Her response is that the only thing her neighbourhood needs is proper infrastructure, not new skyscrapers. This is an example where the outside designers have not been responsive to the desires of the residents, they suggest what they believe is the best solution.

It has proved that clearing projects only relocates the problems of the informal settlements (Kileki Mrema 2008). Some residents might not afford the new housing, some might not want to live there and some people's livelihood might be lost due to the loss of the informal economy. In some upgrading projects, parts of the informal settlement might need to be removed to let the upgrade function properly. We believe that clearing occurs when the designer is not responsive to understand the qualities and issues within the informal settlement. The goal should be to upgrade the settlement without removing the existing structures. This is why it is appropriate to work with small interventions that improve specific parts of the informal settlement. Multiple small interventions at different locations will lead to a better standard within the whole community.

## Puzzle pavement

Puzzle pavement is our design solution towards better streetscapes in informal settlements. Our research shows that the design could improve the conditions and daily life. Some of the features supporting this is the ability to hinder the spread of airborne dust, managing water runoff and facilitating transport and orientation. In our competition submission we presented puzzle pavement as a temporary solution that could be used in the meantime, before the informal settlement is consolidated with the surrounding city. By giving the informal settlement paved roads boundaries between the formal and the informal parts of the city can be erased and that decision makers therefore may be more interested in supplying the informal settlement with proper infrastructure. This could happen, since the puzzle pavement will make the informal settlement resemble the formal city and therefore be more accepted. With upgrading through pavement the differences between the informal and formal city are erased and decision makers can see the possibilities within the informal parts that could benefit the city as a whole. We cannot be sure that this process will take place and if the infrastructure is not provided, the puzzle pavement can as well work as a permanent solution.

Literature was part of our research and we used it to pinpoint which problem to address and solve through design. To work with literature as the main source of information is beneficial, however it could pose problems. The literature we have studied is a generalisation of the problems in informal settlements. We have chosen one of the many problems, generalised it and dispersed it into sub targets to solve through design.

## Further development

The Puzzle pavement would need further product development before being implemented in a real world case. Since we have only tried it in theory, practical aspects need to be considered. How the puzzle pavement would work in different gradients is one example where more development is needed. To be able to place the slabs and allow them to interlock, the ground would have to be somewhat flat. In some cases preparatory work may need to be conducted. We have not examined how the puzzle pavement will work in steeper areas. The combination of rain and steep gradient may affect the anchoring of the slab to the soil. The water management efficiency is also dependent on the existing gradient, some locations might benefit more from using the puzzle pavement than others. Sometimes a low point might be inappropriately located, in which case the outlet of the water could be placed above the lowest point.

Another aspect that needs further development is the grip on the surface of the slab. When plastic is wet it can become very slippery, which might obstruct and even make transport hazardous. One way of preventing this could be to use a structured pattern on the top piece of the slab, which would increase the amount of friction.

The puzzle pavement has four open sides for water transport. This leads to possible leakage in the outline of the pavement. We have two current ideas of how to deal with this issue. One solution would be to shape the road where the puzzle pavement will be placed, into a concave. This would direct the water towards the middle of the road and mitigate leakage at the edges. Another option is to introduce a fourth mould in which a lid for the open sides can be produced. The lids would then prevent water from leaking.

In the scenario presented in the competition submission, the only substance transported in the puzzle pavement is water. In the majority of situations, this might not be the case. During heavy rainfall, dirt, debris and other unwanted material could easily end up in the puzzle

pavement. This might clog up the channels and hinder the transport of water. The slabs would need to be opened and rinsed every now and then to make sure that they work properly. Removing a slab is simple and straight forward but where the responsibility lies to carry out the work is not. Finding the location of the blockage among all the laid out slabs might also be a difficulty. Clogging in the slabs could also result in stagnant water in the puzzle pavement. This could pose a problem since both mosquitoes and bacteria thrive in these environments.

The concept of puzzle pavement could also be used in other context apart from informal settlements, because of the simple production and the use of recyclable materials. One example of an area of use is temporary refugee camps. In this case the ability to relocate the puzzle pavement would also become a beneficial factor.

## Implementing the puzzle pavement

One issue with the puzzle pavement is that there will not be enough plastic available. The access to plastic is depending on the resident's engagement in the project and the abundance of plastic waste in the informal settlement. If plastic is worth money, there could be a risk that no plastic would be turned in to produce slabs. The residents might sell their collected plastic rather than letting it be converted in to puzzle pavement. To solve this issue, we have an idea to offer a compensation to the people that turn in plastics. This could possibly be financed by the local government who probably has interest in the upgrading of the informal settlement. Our idea also includes compensation to the people who are willing to help lay out the slabs and we hope that this will be financed in the same way. Another way to acquire plastic could be by donation. Many areas around the world have a surplus of waste and instead of letting the plastic end up as landfill, it could be donated to the project.

We have not specified what sort of plastic would be best for producing puzzle pavement. There are many types of plastic with different characteristics and qualities. Our aim is that the slab should manage to carry a weight load equivalent to a lighter vehicle. We have studied similar constructions which are able to withstand loads up to three tons. To be able to answer what the maximum load is, a real model would need to be developed and tested, including tests on the thickness of the plastic.

## Method discussion

When conducting the previous project analysis (PPA), we chose to study the top three submissions from the competitions DENCITY 2015 and DENCITY 2016. The advantages of studying previous competitions were that they had been developed within the same framework as the competition we entered. This gave us an opportunity to analyse what made a project successful in this type of competition. The use of the PPA as a method did not contribute with any facts to the project. Competition submissions are often designed with a constructivist approach, where focus is on creating something new and unseen (Lenzholzer, Duchhart & Koh 2013). Instead it provided suggestions and inspiration on how to form our project. This led to generalization as some of the features in puzzle pavement derives from the PPA. There are several different examples of projects in informal settlements and streetscapes which have been realized and proven successful. If we would have analysed these projects our design could have been more anchored in reality which may have influenced our design process.

Since our project has not been site specific, we have relied on literature to provide facts we can relate our design to. In a way, the literature has served as a substitute for a place inventory and has given us a big picture of the issues regarding informal settlements. The facts provided by the literature were in some cases site specific whilst in other they took a more general point of view. This led us to design a general concept to avoid issues with being non site specific. However, this does not mean that our design is universal. Since the real world is not generalizable, there might be several scenarios where the puzzle pavement might not be suitable or desirable to implement.

Early in our design process we discovered that design alone cannot solve comprehensive problems such as economic problems and housing politics. Through the design process we narrowed down our problem space to concerning public space and streetscapes. The design process was a tool for us to test and compare our different ideas. Through our design process we have applied the theories of research through designing. These theories were used to review our own design process and to present it to the reader in a more transparent way. The theories have not affected our design but have helped us to describe and understand the different ways of thinking when designing.

## Further research and questions

Through this master thesis we have discovered that there are a wide range of opportunities for landscape architects to involve in informal settlements. This subject can add to our already versatile profession. Public space is highlighted as an important factor when improving informal settlements. In our competition submission we address a small portion of the many different categories included in public space. Apart from streetscapes and unpaved roads, there are several other fields where further research and design can be made. This includes research on how parks, squares, playgrounds and other categories can be designed to create better environments in informal settlements. Another field of research for landscape architects is how to tackle issues of natural disasters within informal settlements. Since informal settlements are often more exposed to natural disasters than formal cities, ideas and solutions are needed to withstand these hazards.

Further investigation can also be made to find solutions and inspiration within informal settlements. By visiting and studying different informal settlements, ideas and solution can be adopted and used in other parts of the world.

Engaging landscape architects in the subject of informal settlements is something that needs further exploration. This could include how to engage students or collaborating with companies to realize projects. The use of crowd founding and social media could also be a way to finance and implement proposals.

