URBAN ARID GREEN

A sustainable approach to address population growth and urbanisation in arid areas, via a case study to Tamansourt

Rosa de Wolf, January 2023

COLOPHON

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Cover image: View on Tamansourt, photograph taken from roof of social housing complex, by author (May 2022).

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Author
Name: R.J.A. (Rosa) de Wolf
Student number: 4663322
Contact:

Educational institution
University: Delft University of Technology
Faculty: Architecture and the Built Environment
Master: Architecture, Urbanism, and Building Sciences
Track: Urbanism
Graduation lab: Urban Ecology & Ecocities
Adress: Julianalaan 134
2628 BL Delft
The Netherlands

Supervisors
First mentor: Dr. ir. N.M.J.D. (Nico) Tillie
Second mentor: Ir. K.P.M. (Kristel) Aalbers
Delegate of the Board: Dr. ir. H. (Hielkje) Zijlstra

As the common languages in Tamansourt are Arabic and French, some literature and interviews are translated by the author into English as accurately as possible. Any misinterpretation falls on the author.

The Urban Arid Green project searches for a sustainable approach to address population growth and urbanisation in arid areas, via a case study to Tamansourt.

Before the start of my graduation year at TU Delft, I never heard of Tamansourt. On top of this, the Moroccan climate, context and culture were completely new to me. During the Urban Arid Green project, I visited the Marrakech region to familiarize myself a bit more with these aspects.

Part of the research by design presented in this Urban Arid Green project is based on the experiences I gained.

Perhaps you, like me, are unfamiliar with Tamansourt, or Morocco in general. I will introduce the site to you via this ***Urban Arid Green report****. Through the* ***Urban Arid Green Photo book****, I hope to convey some of the on-site experiences.*

De Vernauwing (2002), a painting by Hans Deuss, displays my fascination for the topic of urban design and landscape restoration in degraded areas, and it inspires me daily.

In my opinion, the painting shows the current, disastrous status nature finds itself in. Nature's sunlight is being blocked, and its growth is taken away by a closing gap. For me, the painting shows the urge to widen the gap.

On the other hand, the painting shows the resilience of the natural system. It illustrates how very little it needs to flourish.

To me, the closing gap resembles the human activities that are harming nature worldwide. Nature retaliates with the effects of climate change. We have to act now, change our habits, and reopen the gap.

Luckily, nature does not need to be cared for. However, we can help the natural system by providing it with a kickstart of healthy soil and other fundamental needs.

As an urban designer-to-be, I aim to design for a sustainable interaction between human and natural systems.

Figure 1: De Vernauwing - Hans Deuss, 2002

PREFACE

This Urban Arid Green report is the outcome of a one-year graduation project in the Urban Ecology and Ecocities graduation studio at TU Delft.

I want to thank my first mentor, Nico Tillie, for his infectious enthusiasm for urban ecology and his encouragement throughout the past year. Nico helped me find this interesting project and he got me in contact with Kirstin Miller and Mr Abdelaziz. Who I both want to thank as well, for their feedback and support.

My second mentor, Kristel Aalbers, has been an inspiration to me throughout my full education at TU Delft, as she fueled my passion for urban design since the bachelor programme. I am very grateful for her guidance during this year.

I want to thank all on-site experts, the locals in the Marrakech region and at Al Omrane Tamansourt and of course the experts from practice, Roeland Lelieveld and Tom Wilms for the inspiring conversations.

My family, friends and Luuk were a never-exhausting source of encouragement and support.

Please enjoy reading the Urban Arid Green report, many thanks.

Rosa

GLOSSARY

Agrotourism is a form of tourism that involves any agriculturally based operation or activity.

Agroforestry is a mixed cultivation system where trees (forest) are combined with crops (agriculture) on the same plot.

Al Omrane is a Moroccan state company, an operator-developer that implements the State's policy on housing and urban development.

An arid climate is a dry climate, the potential annual evaporation of soil and evapotranspiration of vegetation exceeds the average annual precipitation.

The biosphere or ecosphere, are all ecosystems on earth together.

Bottom-up is a management form where all stakeholders involved get a voice in decision-making.

Desertification is land degradation in arid to subhumid areas resulting from various factors such as climatic variation and human activities.

Ecocity is an ecologically healthy city. This definition is explained further on page 25.

Ecocity Morocco is a Moroccan national-scale project to design and build new ecocities and eco-districts across the country. The project is led by the Moroccan state company Al Omrane.

Ecocity Builders is a non-profit organisation that develops and implements tools and strategies to build thriving urban centres while reversing patterns of sprawl and excessive consumption.

An ecosystem contains all biotic and abiotic components that interact with each other.

Ecotourism is a form of tourism involving responsible travel by conserving the natural environment and improving the well-being of the locals.

New towns are completely new urban structures, built from scratch.

Overgrazing is the repeatedly grazing of vegetation by livestock/wildlife, at such a pace that the vegetation does not have the time to regrow.

Pathways are a sequence of patterns/guidelines, together forming a pattern language.

Patterns are design statements and/or images that illustrate desired design elements and qualities in (re)development projects.

The pedosphere is the earth's outer layer, including soil and soil formation processes. It is the earth's soil mantle.

Reforestation is the act of regenerating a forest.

Regenerative landscapes restore the environment and encourage long-term sustainability, increase biodiversity, and enhance resilience.

Regreening is the transformation of degraded landscapes via agroforestry and sustainable land management practices.

Rewilding is conserving nature by letting it take care of itself. Natural processes are let to repair damaged ecosystems and restore degraded landscapes.

Top-down is a management form where decisions are made solely by the top of an organisation, company, foundation, etc.

Urbanisation is a shift in population: a decrease in the proportion of the population living in rural areas. Movement from rural to urban areas.

Unsustainable growth is (population) growth that cannot continue at the same rate without creating problems.

The watershed is the total runoff by an area conveyed by the same outlet.

ABSTRACT

The climate crisis and unsustainable growth are worldwide interrelated problems. Population growth increases the demand for natural resources and the demand for housing. This is all putting pressure on the natural system and is strengthening the conflict of space between the built environment, agricultural land and the natural landscape. Drylands are expected to expand due to climate change and human activities. As the natural resources are already scarce in these regions, human societies who live there are challenged even more by population growth. Including the future generations. The conflict of space deteriorates the quality of life and space in these regions. To counteract this development, measures must be taken now.

This research proposal searches for an integral approach to sustainably address population growth and urbanisation in arid regions. This is done via a case study of the Moroccan new town Tamansourt. Tamansourt is one of the nineteen Moroccan new cities developed via the state-led national-scale Villes Nouvelles strategy. Tamansourt, Marrakech's satellite city, is the first new town under this strategy, it is founded in 2004. The spatial analysis, site visit, and interviews conducted in this research show that the city of Tamansourt is still under construction. The city has not reached its target population nor its desired level of urban activity yet. However, environmental issues already manifest themselves in the city, which resulted in the national government's aim to transform Tamansourt into an ecocity.

In the Urban Arid Green project, the vision Tamansourt Ecocity 2040: Regreen to Rewild is formulated. This is a proposal to advance on a transformative framework for Tamansourt towards an ecocity. This could help Tamansourt to reach its original goals, respond to current injustices and face the environmental crises at the same time.

To transition Tamansourt into an ecocity, systemic change is needed. The environment must be harnessed. The now degraded soil quality must be restored. This environmental change can be sparked by making optimal use of the limited amount of water. By educating, training and employing the local community, the ecocity can be co-created, using bottom-up initiatives and top-down support.

To support this systemic change, a common language among all future stakeholders is needed. This common language is developed as a set of urban development guidelines, patterns. This is a brief visual overview of all measures included in the systemic change, vision, and design of Tamansourt Ecocity 2040. The patterns focus on the biosphere and add to the original design guidelines for Moroccan new towns, which were developed by Al Omrane in 2010. Together, they form the Urban Arid Green pattern language which aims to sustainably address population growth and urbanisation in the arid region.

In the Urban Arid Green project, the case of Tamansourt is used to show how to translate these generic patterns and ecocity principles into a unique site-specific design. Design proposals on the neighbourhood scale are made for several key locations in the Tamansourt Ecocity 2040 vision. The design aims to formulate a framework for the stakeholders to use in the city's transition towards an ecocity. This framework aims for a triple scope of better services, amenities, and connections on one hand and to counteract environmental decay and climate change variability on the other. Via an adaptive pathway approach, the process can adapt to future uncertainties, while learning from the past. This approach allows different scenarios to reach the Tamansourt Ecocity 2040 goal.

The process of applying these patterns to the Tamansourt Ecocity 2040 project was one of constantly adjusting, designing, and testing. By testing the method in Tamansourt, other arid landscapes that need to sustainably address population growth and urbanisation, can learn from this, and use it as a tool to communicate with all different stakeholders involved. Every landscape might need to add its own site-specific pathway to the pattern language. By this, the Urban Arid Green Language allows unique dialects for different landscapes.

Tamansourt sets the example to other urban arid areas, being the first new town ecocity, focused on a regenerative productive urban landscape.

Unsustainable growth, aridity, natural resources, new towns, spatial quality, co-create, ecocity

TAMANSOURT CASE STUDY

SYSTEMIC CHANGE

URBAN ARID GREEN

Figure 2: Urban Arid Green Graphical Abstract

CONTENT

INTRODUCTION

This chapter introduces the problem field and problem statement.

CHAPTER'S CONTENT

1.1 Problem Field

Global / Continental / National / First generation / City

1.2 Problem Statement

1

1.1 PROBLEM FIELD

Global - The world population is growing, and it is predicted to continue growing from 7,7 billion in 2019 to 10,9 billion in 2100. Cities today are facing challenges due to this growth. Most of this growth is projected in low-income countries, where societies are more dependent on natural resources. This population growth, together with urbanisation and economic development increases the need for food, water and energy. To produce more food, either crop productivity per area has to increase, or cropland has to expand (Maja & Ayano, 2021).

Drylands, as visualised on the map in Figure 2 on the next page, include dry subhumid to hyper-arid areas.

At the moment, over two billion people live in drylands. Unfortunately, drylands are projected to continue growing due to the effects of climate change (Rajaud & Noblet-Ducoudré, 2017).

The economy of many countries located in arid regions is highly dependent on the agricultural sector. Due to climate viabilities, farmers' crops are threatened by too much, too little or unplanned rainfall (Keeton & Provoost, 2019, p. 34). Increasing demand for water for the agricultural sector, to irrigate the land, increases water insecurity (Hill & Pimentel, 2022).

Unfortunately, in these arid areas, there already is scarce access to natural resources. Limited water is one of the main problems in these areas. On top of, or because of, this, the overall wealth and health of the human societies living in these drylands are lower than for those living in humid areas (Rajaud & Noblet-Ducoudré, 2017).

The African continent is mainly covered by dryland, with a large hyper-arid surface in the northern part of the continent.

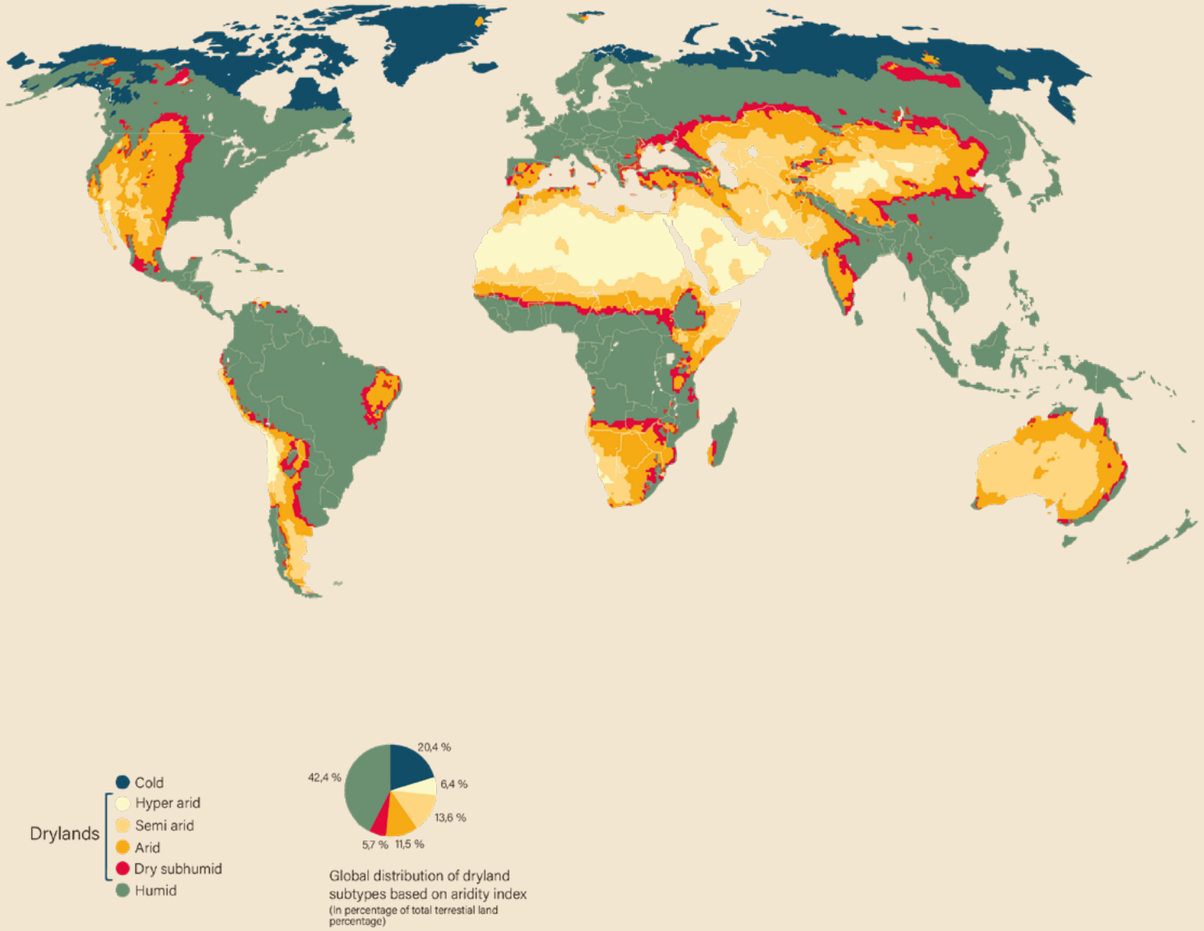


Figure 2: Global distribution of dryland subtypes based on aridity index, (World Atlas of Desertification, n.d.).