## Epilogue

This thesis has enlightened us on that the informal settlements around the world host great potential for becoming flourishing parts of cities, rather than being isolated areas of despair. During our master thesis our main desire was to enter a design competition. Looking at it now, the process has been much more than participating in a competition. We have come to work in a product development manner, a new way of working which we believe can facilitate projects that are non site specific. We have also explored a new topic, realizing that there are multiple ways to contribute to the issues. The more we studied the subject, the more we realized how complex and widespread the problems were. Nonetheless, we believe that landscape architects can and should involve in this matter.



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Photo 1, 2, 3, 4, 5, 6, 7: © Agnes Djurberg. Published with owners permission. Images are edited by Jonathan Anderson and Daniel Eriksson

# Appendix 1

Here we present our competition submission to the competition DENCITY 2017.



# PUZZLE PAVEMENT

## INTRODUCTION

Many informal settlements across the world are recognized by their poor infrastructure and lack of paved streets. In these cases streets often consist of compiled dirt. Many informal settlements are also located in arid climates where water is scarce. During the dry season the lack of water causes dust from the streets to re-swirl, causing poor air quality and a layer of accumulated dust everywhere. Dust in the air has a negative health effect for the residents living in the informal settlement, and mainly affects women and children since they are in greater extent bound to the public space in their daily chores. These climate areas are often exposed to heavy rainfall during the short, yet intense rainy seasons, causing the dirt streets to erode and turn into a muddy sludge. This rain water could be of better use. Apart from these climate-based issues, unpaved streets also contribute to a number of daily problems, including obstructing transport, compromising accessibility, and in some cases, creating hazardous conditions.

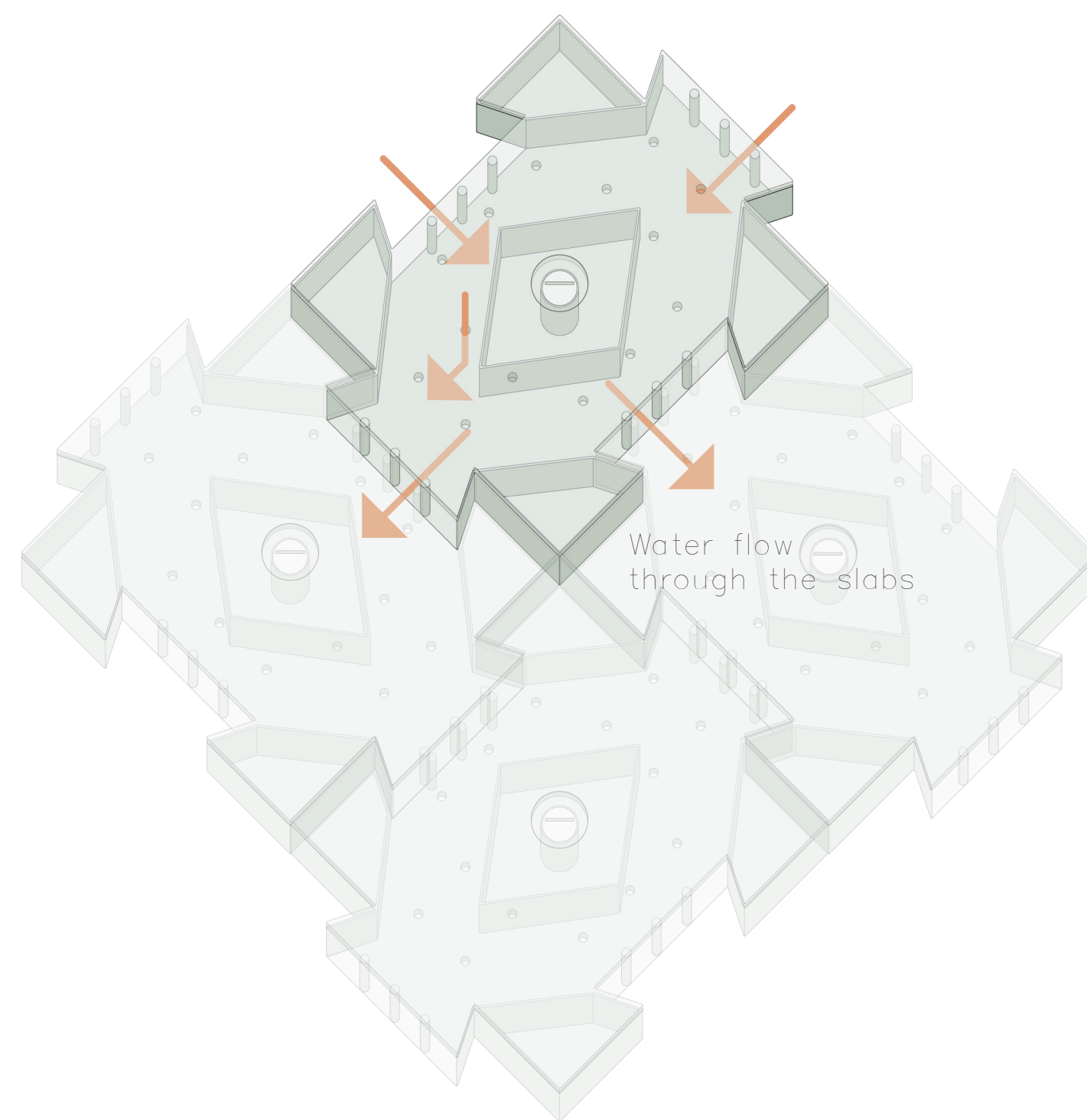
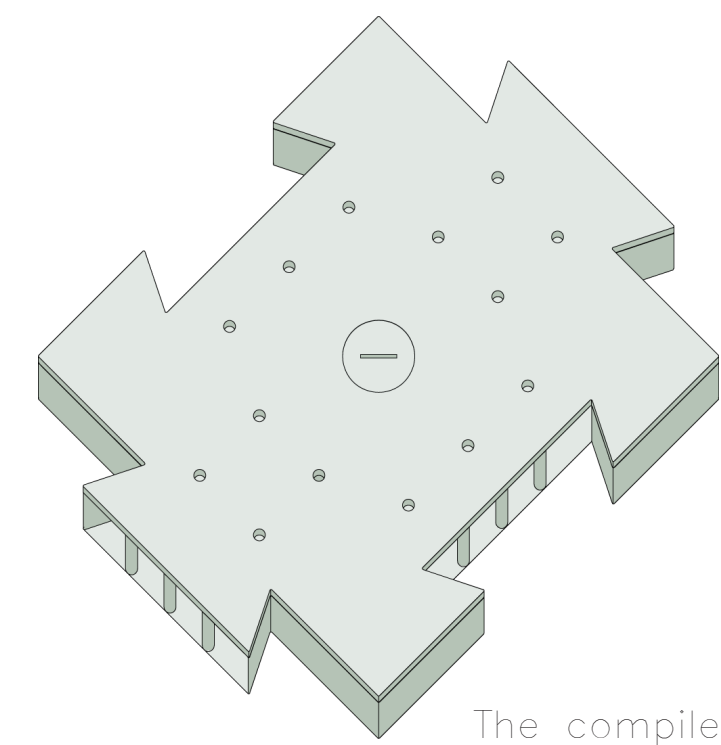
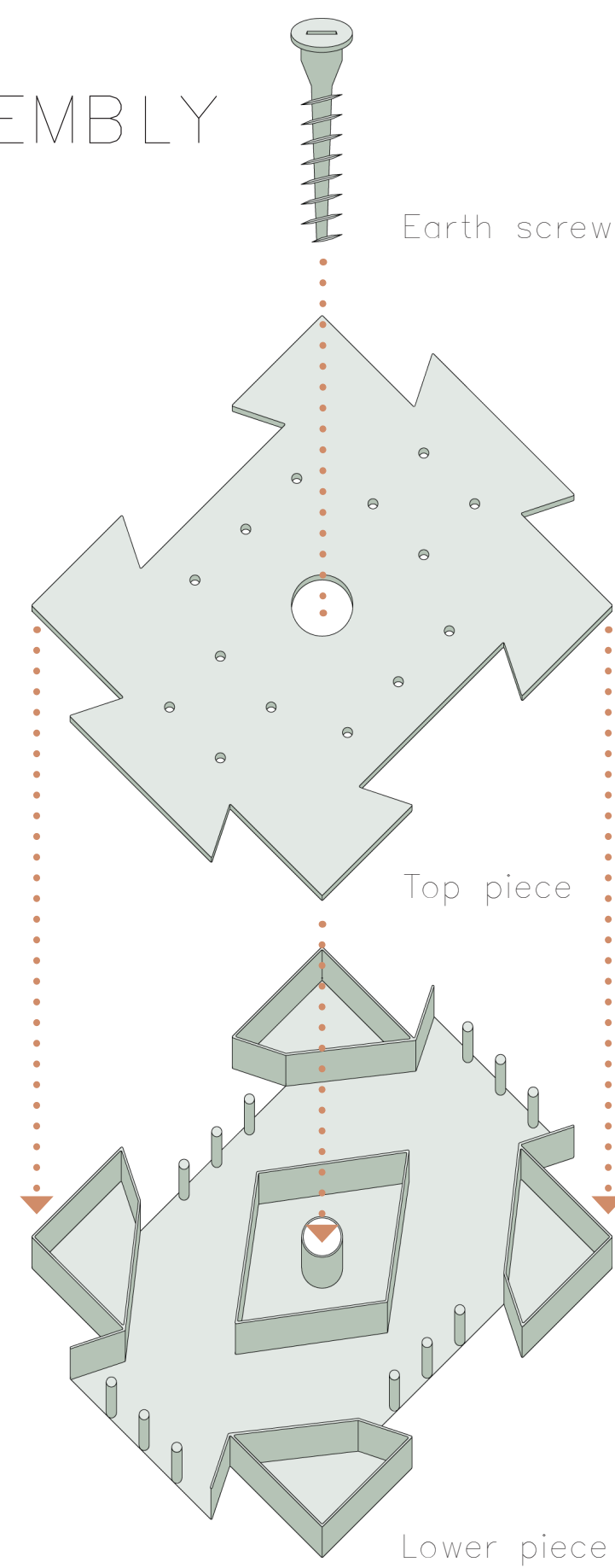
## CONCEPT