Continental - Due to the worldwide trends of urbanisation and population growth, many cities are facing difficulties. This can be dealt with by densifying or expanding already existing cities, or building new urban settlements from scratch. The latter, these so-called new towns, can be found in many countries worldwide.

Africa is an extremely fast urbanising continent, which is accompanied by population and urban growth. Besides land mismanagement and depletion of natural resources, inequalities and social issues are strengthened. In Africa, many new towns have been built (Keeton & Provoost, 2019).

Unfortunately, almost all new towns in Africa are vulnerable to present and future climate variability and climate change (Keeton, 2020). As can be seen in Figure 3 on the next page, the Moroccan new towns all face the risk of desertification.

Figure 3: Climate Change Threats, (Keeton, 2020).

National - Morocco's rapid population and urban and economic growth sparked a drastic change in the Moroccan urban landscape. The growth created a housing shortage. To manage the uncontrolled urbanisation and to support the economic growth of the country, a state-led, national-scale urban development plan arose. With the so-called Villes Nouvelles strategy, nineteen new towns were founded (Côté-Roy & Moser, 2022). The geographical distribution of the new towns in Morocco is shown on the map on page 21, on the next page.

Tamansourt, Tamesna, Lakhyayta and Chrafate are the four first-generation satellite new towns. This first generation of new towns is founded between 2004 and 2009. As shown in de diagram in Figure 4 below, these cities were all developed under the purview of the Ministry of Habitat and Urban Planning. According to Côté-Roy & Moser, (2022 - p. 34), there was scarce consultation between this ministry and other relevant ministries.

Because of this scarce consultation, there has been low governmental support for the first generation of new towns. This is now threatening access to the fundamental services in the new towns (Côté-Roy & Moser, 2022 - p. 34).

Since building a completely new urban, integral structure from scratch concerns a long-term process, not a short-term product, inevitably, the city does not immediately meet all demands and wishes in its first formative years. However, after 18 years, it is time to evaluate the first-generation new towns.

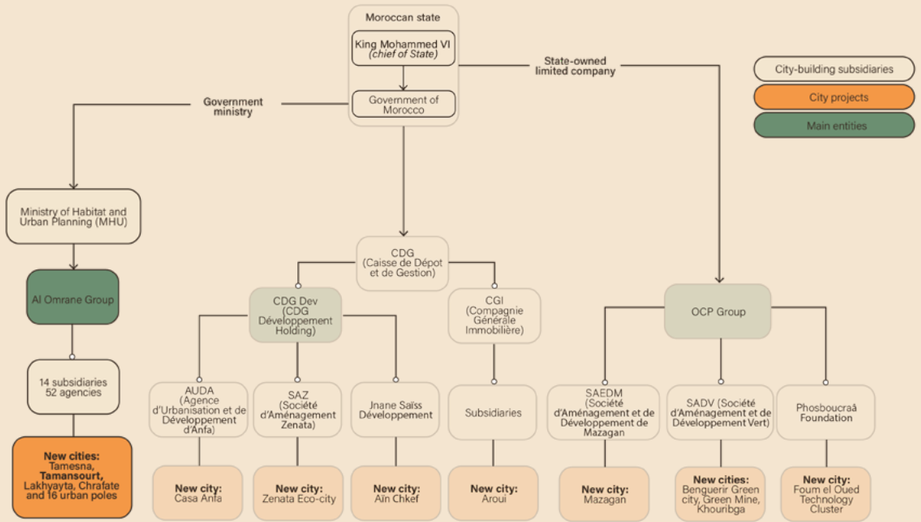


Figure 4: Institutional structure development of Villes Nouvelles. Made by author based on (Côté-Roy & Moser, 2022 - p.34).

Figure 5: Geographical distribution of new cities in Morocco. Made by author based on (Côté-Roy & Moser, 2022 - p.30) >

First generation - The four first-generation new towns are all designed as satellite cities between 2004 and 2009. They were all founded under the purview of the Ministry of Habitat and Urban Planning. At the moment, there is the aim to transform the first-generation new towns, together with three other towns, into ecocities. This transformation project is led by Al Omrane, the state company that developed the cities (Ecocity Morocco, n.d.).

Lakhyayta is located 20 km from Casablanca. The city aims to decongest the economic capital of Morocco and aims to become a new urban and economic hub (International New Town Institute, 2017).

Tamesna is a satellite city of Rabat and was also founded to absorb the fast population growth. In addition, it aims to resettle slum dwellers of the surrounding communities. Since 2015, the development process seems to have stopped due to the lack of finance of two developer companies (Bladna, 2015a). On top of this, fifty buildings have already been demolished as there were severe safety issues (Bladna, 2015b).

Chrafate is located 18km from Tanger and is built as a response to the increasing housing demand. It is planned to house future employees of the nearby Tanger Med and the industrial site of Melloussa and their families. In Melloussa, the Renault factory will be built (Bladi, 2009).

Tamansourt is built in 2004 as the first town built under this strategy, to prevent Marrakech from overpopulation and congestion. Furthermore, Tamansourt stands out by being the oldest new town, covering the largest area and with 450.000 inhabitants, it is aiming for the highest target population.

As visualised in the overview in Figure 6 below, the landscape of each town is very different. Tamansourt is the most barren one.

The total overview of the area, launch dates, urban form, target population and project managers of the nineteen new cities developed in Morocco can be found in Appendix I.

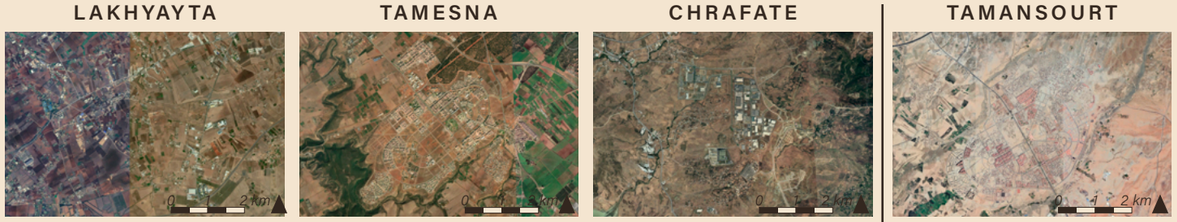


Figure 6: Comparison between first generation of New Towns. Images retrieved from (Google Earth Pro, 2022), facts from (Côté-Roy & Moser, 2022 - p.30).

City - Tamansourt's climate is arid. The city is located in the Tensift Basin. Here, the amount of groundwater and surface water is becoming more and more limited (Fniguire, Laftouhi, Saidi, & Markhi, 2014). The area deals with a strong seasonal contrast with periods of heavy and concentrated rainfall with floods and periods of extreme droughts (Abdelaziz, Driss, Hassane, Rania & Mohammed, 2022).

People moved to Tamansourt to access urban amenities and job opportunities more easily. Most of the housing of Tamansourt is social or affordable, but there are inadequate job opportunities and urban amenities within the city, such as public transport links. The main goal for Tamansourt was to create a low-density, green city with harmonious mix among its residents. Unfortunately, Tamansourt, *nicknamed dormitory city*, did not reach these goals yet (Keeton & Provoost, 2019).

In figure 7 below, the situation of Tamansourt is depicted. The satellite city is located 10 kilometres northwest of Marrakech. In between both cities, the Tensift river is located and Tamansourt is enclosed by two wadis that originate from the Jebilets. Due to the Marrakech - Safi highway, the commute time between Marrakech and Tamansourt is only 15 minutes. Many people living in Tamansourt commute to Marrakech to enjoy activities.

At the moment, in 2022, 70.000 people live in the city while it has a target population of 450.000 people. As its population is growing, the city is still under construction. When Tamansourt, with 1.950 hectares of surface, reaches its target population it would be an intense dense city.

During the site visit in May 2022, I noticed that Tamansourt is indeed lacking some fundamental services, such as a hospital for healthcare or a good public transport system. However, the city is still under construction and Al Omrane Tamansourt plans to add these urban amenities. For instance, they aim to develop a hospital, and other services such as a university campus in the nearby future.

Figure 7: Scheme situation Tamansourt

The images in Figure 8 on the right illustrate the land degradation of Tamansourt. The first image, an areal view from the construction-site-to-be in 1985, shows clear green structures of several wadis. In 2006, two years after the city was founded, these structures are less green. In 2021, the green completely disappeared. The wadis now only function as erosion gulls, lowering the infiltration capacity of the soil. The images on the right clearly show a degradation of the landscape and the ecosystem, along with the shift in focus towards the built environment. These developments seem to be linked.

As mentioned, the city is expected to densify further. This could intensify the degredation when the city continues unsustainable development. For the transition of Tamansourt into an ecocity, as suggested by Al Omrane, spatial redevelopment is needed. The ecocity principles must be translated into a spatial design.

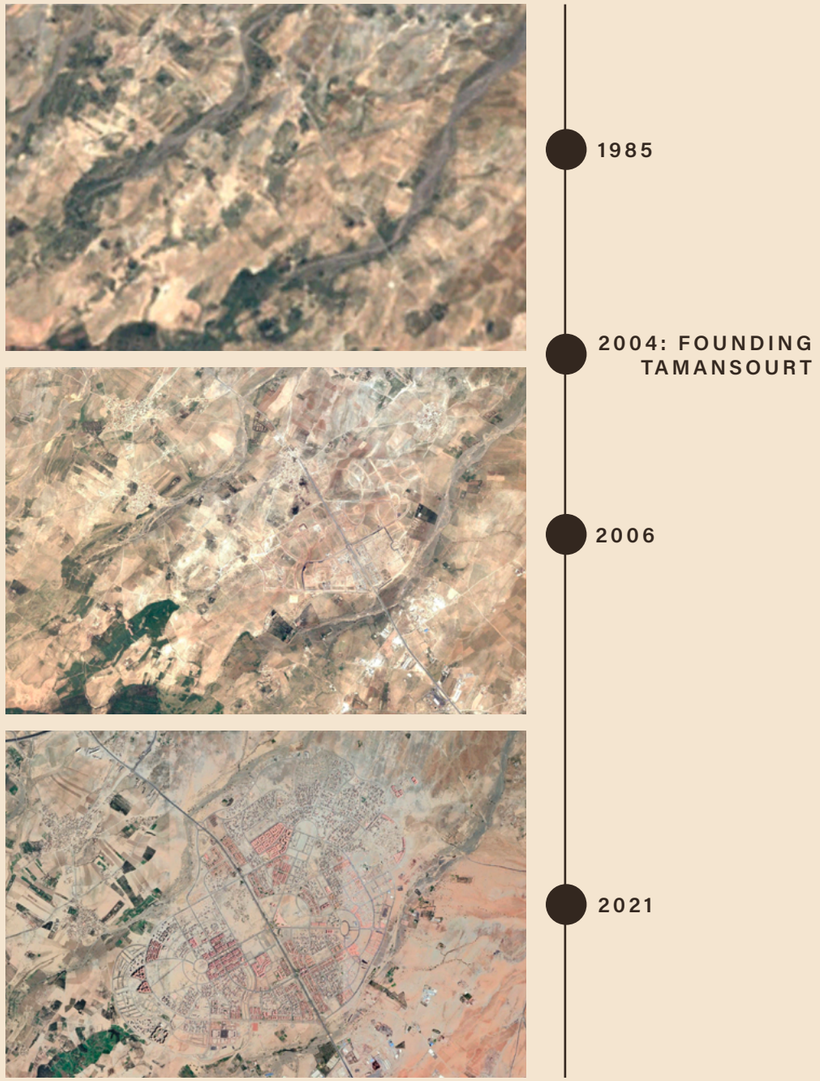


Figure 8: Timeline development site Tamansourt. Images retrieved from (Google Earth Pro, 2022)

1.2 PROBLEM STATEMENT

Natural resources are unequally divided world wide. The wealth and health of human societies living in drylands are affected by the scarcity of these resources. The African continent is mostly covered by drylands. Africa faces the largest population growth and strongest urbanisation rate, which is intensifying pressure on resources.

The Moroccan new towns all face the risk of desertification as a result of climate change, which is strenghtening the scarcity of resources.

Tamansourt is planned to be extremely dense. Most of the housing in Tamansourt is social or affordable. Unfortunately, there are inadequate job opportunities and urban amenities within the city.

The new town now occupies the originally unpaved, natural landscape. The landscape in and surrounding Tamansourt degraded over time, and the linear green structures vanished.

The challenge for this new urban fabric is to facilitate a sustainable interaction between the built environment and the natural system. One that allows Tamansourt to grow into and facilitate a harmonious mix amongst its residents.

The urban fabric of new towns does not have any historical layering and the social layer only started recently. There is no direct appropriation of space. The urban fabric must allow this to develop.

It is time to consider a sustainable and systemic pathway to address population growth and urbanisation in arid areas. In Urban Arid Green, the Moroccan new town Tamansourt will be used to set an example to other urban arid areas.

Within the built environment of Tamansourt, the challenge is to design a public space that stimulates use among residents whilst following the planned dense urban layout. It is critical to rethink the interaction with the public space, to shift focus from Marrakech-oriented (out) to Tamansourt-oriented (in). To make the nickname dormitory-city a thing of the past.

Urban Arid Green will focus on a translation of the ecocity principles into a spatial design that allows a sustainable interaction between the human and natural systems.

PROJECT APPROACH

In Chapter 2 'Project Approach' the research is introduced. The chapter kicks off with the theoretical underpinning and conceptual framework. This results in social and scientific goals and aims for the research project. Based on this, the research questions and methodology of the project are formulated.

CHAPTER'S CONTENT

2

2.1 THEORETICAL UNDERPINNING

Worldwide, people and the planet are facing problems, now and in the future. Urban Arid Green searches for an approach wherein urban design can contribute to solving these problems, by sustainably addressing population growth and urbanisation in arid areas. Already existing literature and notions are reviewed and synthesized to formulate a framework for the Urban Arid Green project.

The layers approach

In the layers approach, developed by De Hoog, Sijmons & Verschuuren (1998), the landscape is explained as a composition of the occupation, network and substratum. Each of these layers is formed by different elements and each layer has a different development timeframe. The upper layer is the most dynamic, and the lowest layer most stagnate. According to the authors, the three layers must be in balance with each other. The natural system must be taken into account in the development and layout of the occupation layer. To make sustainable choices, one must consider all layers, as they affect each other.

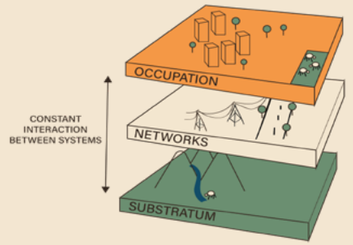


Figure 9: The layer approach by author based on (De Hoog, Sijmons & Verschuuren, 1998).

Sustainable Development Goals

In 2015, the 2030 Agenda for Sustainable Development was launched. This agenda provides a globally shared master plan for sustainable development, specified in seventeen Sustainable Development Goals (SDGs). The goals are a global call for action to build peace and prosperity (UN 2015).

Figure 10: Sustainable Development Goals. (United Nations, 2019).

Integrated Sustainable Development Goals

The Stockholm Resilience Centre (2016) integrated the Sustainable Development Goals of the United Nations as visualised in Figure 11 below.

In this integrated model, the biosphere functions as a foundation for society and economy, and thus for global sustainability. The biosphere includes the SDG's concerning life on land, life below water, clean water & sanitation and climate action (Stockholm Resilience Centre, 2016).

Figure 11: Integrated Sustainable Development Goals. (Stockholm Resilience Centre, 2016).

The integrated SDG's as well as the layers approach emphasize the importance of the biosphere. While designing for global sustainability, it is crucial to incorporate this layer. The biosphere includes all ecosystems on earth together, including ours. Especially in urban areas, the built environment is part of this. The goal is to sustainably address the growth of our own ecosystem, taking into account the others.

Placemaking
Placemaking zooms in on the urbanised landscape. Placemaking is 'a progressive practice and process, in which policymakers, nominated experts, and community stakeholders collaborate to deliver on a mutual vision for change in the built environment, and approaches to community flourishing' (Horgan, 2019).

According to the Place Diagram as formulated by Project for Public Spaces (n.d.), the four main principles to make a great place are Sociability, Uses and Activities, Access and Linkages, Comfort and Image.

The diagram aims to make local designers and decision makers consider general factors which compose a successful public space.

Figure 12: Place Diagram (PPS, n.d.)

Climate change adaption
Due to the events of increased temperatures, heat waves and urban heat island effects, the efforts to create comfort, are altered. According to Santos Nouri & Costa (2017), the place Diagram therefore needs to consider additional aspects concerning climate change adaption.

In the by them reconstructed Place Diagram, the intangibles Continuity, Proximity, Connected, Readable, Walkable, Convenient and Accessible are added.

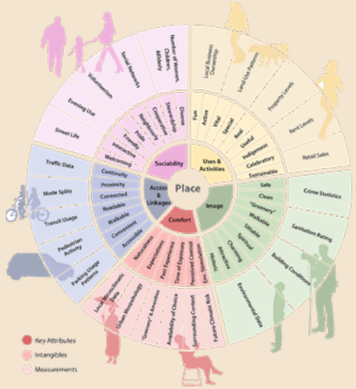


Figure 13: Restructured Place Diagram (Santos Nouri & Costa, 2017)

Nature-based Solutions
Nature-based Solutions have great potential to address the causes and consequences of climate change (Seddon, Chausson, Berry, Girardin, Smith & Turner, 2020).

Nature-based Solutions are 'actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively, adaptively, simultaneously providing human well-being and biodiversity benefits.' (Cohen-Shacham et al., 2016).

Figure 14: Nature-based Solutions approaches and outcomes (van Eekelen & Bouw, 2020, p.14).

Ecosystems seem to play a role in addressing societal challenges and improving comfort for humans and non-humans. As via urban design, we aim to create great places, for all, these ecosystems must be harnessed. Designing with these actions, Nature-based Solutions, becomes an object

Building with Nature
Building with Nature is a knowledge-based approach to implementing Nature-based Solutions.

'Building with Nature means working with, rather than against nature. It goes beyond nature development or nature compensation to integrate natural processes as an essential part of the design' (van Eekelen & Bouw, 2020, pp. 11 - 15).

Building with Nature designs uses natural materials, forces and interaction and creates opportunities for nature to develop. The designs present more cost-effective, resilient and multifunctional solutions and encourage sustainable and innovative practices. They often benefit multiple stakeholders. The Building with Nature design follows five steps of development. The development starts with understanding how the linked physical, ecological and societal systems function (van Eekelen & Bouw, 2020, p.15).

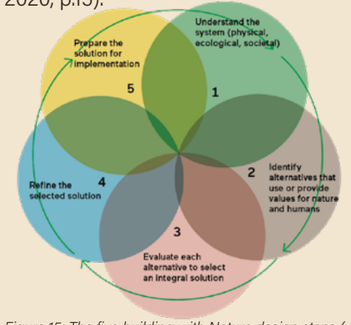


Figure 15: The five building with Nature design steps (van Eekelen & Bouw, 2020, p.15).

Building with Nature seems necessary to include in any sustainable development project. The urban aspect, the built environment, seems to be left untouched in the Building with Nature design approach. Sustainable urban development seems to require more than Building with Nature only, the synergy of Building with Nature and Placemaking seems to express itself in landscape-based urbanism.

Landscape-based urbanism
According to Nijhuis (2022, p.251), landscape-based urbanism is 'a multi-scale planning and design approach for developing resiliency and adaptive capacity by creating flexible, strong socially and ecologically inclusive landscape structures, connecting long-term perspectives with short-term interventions using research through design as wayfinding in a transdisciplinary process..'

Ecocities
The idea of the ecocity matches the landscape-based urbanism approach. The Ecocity Builders formulated the ecocity definition as follows (2010): "*An Ecocity is a human settlement modelled on the self sustaining resilient structure and function of natural ecosystems. The ecocity provides healthy abundance to its inhabitants without consuming more (renewable) resources than it produces, without producing more waste than it can assimilate, and without being toxic to itself or neighboring ecosystems. Its inhabitants' ecological impact reflect planetary supportive lifestyles; its social order reflects fundamental principles of fairness, justice and reasonable equity.*".

Figure 16: What Is An Ecocity? (Ecocity Builders, 2010).

It is needed to understand the landscape as a whole, where seemingly separated systems are interlinked, and constantly interact with each other. This understanding allows us to restore and strengthen the natural system and allows the urban design to aim for great, resilient places that contribute to global sustainability. Places such as ecocities.

2.2 CONCEPTUAL FRAMEWORK

The theories on sustainable development form the backbone of the Urban Arid Green project.

The scheme in Figure 17 shows the conceptual framework of the Urban Arid Green project.

The framework shows sustainably addressing population growth and urbanisation in arid areas as a systemic solution to global sustainability.

It shows the development as a main driver to affect all linked systems within the landscape. This includes the socio-cultural, biological and physical layers.

By Building with Nature, the spaces for action of the Urban Arid Green project, the productive landscape, the urban area and the waterscape, are interlinked with the systems. The developments aim for great, fair and resilient places.

Together, these places form an ecocity. When ecocities work together as one network, they contribute to global sustainability. The development fairly copes with the demographic trends of population growth and urbanisation. It mitigates the effects of climate change and uses scarce natural resources optimally by not using more (renewable) resources than necessary and by producing as little waste as possible.

These positive effects reduce the unequally dived pressure on human societies.

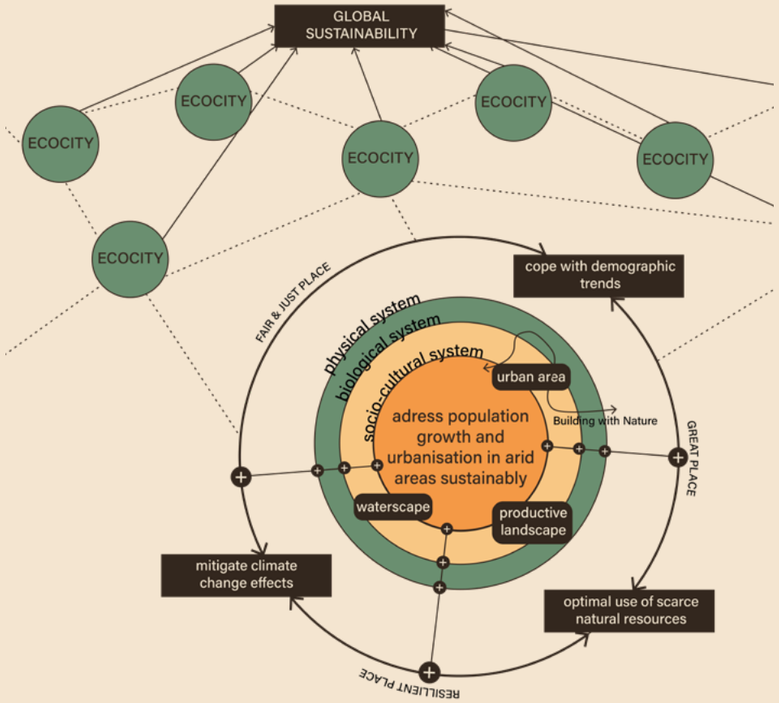


Figure 17: Conceptual Framework Urban Arid Green project.

2.3 RESEARCH AIM

The goal of the Urban Arid Green project is to show how the demand for housing and demand for natural resources can complete each other, instead of competing with each other and the natural system, for space.

The project aims to show how an ecologically healthy and vivid Tamansourt can be established. For this, the destruction of the natural system must be reversed.

The case of Tamansourt will be used to formulate guidelines to design with limited natural resources. These guidelines will be tested and spatially envisioned in the case of Tamansourt.

Many new towns are located in (Africa's) dryland, and therefore Tamansourt will have an exemplary function for other new towns located in these arid regions. Thus, the project aims to counteract the growth of arid areas and desertification and mitigate climate change via a holistic approach.

The **social relevance** of the Urban Arid Green project is to improve the quality of life and space for Tamansourts residents. By designing for a sustainable transition, the project will invest in the future (generations) as well. With this, the aim is to create a more just environment. As Tamansourt will have an exemplary function, this impact can be larger than Tamansourt only.