The puzzle pavement is a concept aimed to fill the gap in the unpaved streetscapes of informal settlements. The production of the puzzle pavement is simple and easy to learn. This allows residents to join in the production, creating a stronger sense of community. By recycling, plastic material can be transformed into puzzle slabs which can be used to pave roads and manage water. The slabs are built from three components: the top piece – creating a flat and permeable surface, the lower piece – managing and transporting water, the earth screw – anchoring the slab.

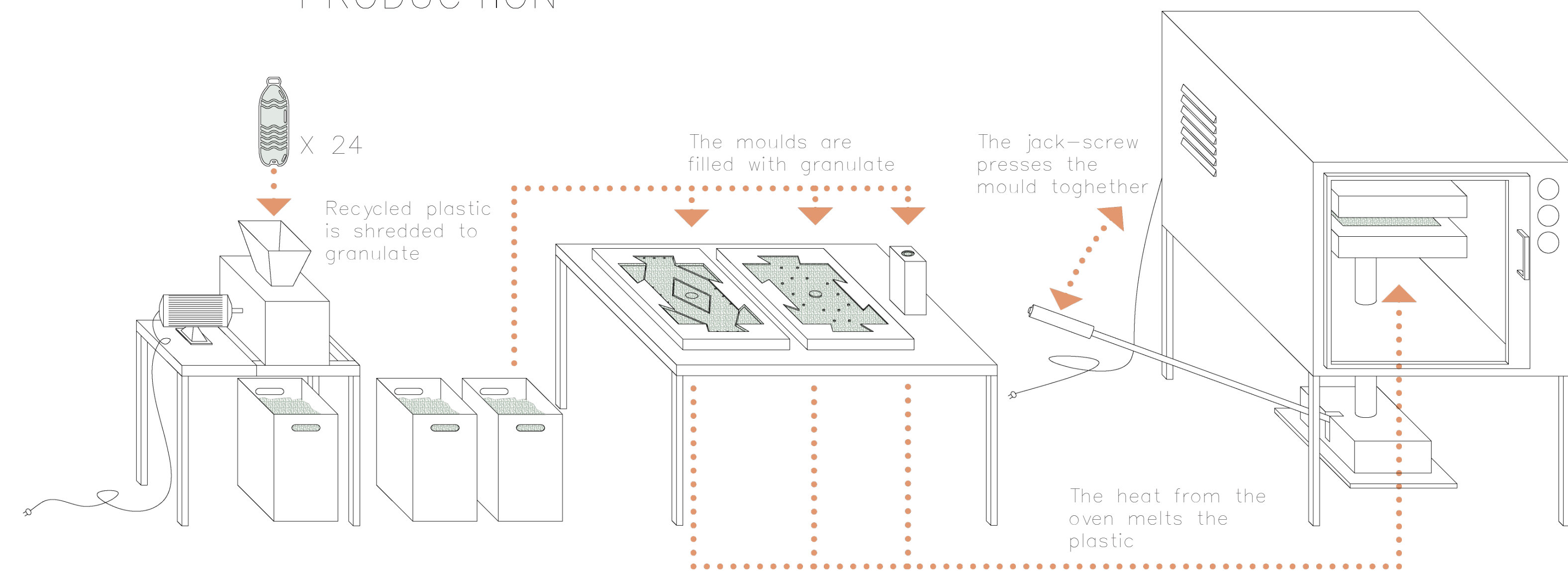
Plastic is shredded into granulate and poured into a mould. The granulate-filled mould is heated in an oven, causing the plastic to melt. By pressing the mould together with a jack-screw the plastic obtains a new shape. Each component of the slab has their respective mould. The production takes place in a simple shed-workshop supplied with electricity. Power can be obtained from existing electricity network or by mounting solar panels on the roof of the shed-workshop. To produce one slab it takes approximately 24 plastic bottles.



## ASSEMBLY



## PRODUCTION

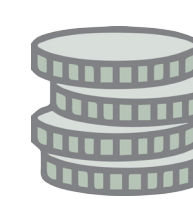


## FEATURES



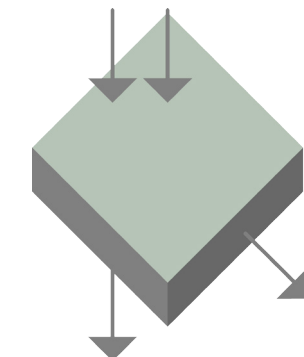
### MANAGE WATER

The puzzle pavement manage water runoff. This water can then be reused.



### AFFORDABLE MATERIAL

The production of the pavement is affordable since the material is recycled plastic.



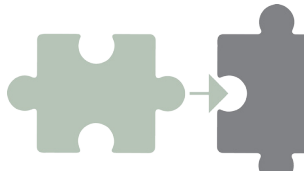
### PERMEABLE JOINTS

Apart from transporting water, part of the rainwater during heavy rainfall drains through the joints into the underlying dirt. This reduces the risk of flooding and moistens the dirt, further preventing re-swirling dust.



### DURABLE

The pavement is able to handle pressure from both pedestrians and lighter vehicles.