On top of this, there is **personal scientific relevance**. After studying at TU Delft, Faculty of Architecture and the Built Environment for 5 years, I've never learned how to design for periods of droughts, let alone in drylands. As in Africa, population growth and urbanisation are the most extreme, urgent challenges concerning urban design are found on the African continent. I think my own urban design vocabulary is lacking on these very important topics. Therefore, I see a scientific relevance for myself, to diminish this knowledge gap.

As shown in Figure 18 below, the top ten universities in the subject of Architecture & Built Environment are mostly located in humid areas. None of them is located on the African continent. Therefore, I believe this knowledge gap is wider than just me and I aim to diminish this potential research & knowledge gap on urban design in arid areas.

There already are best practices focused on this field. Within arid areas, there has been done a lot already. Initiatives such as Africa Wood Grow already aim for the regeneration of (semi-)arid areas. However, there is a missing link between the initiatives.

Urban Arid Green aims to bridge the gap between academia and practice.

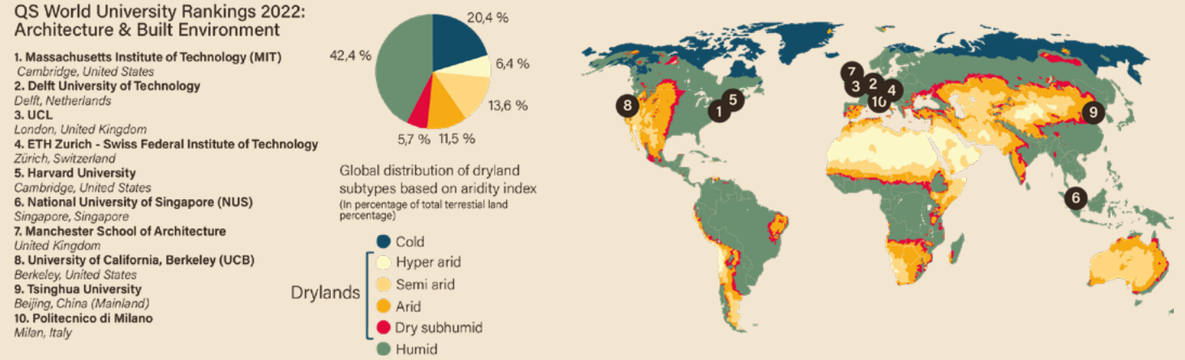


Figure 18: Global distribution of drylands (World Atlas of Desertification, n.d.) and QS Top 10 Universities Architecture & Built Environment (Top Universities, 2022).

2.4 RESEARCH QUESTIONS

Urban Arid Green searches for an approach to synergize human, natural and agricultural activities in the urban area. The focus lies on arid areas, to support the growing societies that face difficulties due to unequally divided resources.

The main research question this project aims to answer is:

How can population growth and urbanisation be sustainably addressed in arid regions?

The case of the urban, arid Tamansourt is studied to answer this question.

To answer this question, five sub-questions are formulated.

1. **How are population growth and urbanisation addressed in Morocco?**
2. **What is the current spatial quality of Tamansourt?**
3. **What are the goals and aims for Tamansourt?**
4. **How can Tamansourt systemically transition into an ecocity?**
5. **How can the ecocity principles be translated to a spatial design?**

These questions will be answered via an (spatial) analysis, by formulating a vision, strategy, and by designing for the potential spatial outcome, as shown in Figure 19 below. This methodology will be explained more in detail in the following paragraph.

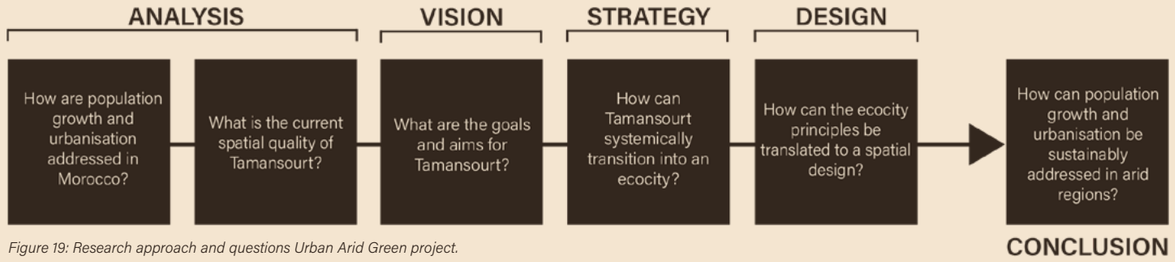


Figure 19: Research approach and questions Urban Arid Green project.

2.5 METHODOLOGY

The problem statement, space for action, conceptual framework and research question are explained already, based on the literature review.

Figure 20 on the next page is used to explain the methodology of the Urban Arid Green research by design project more in detail.

As explained in the introduction, Tamansourt is one of many arid new towns that is experiencing difficulties. Via a case study of Tamansourt, experience in facing these challenges will be gained. An approach will be formulated to sustainably address population growth and urbanisation. This process is generalised to be transferable to other locations and answer the main research question.

Analysis
The project started with a literature review of Moroccan policymaking on population growth and urbanisation and a comparison between the four-first generations of Moroccan new towns. Next, the analysis continues on the population of Tamansourt and water insecurities in Morocco. The spatial analysis following focuses on urban morphology. Here, the guidelines regarding the architecture, urban planning and landscape of Moroccan new towns formulated by the state-led company Al Omrane in 2010 are analysed to formulate an understanding of the urban form of this city under construction. Next, the Tensift Basin and agricultural activities and the vegetation in Tamansourt are studied.

Site visit and dialogues
During the site visit to Tamansourt, the effect of local vegetation on the climate was studied and dialogues with the local community were held. Compared to The Netherlands, Morocco is very different in culture. To better understand Moroccan culture, I started a one-year course in Modern Standard Arabic at NHA in February 2022. This effort helped me understand the culture a bit better, I believe this eased cross-cultural conversations.

Expert interviews
As the field of urban design does not cover the total scope of the project, lessons are learnt from expert interviews on ecosystem restoration via afforestation and water safety by nature-based solutions.

The four important principles formulated by Diener & Crandall (1978) were always kept in mind during the (preparation of) the communication with the locals and experts:

- Research participants should not be subjected to harm in any way whatsoever.
- Full consent was obtained from the participants before the study.
- To protect the privacy of research participants, all conversations with the locals are anonymised. The expert interviews were not anonymised and this was agreed on by the participants. The texts resulting from these interviews are approved by the experts. They could correct and exclude any information from the report.
- To avoid any deception or exaggeration about the aims and objectives of the research, the participants were informed of the project beforehand. Before the start of the dialogues, it was clearly stated that the research was part of an educational project.

Besides the dialogues with locals and experts, Al Omrane Tamansourt gave feedback on and input for the proposed project during a site visit on May 31, 2022.

Vision
Based on the analysis and the dialogues, a vision for Tamansourt is formed. This vision; Regreen to Rewild, Tamansourt Ecocity 2040 draws upon the original vision of Al Omrane and the Ecocity Builders. The already planned built volumes are fully kept intact.

Systemic change
The systemic change needed for this transition is defined. This results in environmental, policy and behavioural change.

Strategy
Tamansourt is not the only city that is pressured by climate change, population growth, urbanisation and scarce natural resources. To develop a strategy useful for other cities as well, the process is made understandable for all future

stakeholders, the Urban Arid Green pattern language is formulated.

The guidelines formulated by Al Omrane (2010) are translated and included in this language as one of four pathways. Three additional pathways, Circularity & Ecology, Supportive Lifestyles and Facilitating Fabric are formulated.

These guidelines are based on the analysis, interviews and formulated vision and systemic change. The focus of these socio-spatial guidelines lies in the biosphere to support the transition into an ecocity. Together, they form the Urban Arid Green Language.

Design
On key locations, design proposals have been made. First, a city scale plan shows that the urban form needs to transition from Marrakech- to Tamansourt-oriented. This transition is supported by a mobility shift. Due to this mobility shift, local hubs can sprout in the urban form. These local hubs are in constant exchange with the central hub, and both contribute to regreening the landscape.

Transferability
The design proposal explains how to translate ecocity principles into a potential spatial outcome. It provides Tamansourt with a framework to appropriate itself. Tamansourt functions as an example to other urban arid areas that aim to (re-)develop sustainably, under the pressure of scarce resources, population growth and urbanisation.

Via this methodology, the designed process is tested and finetuned, and sets an example to other urban areas.

By this, the main research question *'How can population growth and urbanisation be sustainably addressed in arid regions?'* is answered.

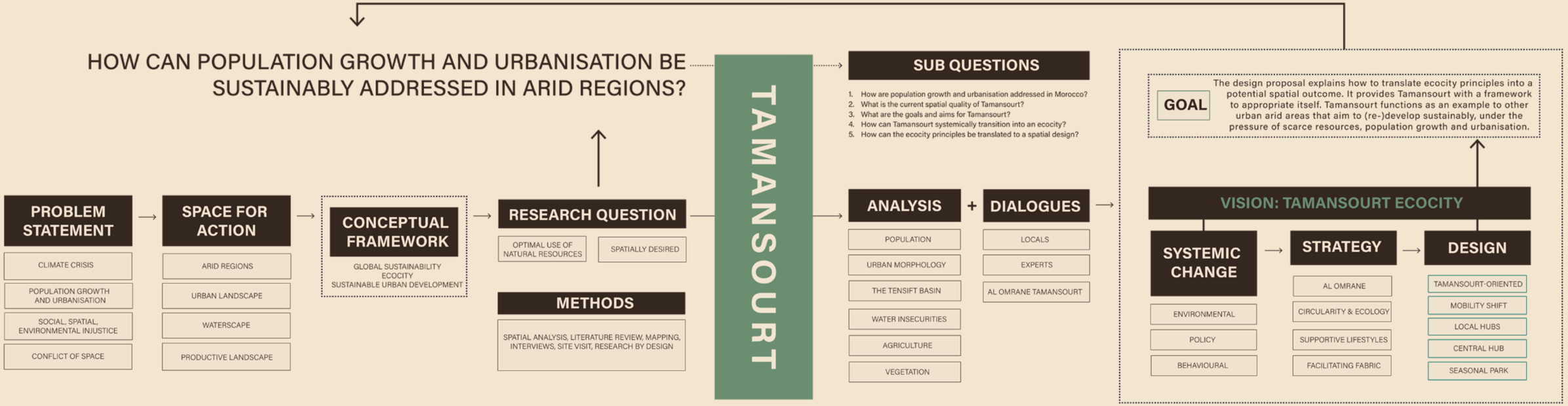


Figure 20: Methodology Urban Arid Green project.

ANALYSIS

Chapter 3 'Analysis' includes spatial analysis of Tamansourt. The methods used in this analysis are the site visit to the Tamansourt region in May 2022, literature reviews and mapping.

CHAPTER'S CONTENT

3

3.1 THE PEOPLE OF TAMANSOURT

Tamansourt is founded in 2004. The information in the population tree below, retrieved from city-facts (n.d.), shows the population of Tamansourt in 2015. Because of the rapidly growing population of the new town, the ratio might have changed since then.

What stands out in the population tree is the largest amount of people of age between 0 and 5. This suggests that most large families with young children live in Tamansourt. The median age is 24.6 years old. The ratio of females/ males is about equal.

As most of the housing of Tamansourt is social or affordable (Keeton & Provoost, 2019), it is assumed that the income of the population in Tamansourt is lower.

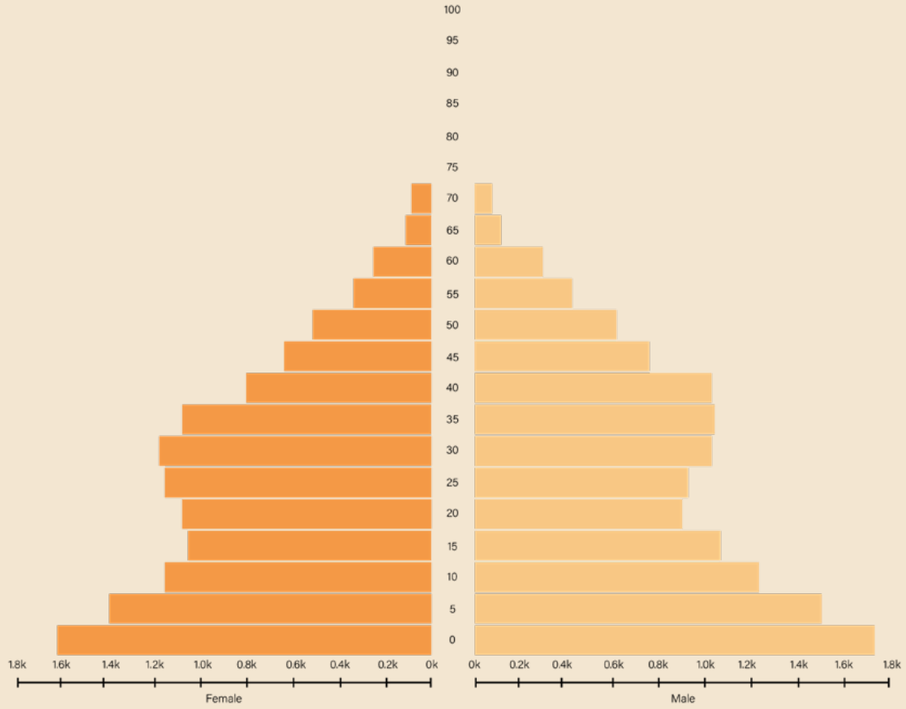


Figure 21: Population Tree Tamansourt, up untill 2015. City-facts (n.d.).