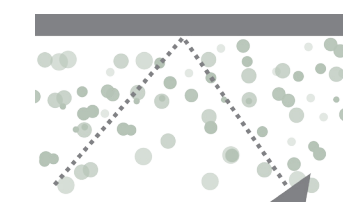
### EASY ASSEMBLY

When combining the different pieces with each other, the size and shape of the slabs are suitable for simple assembly and material efficiency.



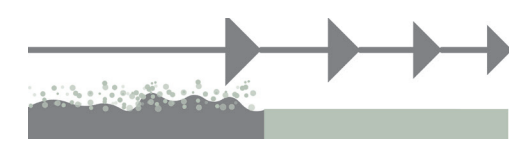
### LOCALLY PRODUCED

Producing the slabs locally minimizes cost and generates work and income opportunities for people living in the informal settlements.



### PREVENT RE-SWIRLING DUST

By covering the dirt roads, the puzzle pavement hinders the spread of dust into the air and helps improve the air quality.



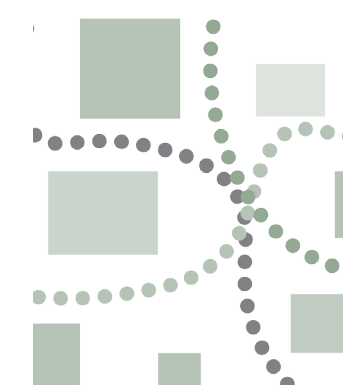
### SLOW DOWN EROSION

The internal design of the slab slows down the speed of water during heavy rainfall and therefore reduces the risk of erosion on the underlying dirt streets.



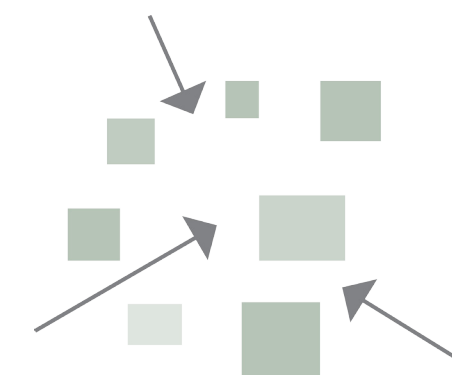
### EASE OF TRANSPORT

The pavement supplies a flat surface to facilitate safer transport.



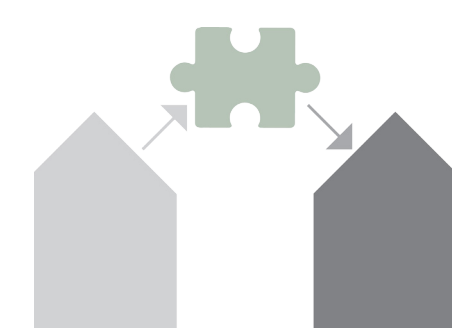
### EASY ORIENTATION

By using different colours of the pavement, streets can easily be recognized. This provide better orientation and allows people to associate themselves with different areas.



### PLACED ANYWHERE

The slabs can be fitted almost anywhere.



### POSSIBLE TO RELOCATE

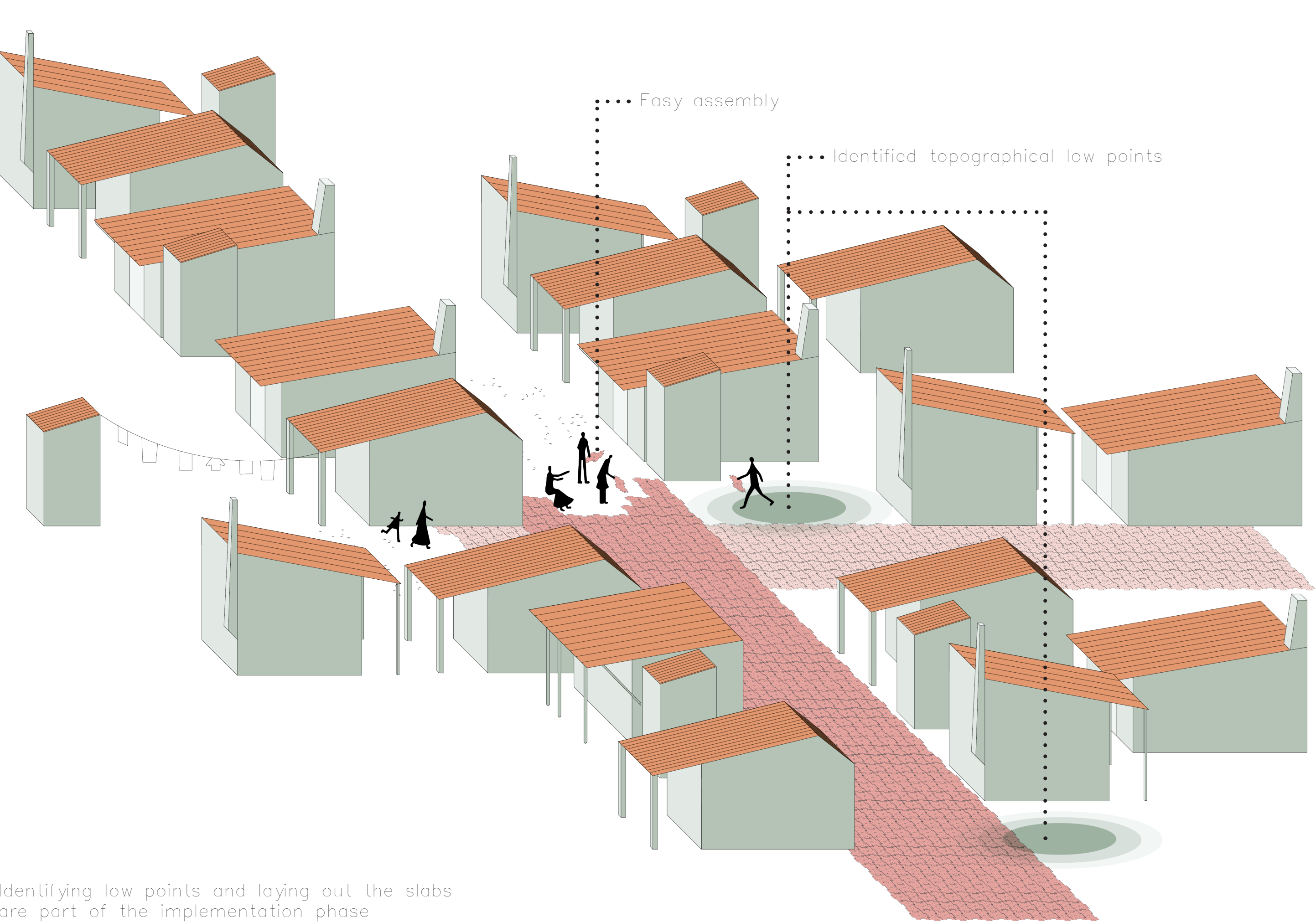
If infrastructure investments are made demanding replacement of the puzzle pavement, the slabs and the workshop can be relocated to another informal settlement where it is needed.