3.2 URBAN MORPHOLOGY OF TAMANSOURT

The urban formation, morphology, design and amenities are studied via literature review and experience-based research during the site visit in May 2022.

Several goals have been formulated for Tamansourt. The new town should accommodate demographic growth and urban sprawl and it should allow an economic revival. Furthermore, a low-density urban fabric with a green appearance should be created. The fabric should be interwoven with a wide variety of housing types to meet all potential demands (Abdelaziz, Driss, Hassane, Rania & Mohammed, 2022).

With 19,5 km² and 450.000 inhabitants, the aimed density is 23.077 inhabitants/km². This exceeds the ideal urban density of 15.000 inhabitants/km² as formulated by the UN-Habitat (2017).

Learned during the site visit, in Islamic towns, the mosque should always be the highest building in a city as it is an important sightline. Therefore, Tamansourt mainly consists of low-rise buildings. With this immense density, there is little open public space left.

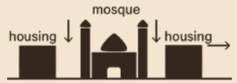


Figure 22: Diagram depicting building levels Islamic cities

The little open public space is covered by infrastructure, mainly wide strips of asphalt. Pedestrians cross the main avenue via pedestrian bridges, slow traffic gives way to fast traffic.

Figure 23: photograph pedestrian bridge main avenue Tamansourt

Because of the lack of historical layering, Tamansourt is very different from traditional Moroccan towns. Figure 24 below shows the current construction status of Tamansourt. The map shows the finished areas in orange, the other areas within the city's border (the outer road) are still to be developed or under construction.

Learning from the site visit in May 2022, there are few activities and services in Tamansourt, compared to cities with similar densities. On top of this, the job opportunities in Tamansourt mainly involve the construction sector in the city itself.

Outside the city's borders, formed by the outer road, the natural, barren landscape begins. People transport via private cars and stay inside due to a lack of activity outside. The urban form of Tamansourt, and thus the life of its inhabitants, is Marrakech- as well as private-oriented.

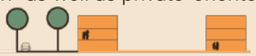


Figure 25: Diagram depicting mono-functional, private-oriented buildings and infrastructure.

However, Al Omrane planned several extensions to the city. They plan to add a university campus on the southwest, an industrial site with an economic zone on the west and even more social housing on the north. These areas will be developed outside the city borders displayed in Figure 24. With these extensions, Tamansourt is still aiming for that desired social mix and economic revival.

Both the zoning plans and phasings of the city are displayed in Figures 26-29 on the next page.

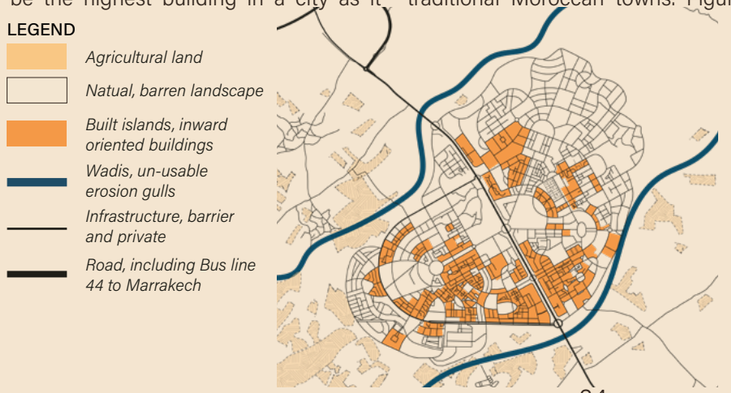


Figure 24: Map showing current status Tamansourt. Based on Google maps (March 2022).

ZONING

Figure 26: Zoning plan of Tamansourt. (Al Omrane Marrakech, 2008. p-181).

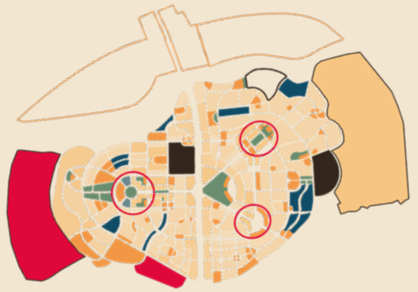


Figure 28: Zoning plan of Tamansourt with planned extension. (Al Omrane Marrakech, 2008. p-181, 183).

LEGEND *

Public facilities

- University campus
- Extenstion campus
- Parks
- Cemetery
- Old urban settlements
- Centres
- Industrial zone and economic activities
- Education / public health / culture and sports centers
- INT1: Artisanal activity zone & business centers
- INT2: Artisanal activity zone & business centers

Residential categories

- B: Flats, appartment buildings
- C1: Flats, appartment buildings
- C2: Mostly Villas
- D1: Villas
- D2: Villas
- E1: Economic habitat (with commercial), 72m²
- E2: Economic habitat, 70-100m², with commercial 100-150 m²
- E3: Economic habitat, 72m² or 70-100m², with commercial 72m² or 100-150 m²
- Extension

** Code (B,C,D,E,INT) based on (Al Omrane Marrakech, 2008. p-181, 183), legend corresponds to visionary model at Al Omrane office Tamansourt, shown on page 70.*

PHASING

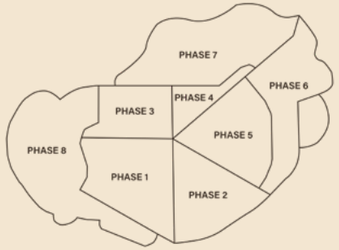


Figure 27: Phases construction Tamansourt. (Al Omrane Tamansourt, 2013).

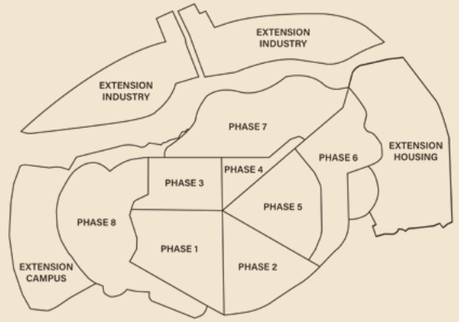


Figure 29: Planned extension Tamansourt based on (Al Omrane Marrakech, 2008. p-183) and (Al Omrane Tamansourt, 2013).

LEGEND

- *Campus: University campus*
- *Housing: social housing, continuity with social housing in Tamansourt, oriented towards the Jebilet.*
- *Industry: Industrial zone and economic activities, located near highway interchange.*

To understand the morphology of Tamansourt, the design guidelines formulated for Moroccan new towns are studied. These are 41 design guidelines for the development of new towns, formulated by the Al Omrane in 2010. The guidelines are shown below and on the next page.

For this research, the guidelines are categorised into the categories: Urbanised Landscape (U), Infrastructure and Transport (T), Configuration (C), Buildings, and Architecture (B). Furthermore, the patterns are titled based on the literature and are numbered.

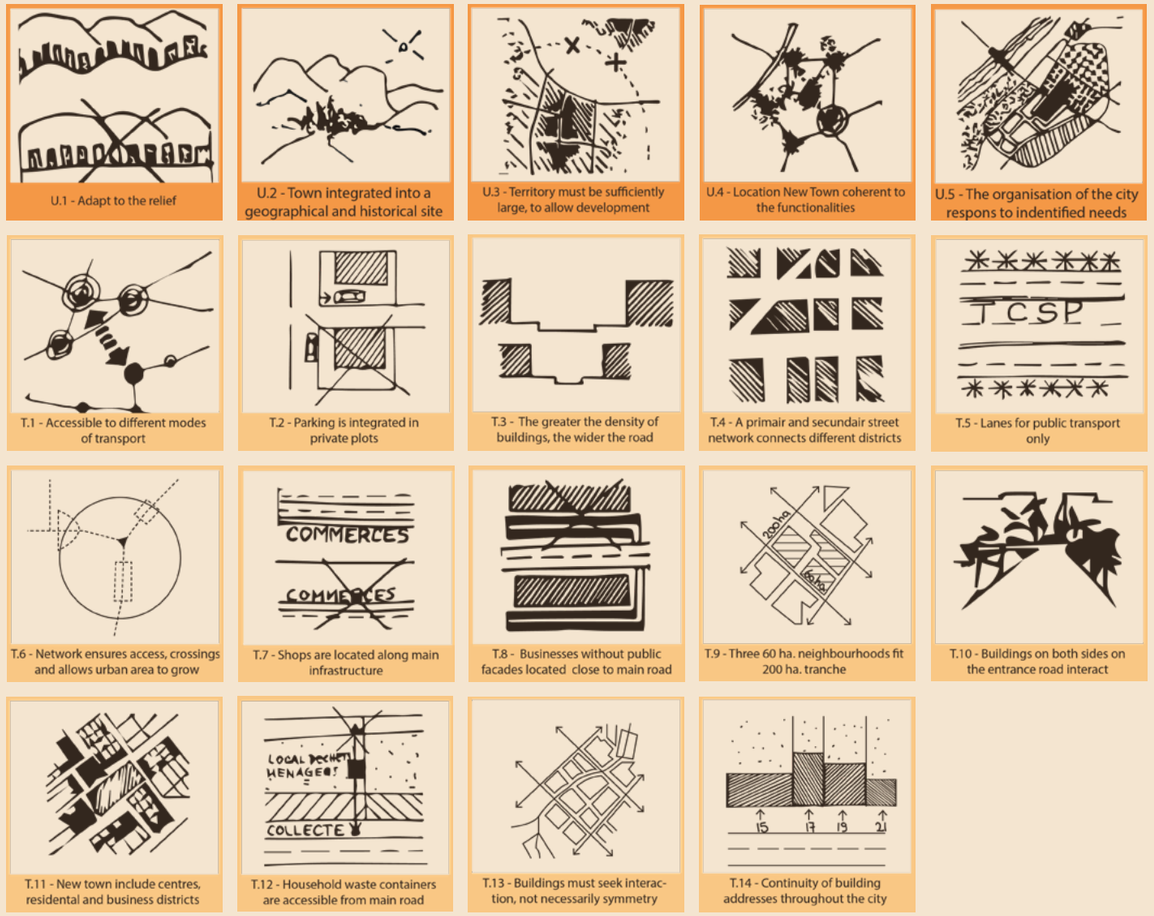


Figure 30: Overview of design guidelines formulated by Al Omrane in 2010. Made by author, based on (Holding d'Aménagement AL OMRANE, 2010).

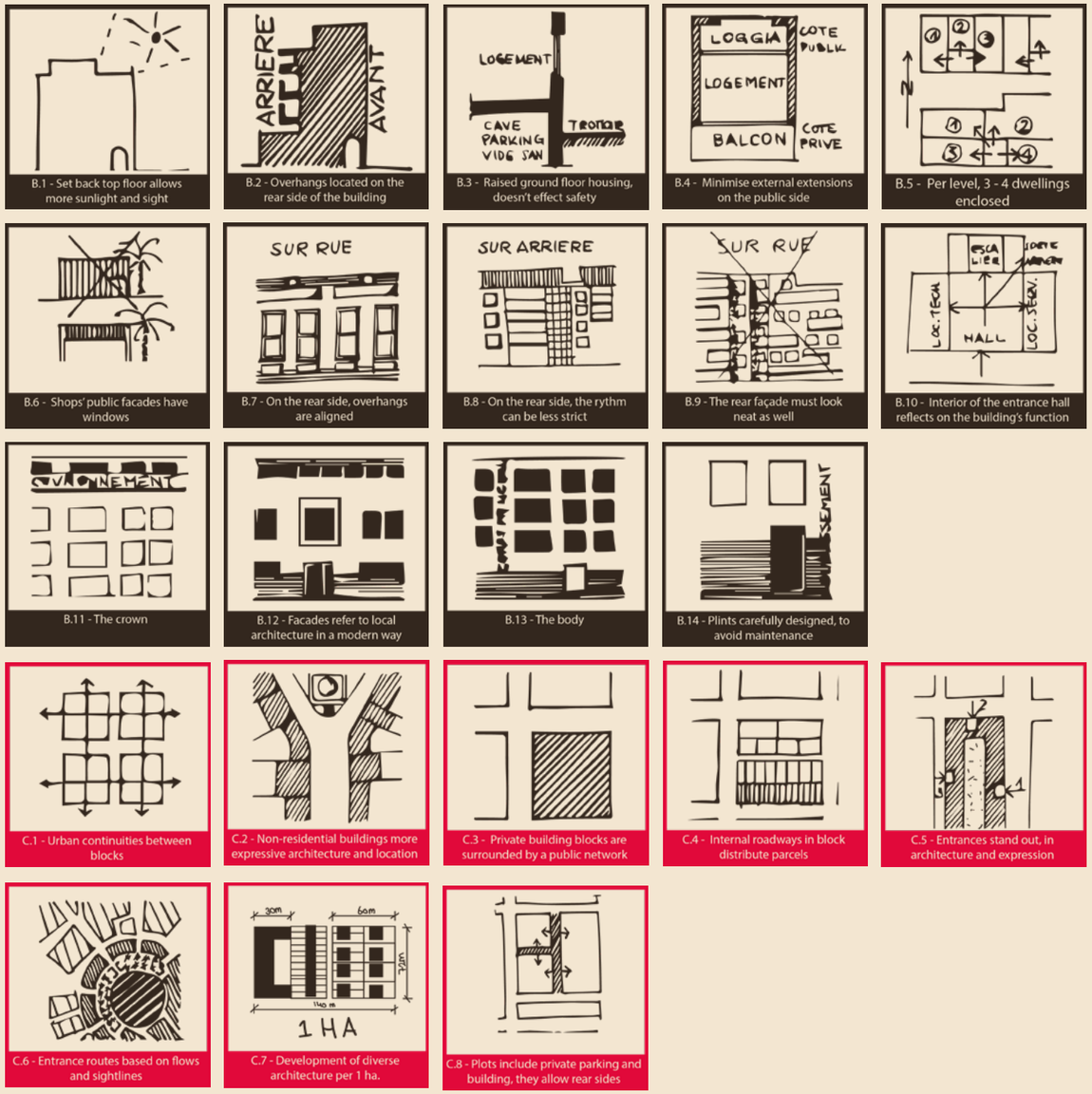


Figure 31: Integrated Sustainable Development Goals. (Stockholm Resilience Centre, 2016)