# PUZZLE PAVEMENT

## SCENARIO

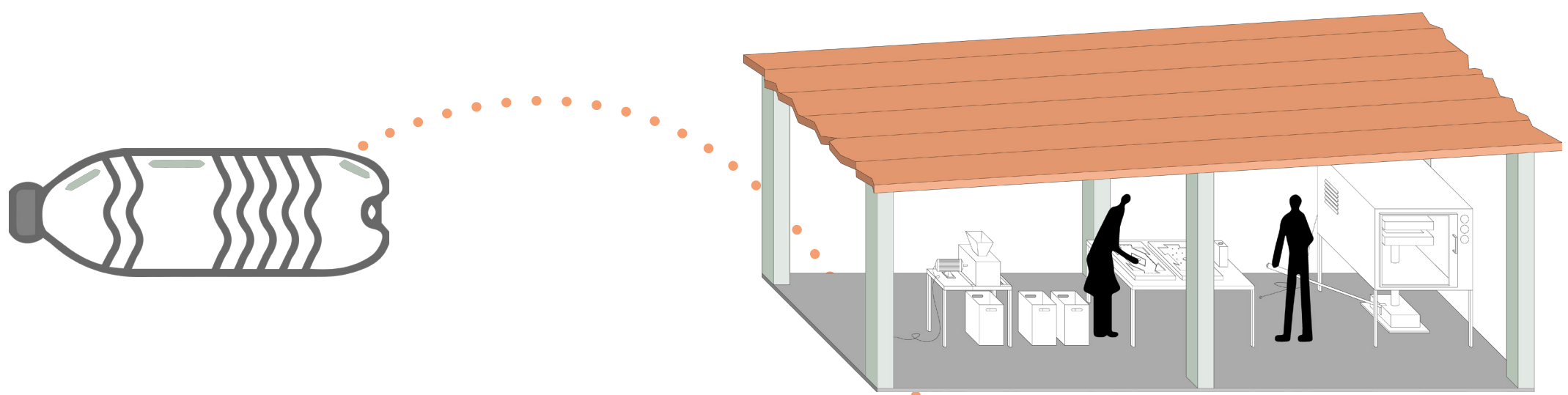
To present the process of our concept we created a scenario where the puzzle pavement could reach its full potential through its implementation in an informal settlement located adjacent to a larger city. The border between the city and the informal settlements is obvious as the quality of buildings and infrastructure is much lower in the informal settlement. The scenario is located in an arid climate with periodically heavy rainfall. In the informal settlement there are no paved streets. There is a lack of fresh water and the air quality is poor due to dust. This leads to many problems. The dirt roads are bumpy which makes transportation unnecessarily hard. Since the informal settlement is not legally accepted there are no street names, leading to difficulties in orientation within the dense overcrowded settlement. During the dry season dust from the unpaved roads re-swirls, polluting the air and creating a layer of dust everywhere. The poor air quality has negative health effects on the residents. The main problem during the rainy season is erosion. The water causes erosion on the streets, leaving a muddy and rough sludge behind. It can also undermine structures and houses. Most of the rainwater is absorbed and drained by the soil and can therefore not be used. The lack of fresh water forces the residents to buy their drinking water by bottle and constitutes a daily expense.



Identifying low points and laying out the slabs are part of the implementation phase

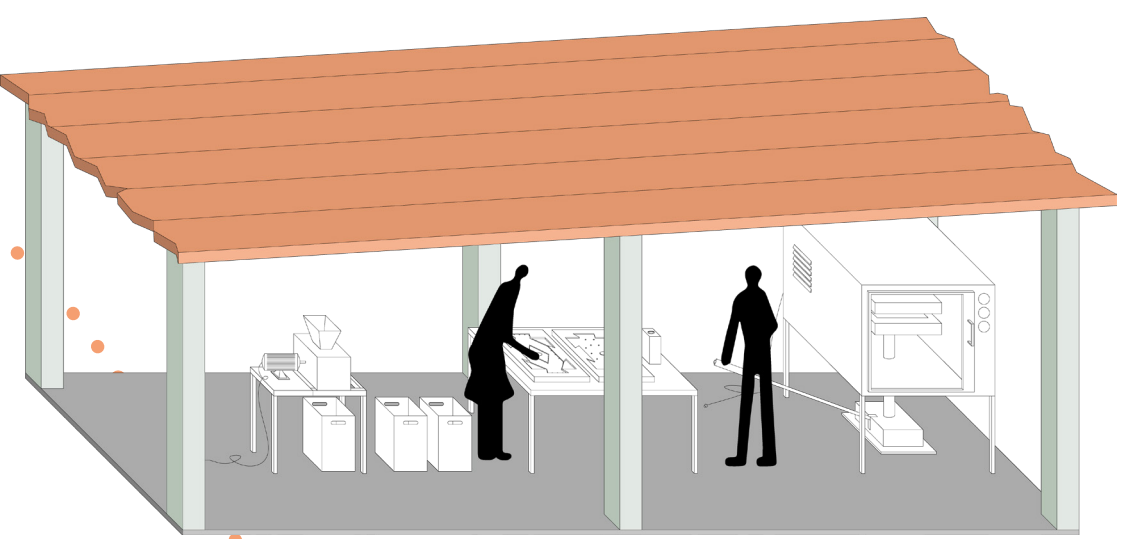
## PREPARATION PHASE

The preparation phase involves identifying potential sites within the informal settlement where the puzzle pavement is most needed. This will be the streets where problems concerning transportation, erosion and dust are at its worst. Low points to where the water can be directed must also be identified. The residents have knowledge of where to begin. A small shed-workshop is built where it is easy to locate. The workshop needs access to electricity. In the workshop are all the tools needed for producing the puzzle pavement.



## PRODUCTION PHASE

The production phase starts with collecting plastic and sorting after colour. Residents who collect and supply plastic receive compensation for their effort. Production of the puzzle pavement starts and the simple process is taught to the residents, allowing for self-sufficiency.