Figure 31 above again shows how the Stockholm Resilience Centre (2016) integrated the Sustainable Development Goals of the United Nations.

As visualised, the biosphere includes the Sustainable Development Goals concerning life on land, life below water, clean water and sanitation and climate action. In this integrated model, the biosphere functions as a foundation for the social and economic layer, and thus for global sustainability (Stockholm Resilience Centre, 2016).

In the Urban Arid Green Pattern Atlas, the patterns by Al Omrane are studied more in detail. The analysis of the guidelines shows that none of them focuses on the biosphere. Therefore, the foundation of Tamansourt is unsteady to start with.

Additional design guidelines that focus on the biosphere should be formulated for these Moroccan new towns. This contributes to a steady society and economy. It might also contribute to the original goal to create a green city, via an integral approach.

To do this, and to restore Tamansourt's foundation, life on land and water, sanitation, clean water, and climate action are studied in the spatial analysis following.

Figure 32: Photograph Tamansourt Medina. By author on 31 May 2022 >

3.3 THE TENSIFT BASIN

When preparing the soil for construction, the soil ecosystem is destructed (van den Berg et al., 2022. pp. 70-71). As in most cities, the soil in Tamansourt is largely covered by buildings, infrastructure and hard surfaces in public spaces.
This is harming soil structure and biodiversity as water and oxygen can penetrate far less well into the soil (van den Berg et al., 2022. p.70-71).

As shown in the map on the left below, Tamansourt is located within the Tensift Basin, the watershed of the Tensift. The Tensift originates in the High Atlas. Some smaller rivers and wadis add to the Tensift. Because of the natural flow of the water, from high to low, the Tensift flows into the North Atlantic Ocean. Because of this geography, the Tensift Basin is enclosed by the North Atlantic Ocean, Jebilet and the High Atlas.

In (semi-)arid areas, such as Tamansourt, soil erosion is the most crucial factor in land degradation. Morocco is made vulnerable to soil erosion by natural climatic, edaphic, and topographic conditions. The average soil loss in the Tensift watershed is evaluated at 44.03 t/ha/year. With slight erosion on the lower part of the watershed, and more extreme erosion rates upstream. Especially barren land and scrubland on steep slopes have a high rate of soil erosion (Meliho, Modeste & Khattabi, Abdellatif & Mhammdi, Nadia, 2020).

As shown in the map on the right below, Tamansourt is enclosed by two wadis. the north/northeast side of Tamansourt is 36 meters higher than the south/ southwest side. Unfortunately, these wadis have become barren erosion gullies.

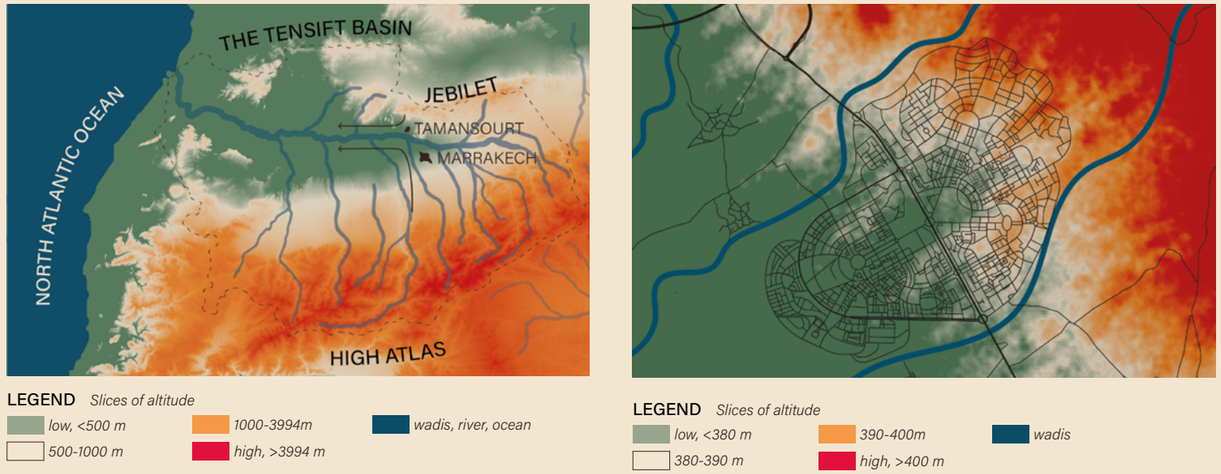


Figure 34: Left: SRTM elevation data, map the total Tensift basin. Right: SRTM elevation data, map Tamansourt.

< Figure 33: Photograph Tamansourt taken from roof social housing complex, view on Jebilet. By author on 31 May 2022.

The soil in Tamansourt is arid and rocky, as visualised in Figure 35 on the right. Due to the absence of vegetation, there is a lack of water infiltration. During periods of heavy rainfall, water is not infiltrated. Next to the run-off and soil loss, this creates a loss of precious, scarce water together with unpleasant and unsafe situations of flooding. In summer periods, there are extreme droughts where wadi beds dry up completely due to high evaporation, as visualised in Figure 42.

To improve the quality of life and space, the design of the urban landscape and the development of Tamansourt should focus on land conservation and soil restoration.

Next to erosion, other aspects are contributing to soil degradation, as shown in Figure 36 below. Processes and mechanisms as well as factors and agents are more fixed. Activities are changeable.

Therefore, the causes and activities on site will be studied in the next paragraphs. Three strategies for restoring and managing soil quality to mitigating risks of soil degradation are shown in Figure 37 below. These strategies need to be taken into account in the redevelopment of Tamansourt.

Figure 35: Photographs soil Tamansourt.

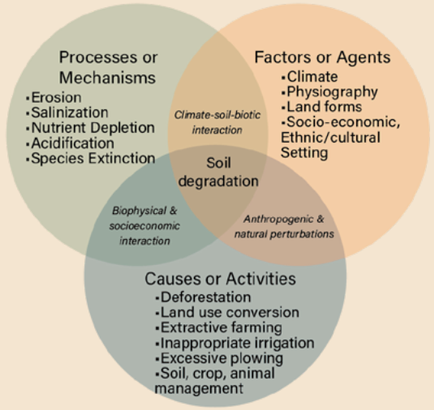


Figure 36: The process-factor-cause nexus as a driver of soil degradation. (Lal, 2015).

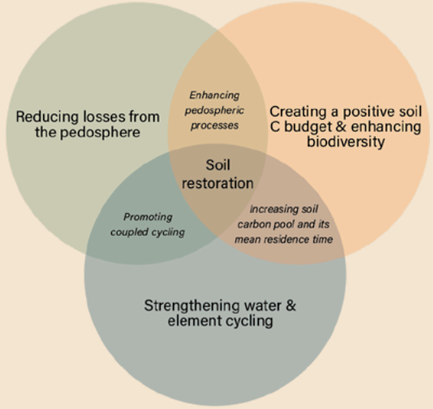


Figure 37: Three strategies for restoring and managing soil quality for mitigating risks of soil degradation. (Lal, 2015).

The waterbodies enclosing Tamansourt are shaped by water erosion. To design for soil restoration on these linear elements, they first have to be mapped more in detail. One longitude section and two cross-sections have been made per wadi. The locations of these sections are shown in Figure 38 to the right. As visualised in Figures 39 and 40, there is a height difference of up to 36 m along the length of Tamansourt. The width and depth of the wadis differ per location. However, they are 40 to 80 meters wide and roughly 3 meters deep. The planned unbuilt buffer zones are 150-400 meters wide.

Figure 38: Locations of longitude sections and cross sections. Image from (Google Earth Pro, 7.3.4.8642, 2022)

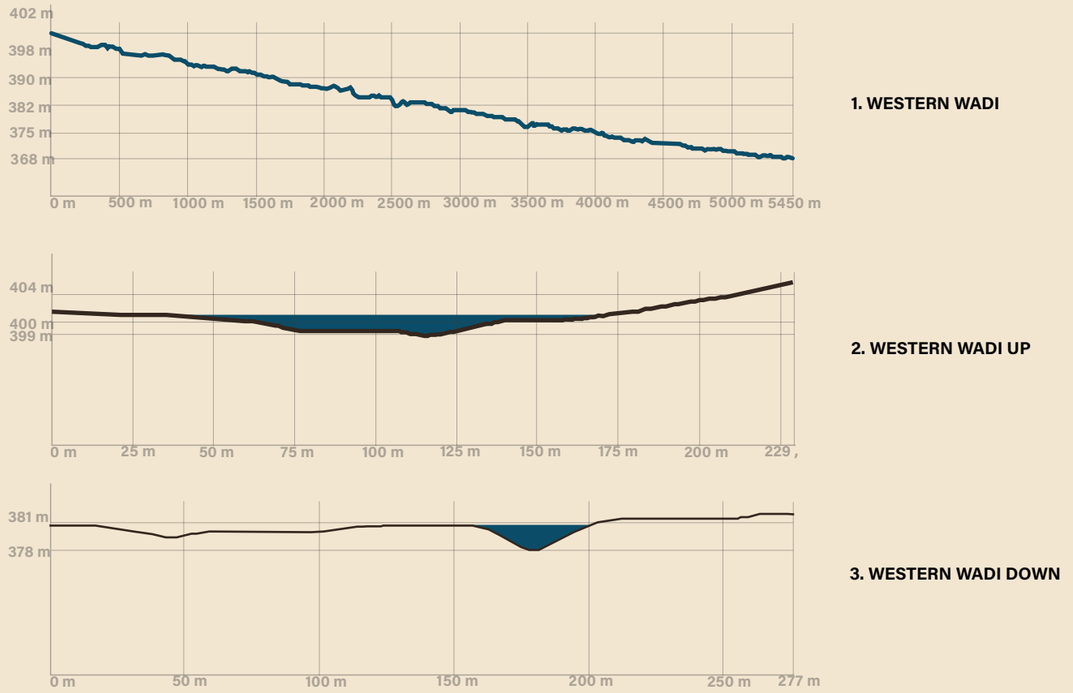
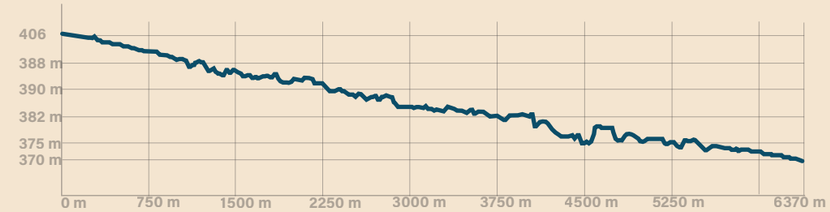
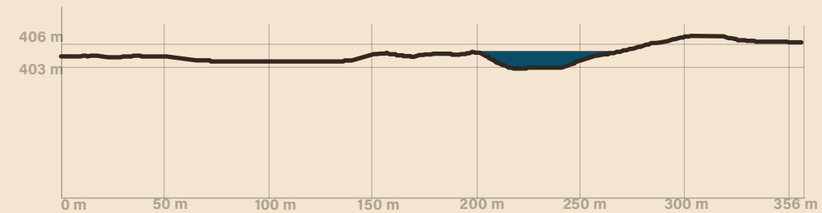


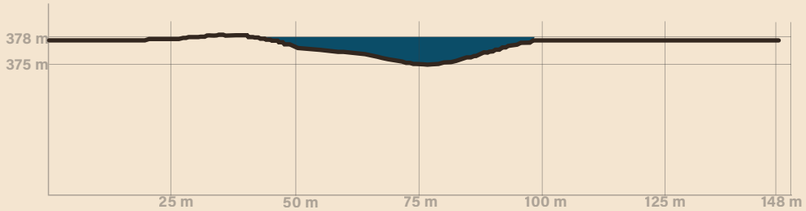
Figure 39: Longitude section and cross sections western wadi.



4. EASTERN WADI



5. EASTERN WADI UP



6. EASTERN WADI DOWN

Figure 40: Longitude section and cross sections eastern wadi.

Figure 41: Photograph impact wadi on vegetation Tensift basin, Atlas mountains. By author on 23 May 2022 >

3.4 WATER INSECURITIES IN MOROCCO

In Morocco, a severe water shortage is expected in 2030 due to rising water demands and declining precipitation by climate change. The water supplies are mainly stressed by the rising demand for water in the agricultural sector, as 80% of Morocco's water is annually used in irrigation of agriculture. In 2020, the National priority programme to supply drinking water and irrigation 2020-2027 set 5 objectives to improve water security in Morocco (Ennabih, 2020):

1. Building new dams to rise the water supply.
2. Better managing the water demand and valuation, particularly in agriculture.
3. Enhancing the supply of drinking water in rural areas.
4. Using recycled wastewater for irrigating green spaces.
5. Sensitizing and heightening awareness of the importance of preserving water resources and rationalizing their use.

Agriculture is a critical sector of the Moroccan economy. In 2008, the Green Morocco Plan was launched. This is an agricultural strategy to enhance output via irrigated fields, mechanizing agriculture and supply chains. The strategy favours export-oriented agriculture and strengthened the economic growth of the country, as it provides 38% of national employment and 13% of the GDP (Oxford Business Group, n.d.). The strategy dropped the number of undernourished Moroccans by 25% (Hill & Pimentel, 2022).

However, the strategy also strengthened social inequalities as big farmers are export-oriented and gained profit from the strategy while the traditional Moroccan farmers did not benefit from the modernization and relied on rainfall and aquifers (Ennabih, 2020).

Due to climate change, the rainfall is getting more unpredictive which results in failed harvests (Kangalawe & Lyimo, 2013).

The traditional farmers are therefore still vulnerable to drought, and thus the current irrigation policies make Moroccan society even more vulnerable to climate change (Ennabih, 2020).

A new programme, Generation Green 2020-2030 was set as a response to the uneven gains from the Green Morocco Plan and focuses on individuals and rural regions. It aimed to modernise and diversify traditional agricultural development. Morocco's emphasis on export made the agricultural sector shift away from certain products such as cereals. Unfortunately, the war in Ukraine exposes its vulnerability to price shocks. In Morocco, 12% live marginally above the poverty line. Middle-class households spent 40% of their income on food. Thus, price shocks could have dramatic effects on consumption (Hill & Pimentel, 2022).

To avoid constrain in economic development, rising food prices, social and political instability and water shortage, the hydraulic and agricultural policies must be rethought. A systemic change is needed.

Regarding the objective to use recycled wastewater for irrigating green spaces, a lot has happened in the Marrakech region. The country's largest reuse project is in Marrakech, where water is reused primarily to irrigate golf courses. In total, wastewater in Morocco could generate more than 13% of Morocco's total water demand of 2.5 billion m^3, highlighting the importance of wastewater treatment (Alhamed, Biad, Saad, & Masaki, 2018).

Every day, water is used and goes to waste in Tamansourt. The rainfall is unpredictive and therefore the vegetation cannot rely on rainwater only. To make optimal use of the limited water, the options to lower the water usage, and reuse water should be explored. There are plans for a wastewater treatment plant in Tamansourt, however, this is too expensive for now (see chapter 4.3).

The framework of the ecocity can be used to rethink the hydraulic and agricultural system, as a more self-sustaining resilient structure is key to solving the problem of water scarcity.

< Figure 42: Photograph showing dried-up wadi beds. By author on 1 June 2022.

3.5 AGRICULTURE IN TAMANSOURT

The economic dependence on agriculture was important in the choice of location for Marrakech's satellite city. The area surrounding Marrakech is suitable for agriculture. To avoid Marrakech from expanding into this land, the location of Tamansourt was chosen on degraded soil and land not directly suitable for agriculture. This way, the agricultural land was not gone to waste due to the construction of the satellite city. This is visualised in Figure 44 below.

However, there is some agricultural land present surrounding Tamansourt. This mostly includes wheat, argan and olive. The location of these fields is shown in Figure 45 on the next page.

February is the rainiest month in Tamansourt. In total, the rainfall counts a maximum of 255 mm per year, whilst the evaporative demand is annually recorded at 1600 mm per year on average (Abdelaziz, Driss, Hassane, Rania & Mohammed, 2022). Therefore, the crop fields in Tamansourt are irrigated.

Furthermore, livestock such as goats and sheep can be found grazing the little natural vegetation present. The agricultural operation in Tamansourt is visualised via the photographs on pages 52-53.

These ways of farming are depleting the soil. However, for farmers, it seems the most efficient way, which is financially highly important.

When Tamansourt expands, agricultural land has to make space for the built environment as well. This development is visualised in Figure 46 on the next page.

By eliminating agricultural land, the conflict over space is strengthened further. From the founding of Tamansourt, nature is giving in to the conflict of space. In the nearby future, agricultural land is giving in as well.

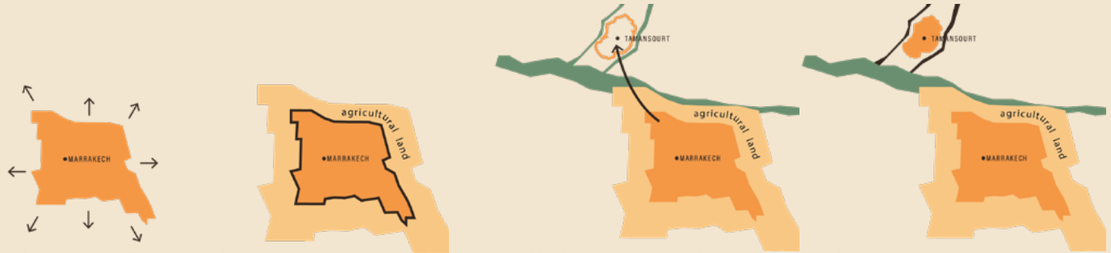


Figure 44: scheme expansion limit Marrakech, Tamansourt as solution to maintain agricultural land and support population growth and urbanisation.

< Figure 43: Photograph of man watering the front garden of cultural building Tamansourt. By author on 31 May 2022.

Figure 45. Map showing agricultural land present surrounding Tamansourt now.

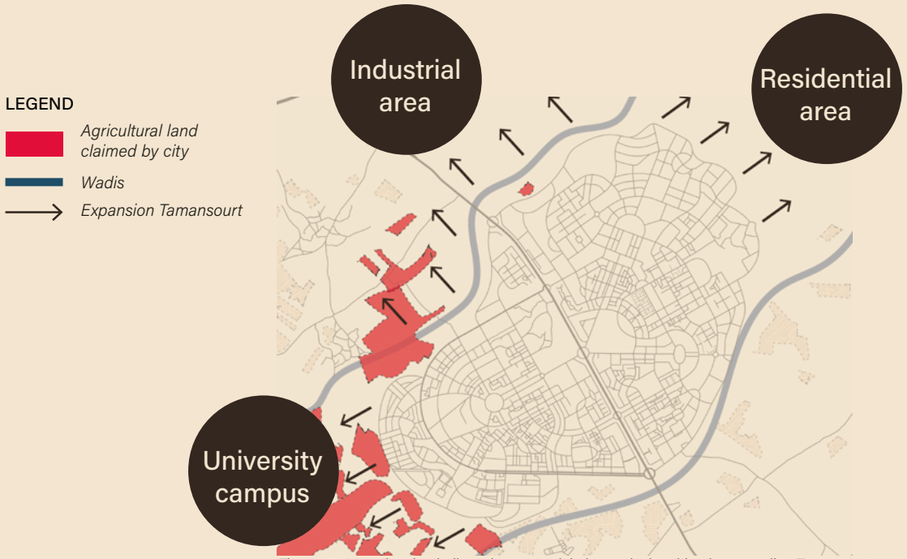


Figure 46: Map showing built environment claiming agricultural land surrounding Tamansourt.

As agriculture is part of Morocco's identity and economy, agricultural activity could be (re-)introduced within Tamansourt. A (partly) local food chain fits the transformative framework towards an ecocity.

Besides the economic and cultural value of sustainably reintroducing agricultural activity, it can contribute to restoring soil quality. Controlled grazing, cover cropping, residue mulching and conservation agriculture are key techniques related to the agricultural sector to do this (Lal, 2015).

The conversion from natural to agricultural landscapes however changes the ecosystem processes. As there is little natural vegetation present now, this can result in a positive outcome for Tamansourt, provided it is set up correctly.

According to Zhang, Li, Jiang, Tian, Li & Xiao (2011), issues involving environmental conservation and food security could be helped by developing perennial crops through breeding. This is more effective than systems based on annual crops as it provides multiple ecosystem services that are essential for sustainable production. It protects against soil erosion, conserves water and nutrients, stores more carbon below ground, and builds better pest tolerance.

Crop and phase rotations are important to make sure the soil remains healthy and productive. Rotating annuals and perennials could be most beneficial. As perennials deplete the water in the subsoil and the annual crops allow to refill this buffer during subsequent years (Batello, Wade, Cox, Pogna, Bozzini & Choptiany, 2014). This is depicted in the scheme in Figure 47 below.

A decrease in genetic diversity among crops occurred in Morocco. Native species are best suited to changing climate conditions, unfortunately, the decrease was mostly among these species (Hill & Pimentel, 2022).

When (re-)introducing agriculture in Tamansourt, the city can work to reconstitute these resilient native species. By this, the local, traditional Moroccan can be empowered, following the Generation Green 2020-2030 programme.

By including sustainable food production in Tamansourt, food transport and packaging is limited (Trainer, 2019).

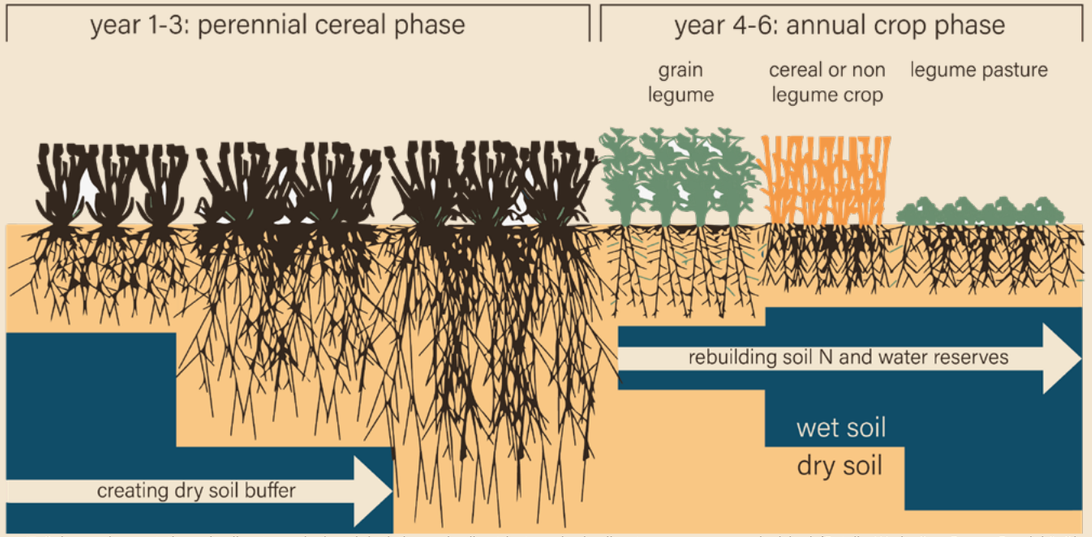


Figure 47: Scheme phase rotation subsoil water and mineral depletion and soil nutrients and subsoil water reserves are replenished. (Batello, Wade, Cox, Pogna, Bozzini & Choptiany, 2014, p. 180).

Figures 48 - 49: Photographs livestock grazing wadi and agricultural operations in Tamansourt. By author on 24 May 2022 >

3.6 VEGETATION IN TAMANSOURT

As there is a lot of social and affordable housing present in Tamansourt, and the city is planned to be very dense, there is little private outdoor space present. Therefore, private green is not contributing much to the overall vegetation cover in Tamansourt. However, some houses that do include private gardens, show a burst of diverse green as visualised in Figure 50 below. This shows that some residents are willing to invest their time and/or money to green their environment.