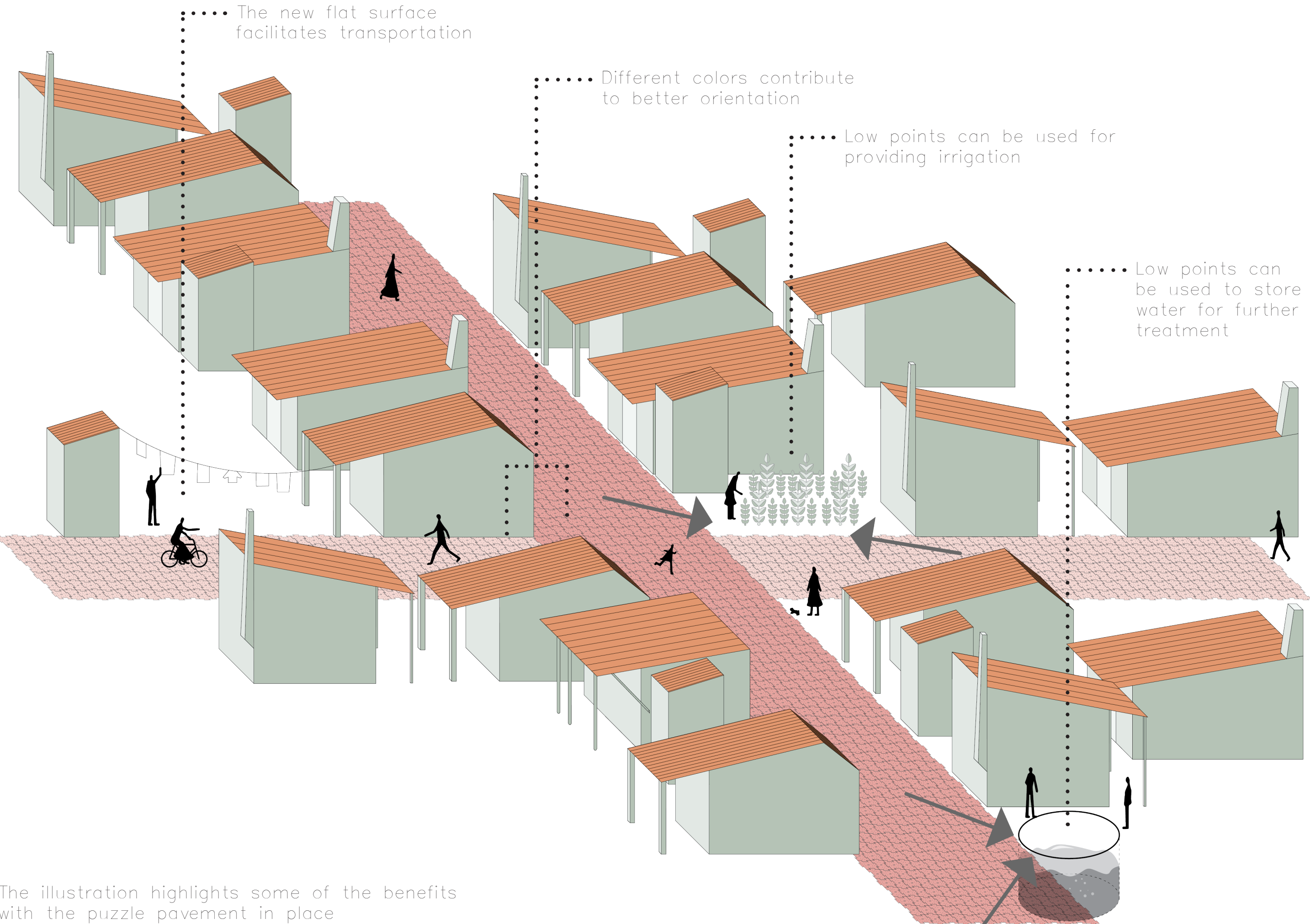


## IMPLEMENTATION PHASE

Laying out the puzzle pavement constitutes the implementation phase. The finished product will be placed along streets, in front of houses and in open spaces, creating a seamless pavement. Residents helping to lay out the slabs are compensated. The implementation phase proceeds simultaneously with the production phase.

Using different colours on the slabs in different streets and spaces, contribute to better orientation in the informal settlement. The different colours can resemble street names, which lets the people recognize themselves as residents of the settlement giving them a greater sense of belonging to the neighbourhood.

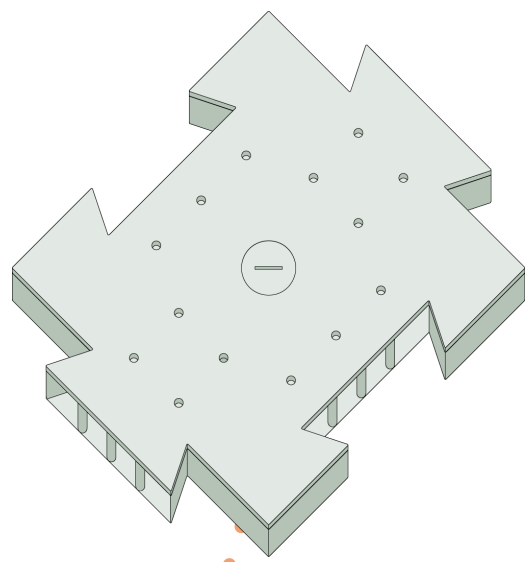
One of the main functions of the puzzle pavement is to facilitate means of transport by creating an even surface of the streets. By covering the existing dirt streets the pavement reduces the amount of dust in the air and thus contribute to a cleaner and less hazardous air quality. When heavy rainfall occurs, the puzzle pavement helps by slowing down the movement of water runoff, reducing the risk of erosion. The puzzle pavement leads rainwater to topographical low points. The water can either be stored or be directed to plants as irrigation. Stored water can be reused for irrigation or treated for drinking water.



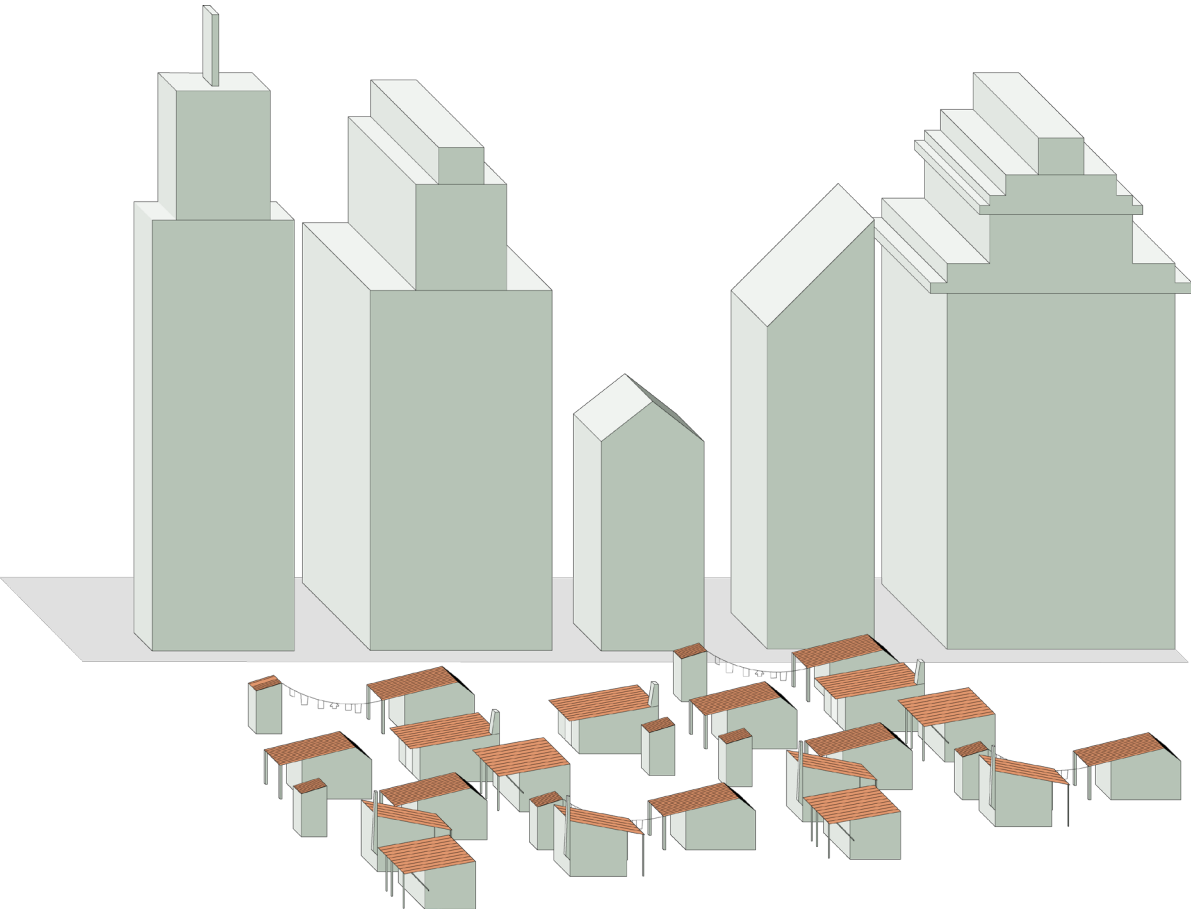
The illustration highlights some of the benefits with the puzzle pavement in place

## CONCLUDING PHASE

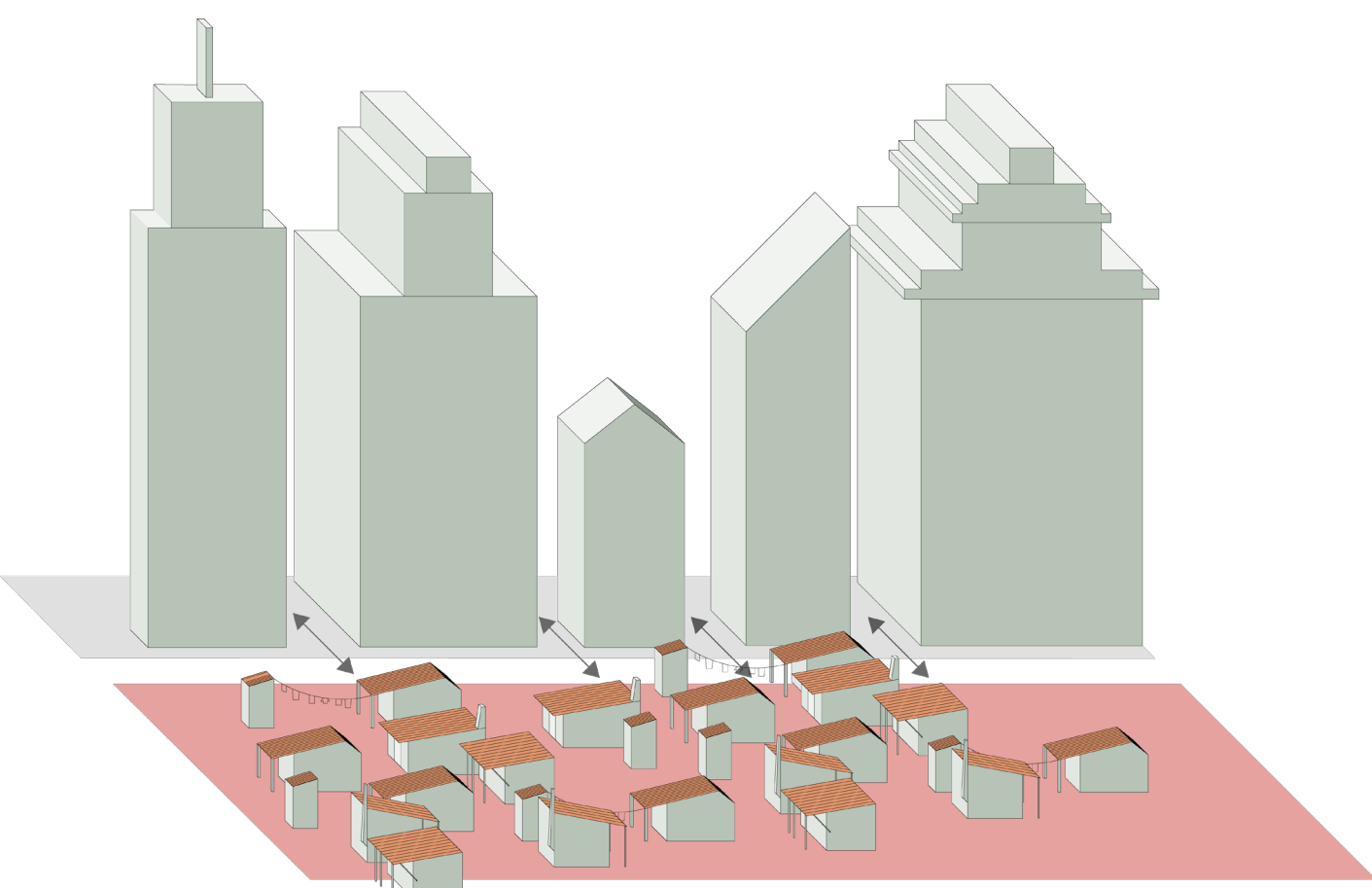
In the concluding phase the puzzle pavement has strengthened the bonds and erased part of the differences between the informal settlement and its surrounding city. The puzzle pavement is in this case not meant to be a permanent solution, but rather a way of consolidating the informal settlement with the city. If the informal settlement is legally accepted and investments are made in the area, real pavement, named streets and infrastructure can replace the puzzle pavement. The puzzle slabs and the workshop can easily be removed and relocated to another informal settlement where it is needed.



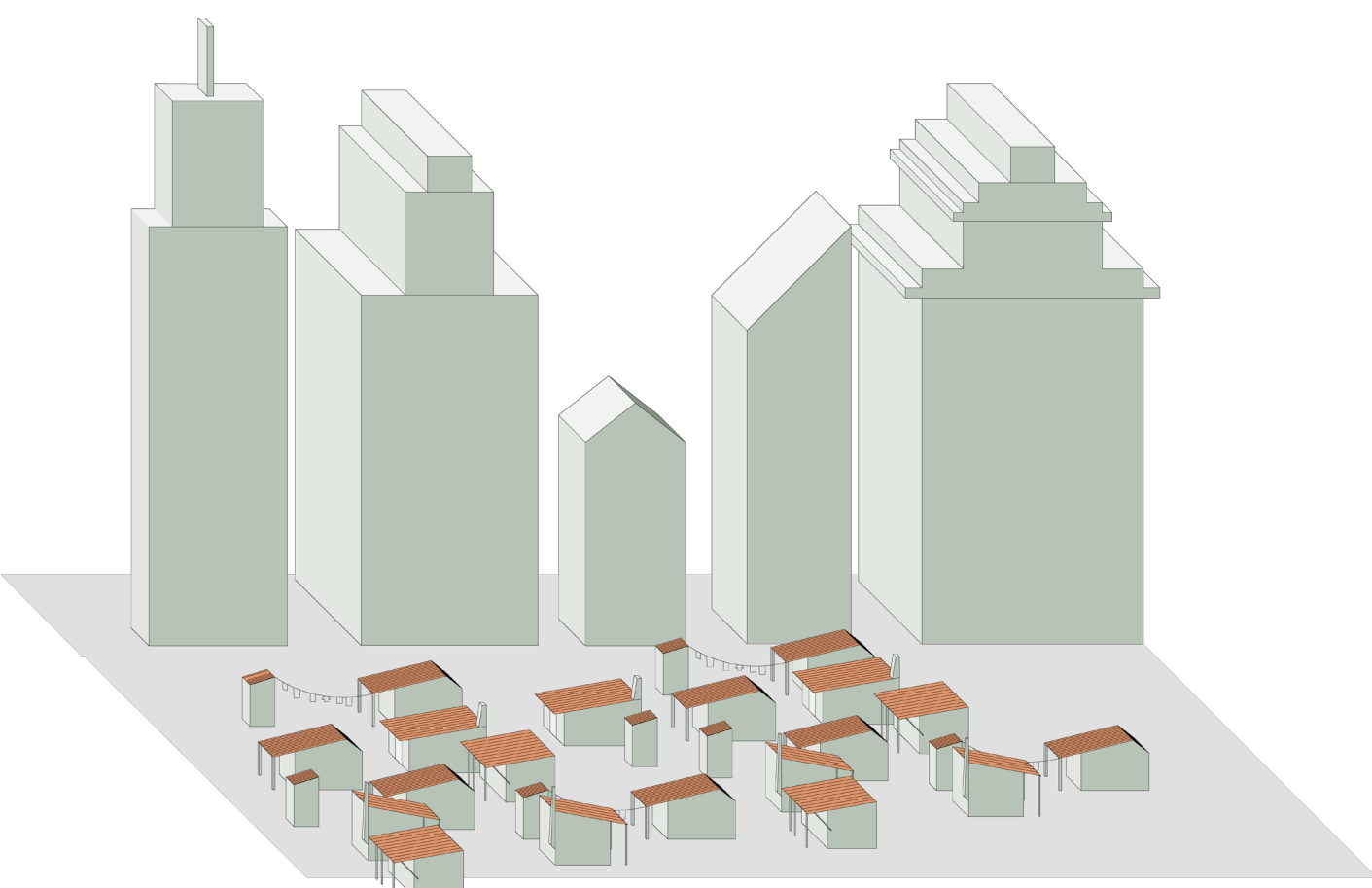
## CONSOLIDATION PROCESS



The informal settlement adjacent to the city



The puzzle pavement creates consolidation between the informal settlement and the city



When the puzzle pavement is replaced with permanent infrastructure it can be relocated



## INTRODUCTION

Many informal settlements across the world are recognized by their poor infrastructure and lack of paved streets. In these cases streets often consist of compiled dirt. Many informal settlements are also located in arid climates where water is scarce. During the dry season the lack of water causes dust from the streets to re-swirl, causing poor air quality and a layer of accumulated dust everywhere. Dust in the air has a negative health effect for the residents living in the informal settlement, and mainly affects women and children since they are in greater extent bound to the public space in their daily chores. These climate areas are often exposed to heavy rainfall during the short, yet intense rainy seasons, causing the dirt streets to erode and turn into a muddy sludge. This rain water could be of better use. Apart from these climate-based issues, unpaved streets also contribute to a number of daily problems, including obstructing transport, compromising accessibility, and in some cases, creating hazardous conditions.

## THE CONCEPT

The puzzle pavement is a concept aimed to fill the gap in the unpaved streetscapes of informal settlements. The production of the puzzle pavement is simple and easy to learn. This allows residents to join in the production, creating a stronger sense of community. By recycling, plastic material can be transformed into puzzle slabs which can be used to pave roads and manage water. The slabs are built from three components: the top piece – creating a flat and permeable surface, the lower piece – managing and transporting water, the earth screw – anchoring the slab.

Plastic is shredded into granulate and poured into a mould. The granulate-filled mould is heated in an oven, causing the plastic to melt. By pressing the mould together with a jack-screw the plastic obtains a new shape. Each component of the slab has their respective mould. The production takes place in a simple shed-workshop supplied with electricity. Power can be obtained from existing electricity network or by mounting solar panels on the roof of the shed-workshop. To produce one slab it takes approximately 24 plastic bottles.

The puzzle pavement fulfils the following features:

- **MANAGE WATER**

The puzzle pavement manage water runoff. This water can then be reused.

- **PREVENT RE-SWIRLING DUST**

By covering the dirt roads, the puzzle pavement hinders the spread of dust into the air and helps improve the air quality.

- EASE OF TRANSPORT

The pavement supplies a flat surface to facilitate safer transport.

- SLOW DOWN EROSION

The internal design of the slab slows down the speed of water during heavy rainfall and therefore reduces the risk of erosion on the underlying dirt streets.

- AFFORDABLE MATERIAL

The production of the pavement is affordable since the material is recycled plastic.

- LOCALLY PRODUCED

Producing the slabs locally minimizes cost and generates work and income opportunities for people living in the informal settlements.

- DURABLE

The pavement is able to handle pressure from both pedestrians and lighter vehicles.

- EASY ASSEMBLY

When combining the different pieces with each other, the size and shape of the slabs are suitable for simple assembly and material efficiency.

- PLACED ANYWHERE

The slabs can be fitted almost anywhere.

- EASY ORIENTATION

By using different colours of the pavement, streets can easily be recognized. This provides better orientation and allows people to associate themselves with different areas.

- PERMEABLE JOINTS

Apart from transporting water, part of the rainwater during heavy rainfall drains through the joints into the underlying dirt. This reduces the risk of flooding and moistens the dirt, further preventing re-swirling dust.

- POSSIBLE TO RELOCATE

If infrastructure investments are made demanding replacement of the puzzle pavement, the slabs and the workshop can be relocated to another informal settlement where it is needed.

## SCENARIO

To present the process of our concept we created a scenario where the puzzle pavement could reach its full potential through its implementation in an informal settlement located adjacent to a larger city. The border between the city and the informal settlements is obvious as the quality of buildings and infrastructure is much lower in the informal settlement. The scenario is located in an arid climate with periodically heavy rainfall. In the informal settlement there are no paved streets. There is a lack of fresh water and the air quality is poor due to dust. This leads to many problems. The dirt roads are bumpy which makes transportation unnecessarily hard. Since the informal settlement is not legally accepted there are no street names, leading to difficulties in orientation within the dense overcrowded settlement. During the dry season dust from the unpaved roads re-swirls, polluting the air and creating a layer of dust everywhere. The poor air quality has negative health effects on the residents. The main problem during the rainy season is erosion. The water causes erosion on the streets, leaving a muddy and rough sludge behind. It can also undermine structures and houses. Most of the rainwater is absorbed and drained by the soil and can therefore not be used. The lack of fresh water forces the residents to buy their drinking water by bottle and constitutes a daily expense.

The scenario include four phases;

**The preparation phase** involves identifying potential sites within the informal settlement where the puzzle pavement is most needed. This will be the streets where problems concerning transportation, erosion and dust are at its worst. Low points to where the water can be directed must also be identified. The residents have knowledge of where to begin. A small shed-workshop is built where it is easy to locate. The workshop needs access to electricity. In the workshop are all the tools needed for producing the puzzle pavement.

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Laying out the puzzle pavement constitutes **the implementation phase**. The finished product will be placed along streets, in front of houses and in open spaces, creating a seamless pavement. Residents helping to lay out the slabs are compensated. The implementation phase proceeds simultaneously with the production phase.

Using different colours on the slabs in different streets and spaces, contribute to better orientation in the informal settlement. The different colours can resemble street names, which lets the people recognize themselves as residents of the settlement giving them a greater sense of belonging to the neighbourhood.



One of the main functions of the puzzle pavement is to facilitate means of transport by creating an even surface of the streets. By covering the existing dirt streets the pavement reduces the amount of dust in the air and thus contribute to a cleaner and less hazardous air quality. When heavy rainfall occurs, the puzzle pavement helps by slowing down the movement of water runoff, reducing the risk of erosion. The puzzle pavement leads rainwater to topographical low points. The water can either be stored or be directed to plants as irrigation. Stored water can be reused for irrigation or treated for drinking water.

**In the concluding phase** the puzzle pavement has strengthened the bonds and erased part of the differences between the informal settlement and its surrounding city. The puzzle pavement is in this case not meant to be a permanent solution, but rather a way of consolidating the informal settlement with the city. If the informal settlement is legally accepted and investments are made in the area, real pavement, named streets and infrastructure can replace the puzzle pavement. The puzzle slabs and the workshop can easily be removed and relocated to another informal settlement where it is needed.



DANIEL ERIKSSON

## PROFESSION

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## DENCITY COMPETITION ID

17-3779

Daniel Eriksson comes from the small country town of Skänninge, Sweden. He is a senior year landscape architect student at the Swedish University of Agricultural Sciences in Uppsala. In his future career he wishes to work with how design can address important issues of the world, design being a way to solve problems rather than achieving mere aesthetic values. Landscape architecture as interpreted by Daniel is a way of improving an area with a holistic approach. By working in the public realm a landscape architect has the ability to design solutions that affects everybody. The competition DENCITY 2017 constitutes a part of Daniels and Jonathans master thesis.

When Daniel has time to spare from trying to save the world he likes to do sports such as road cycling and alpine skiing. He is also interested in music, art and food. Daniel was interested in this particular competition as it, as well as himself, strives to implement design as a tool for solving real world problems.



JONATHAN ANDERSON

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## DENCITY COMPETITION ID

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Jonathan is from the city of Gothenburg in Sweden. During the last five years he has studied landscape architecture at the Swedish University of Agricultural Sciences in Uppsala. The combination of nature and design was the key factor that attracted Jonathan to becoming a landscape architect, but also the ability to design the outdoor environment and in turn affecting peoples everyday life.

During Jonathans spare time he likes to spend time outdoors, both for recreation purpose and sport. He also enjoys smaller project, restoring broken things and making them work again.

Jonathan has spent one term abroad, studying at the University of Manitoba in Canada. During this term he found the theory of urban acupuncture interesting where using small scale interventions can transform to the larger urban context. During his internship he had the opportunity to work at Tengbom in Stockholm, ranked as the fourth most innovative practice in the world by Fast Company. Today he is studying his last year of his masters, where the competition DENCITY 2017 is part of his and Daniels master thesis.