Figure 50: Photograph contrast private and public green.

There are many neighbourhoods without private gardens, therefore, the city depends on public green. For the first ten years after planting, Al Omrane Tamansourt took care of this. Now, the municipality is more self-sufficient and should take over this task. However, maintenance is expensive and not always a top priority (see chapter 4.3). Nonetheless, the availability of water is essential for vegetation. Waiting for the rain to come is not an option for every specie.

Part of the vegetation in public spaces can be found in public parks, as shown in Figure 51 below. More parks are (to be) planted, however, this takes time.

Figure 51: Photographs park.

in paragraph 3.2 Urban Morphology, pattern T.5, shows the aim for green main avenues, this outcome is visualised in Figure 52 below.

Figure 52: Photographs green alongside infrastructure.

The majority of the vegetation within the city is planted by Al Omrane. The vegetation palette used for Tamansourt is shown in Table 1 on the right. This palette includes mostly alien species. Unfortunately, in Tamansourt, vegetation cover is absent in most areas, as shown in Figure 53 below.

Figure 53: Photographs absence of vegetation cover in unfinished and finished areas.

The vegetation palette for Tamansourt by Al Omrane:

	Scientific name	Scientific name
trees and palms	Washingtonia robusta	Melia azedarach
	Phoenix dactylifera	Erythrina caffra
	Phoenix canariensis	Sophora japonica
	Phoenix roebelinii	Lagunaria patersoni
	Chamaerops humilis	Schinus terebinthifolios
	Bismarckia nobilis	Schinus molle
	Butia capitata	Branchychiton pop.
	Araucaria eexcelsa	Citrus aurantium
	Cupresus sempervirens	Ficus benjamin
	Ficus retusa	Callistemon viminalis
	Spathodea camanutala	...strum japonicum
	Jacaranda mimosifolia	Bauhinia variegata
shrubs	Plumbago capensis	Duranta repens
	Polygala myrtifolia	Carissa grandiflora
	Acokanthera sp.	Jasmins (officinale, sambac,...)
	Nerium oleander	Bougainvillier Janah
	Bougainvillea glabra	Continus coggygria
	Myrtus communis	Phormium tenax
	Dracaena draco	Cordyline australis
	Westringea fruticosa	Solanum rantonetii
	Pittosporum tobira	Thuya occidentalis
perennials and flowering plants	Lavande	Pennisetum setaceum
	Festuca glauca	Stipa tenuifolia
	Acorus gramineus	Cuphea sp.
	Gaura lindheimeri	Nerium oleander nana
	Rosier	Tulbaghia violacea
	Eurypos	Arctotis sp.
	Gazania sp.	Géranium Lierre
	Impatiens nouvelle Guinée	Chrysanthèmes
	Dimorphoteca	Pétunia
	Pervenche	Verveine
cover	Gnaphalium lanatum	Hedera helix
	Rosmarinus prostratus	Vinca major
	Vinca major variegata	Ficoïde fin
	Pennisetum clandestinum	Paspalum sp.

Table 1: The vegetation palette for Tamansourt by Al Omrane.

Only outside the city some natural landscape and vegetation can be found.

The vegetation species that are observed during the site visits on May 24 and 31, 2022 in Tamansourt and its surroundings are shown in Table 2 on the right. Most of this green is maintained by the municipality and is irrigated.

Fieldwork has been done in Tamansourt on Tuesday, May 31, 2022. During this fieldwork, the temperature was measured at the same time, during a very hot period of the day. The temperature was tested at different locations at a height level of one meter. The temperature in the shade of the Washingtonia robusta (Figure 54) was 13.6 degrees Celsius cooler than it was in the built area where vegetation was absent (Figure 55). This results in people relaxing and resting in the little shade present, as captured in Figure 56 below. The vegetation is thus creating a more comfortable urban climate in Tamansourt, it cools the city.

However the study by van den Berg et al. (2016) was conducted in European cities, it found that environments with more green space reported better physical and mental health for people living in these environments. The research shows that higher scores on mental health and vitality scales are independent of cultural and climatic contexts.

The effects of adding more vegetation to Tamansourt are therefore promising.

List of species observed on location:

	Scientific name	Scientific name
trees	Olea europea	Citrus aurantium
	Ziziphus jujube	Argania spinosa
	Eucalyptus camaldulensis	Ficus microcarpa
	Washingtonia robusta	Tecoma stans
	Populus fremontii	Cupressus sempervirens
	Jacaranda mimosifolia	
shrubs	Euonymus japonicus	Parkinsonia aculeata
	Nicotiana glauca	Agave shawii
	Cenchrus setaceus	Agave sisalana
	Scolymus hispanicus	Agave americana
	Suaede vera	Plumbago auriculate
	Lagerstroemia indica	Agave americana 'Variegata'
	Leptospermum scoparium	Atriplex cansescens
	Callistemon citrinus	Cylindropuntia imbricata
	Duranta erecta	Nerium oleaner
	Cousinia thomsonii	
cover	Solanum elaeagnifolium	Carpobrotus chilensis
	Chorizanthe rigida	Hololachane soongarica
	Tradescantia pallida	

Table 2: List of vegetation observed in Tamansourt and Marrakech region May 2022.

Figure 54: Weather station, 1 m height, in shadow Washingtonia robusta.

Figure 55: Weather station, 1 m height, sunny and paved spot.

Figure 56: Photograph showing people seeking shade from vegetation.

On top of creating a more comfortable urban climate, vegetation can play a big role in restoring soil quality, by creating a continuous vegetative cover (Lal, 2015).

To create a more comfortable climate and restore the soil quality, vegetation should be included more in the urban layout.

The aim to include more vegetation in the urban design matches both the vision of Al Omrane Tamansourt and the Ecocity Builders group.

The Ecocity Builders team shared the feedback on plants/biodiversity from IUCN from the Ecocity Morocco jury. The recommendation of the jury is to propose native species and take into consideration the ecological characteristics of the surroundings. The list by IUCN of recommended species, with important ecosystem services, is shown in Table 4 on the right. According to the jury, the final selection would have to be made depending on the characteristics of the plantation sites.

In table 5, the list of recommended species by Abdelaziz, Drizz, Hassane, Rania & Mohammed (2022), a group of Moroccan experts on site, is presented.

For each of the presented species included in the different tables, an overview of the species' origin and facts is shown in the Urban Arid Green Species Catalogue.

List of recommended species by IUCN:

	Scientific name	Scientific name
trees	Quercus ilex	Cupressus atlantica
	Quercus coccifera	Phyllirea angustifolia
	Quercus faginea	Myrtus communis
	Quercus canariensis	Rosmarinus officinalis
	Quercus rotundifolia	Chamaerops humilis
	Quercus suber	Ceratonia silicua
	Olea europea sylvestris	Rhamnus alaternus
	Olea europaea maroccana	Rhamnus cathartica
	Pinus halepensis	Juniperus phoeniceae
	Pinus pinea	Teucrium fruticans
	Pinus pinaster	Arbustus unedo
	Tetraclinis articulata	Ruscus hypophyllus
	Argania spinosa	Maytenus senegalensis
	Vachellia gummifera	Periploca laevigata
	Ziziphus lotus	Pistacia lentiscus
	Pistacia atlantica	

Table 3: The vegetation species recommended by IUCN.

List of recommended species by Abdelaziz, Driss, Hassane, Rania & Mohammed, 2022:

	Scientific name	Scientific name
trees and palms	Whashingtonia robusta	Brachychiton populneus
	Olea europea	
shrubs	Retama raetam	Yucca Mediostriata
	Acacia saligna	Yucca Variegata
	Cacti	Yucca Superba
	Yucca Nobilis	Pistacia lentiscus L

Table 4: The vegetation species recommended by (Abdelaziz, Driss, Hassane, Rania & Mohammed, 2022).

3.7 CONCLUSION ANALYSIS

Regarding ecological issues, Tamansourt is currently in a downward spiral. The snowmelt and periods of heavy rainfall create very intense run-off and degradation of the land. The flooding wadis may affect people's safety, especially when climate change worsens the conditions.

The unsustainable agricultural and pastoral activities, together with the absence of vegetation cover strengthen the lack of water infiltration of the arid soil. These unsustainable human activities are depleting the soil, creating very barren and degraded ground. The use of water from the aquifer lowers the groundwater level.

Due to climate change, temperatures are rising and water is evaporating even faster, creating even longer periods of extreme drought.

Because of the settlement of Tamansourt in this specific location, and due to human activities, the human society living in Tamansourt is facing difficulties.

This conclusion is summarised in Figure 58 below. By introducing several urban amenities to the city, such as a university campus and business district, Al Omrane aims to create a harmonious mix among residents and stimulate economic activity. This might create a more vivid Tamansourt.

Restoring the soil quality is seen as a possible solution to create a more comfortable and ecologically healthy living environment.

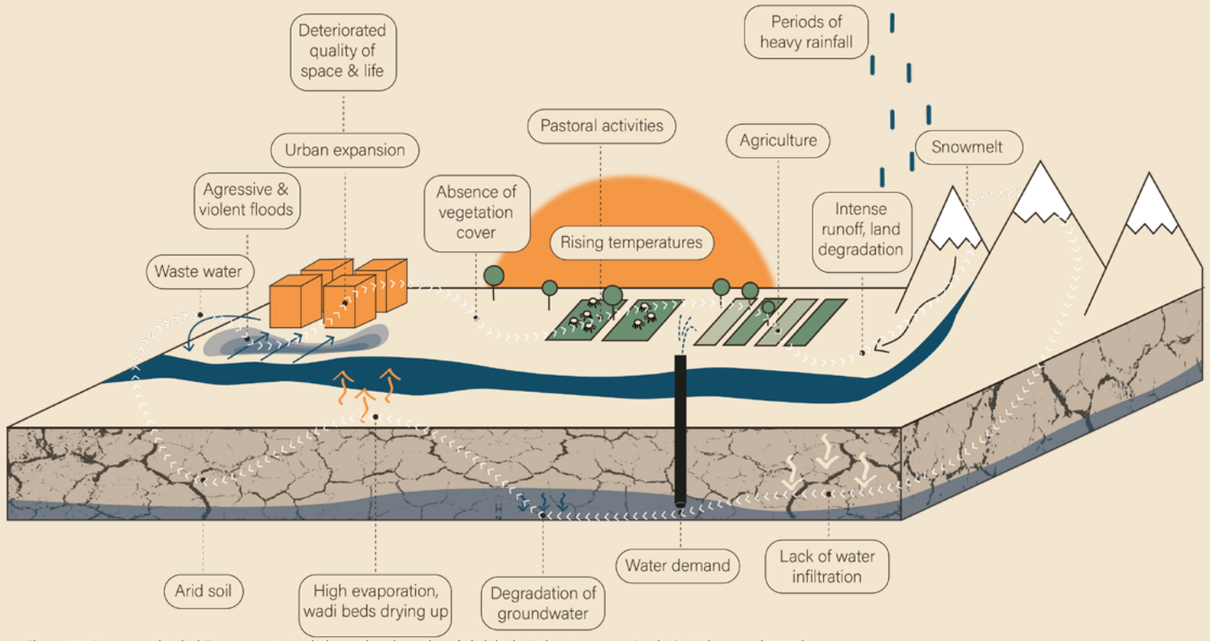


Figure 58: Downward spiral Tamansourt. Made by author, based on (Abdelaziz, Driss, Hassane, Rania & Mohammed, 2022).

< Figure 57: Photograph showing misuse by burned garbage, absence of vegetation cover, and potential as green sprouts on unbuilt land. By author on 24 May 2022.

DIALOGUES

To better understand the site, as a physical and non-physical place, Chapter 4 'Dialogues' starts with the results of the on-site conversations held in May 2022.

Secondly, two interviews with experts in ecosystem restoration and Nature-Based Solutions have been conducted.

The Moroccan state-led company Al Omrane Tamansourt gave input and feedback on the project during a site visit on 31 May 2022.

Together with the spatial analysis of the previous chapter, the outcome of these interviews is the main input for the vision, strategy and design outcome of the project.

CHAPTER'S CONTENT

4

4.1 LEARNING FROM LOCALS

A conversation with a Berber in Imlil

Although the Moroccan new towns are founded to support urbanisation and population growth, not everyone is eager to let rural life behind. A conversation with a Berber living in Imlil, a small village in the Atlas mountains South of Marrakech, provided great insides into Berber life. The man, whose third daughter was born only four days ago, explained what the difference between living in Marrakech and the mountains was to him. It never crossed his mind to move to Marrakech, as he loved the peacefulness and quietness of the mountains. Marrakech was way too crowded and busy for him. He grew up in Imlil and was not planning to move anywhere else.

As he lived in the mountains his entire life, he has a lot of knowledge of the landscape. On the foot of the Atlas Mountains grow argan and citrus. The argan fruit is used in food production for oils and argan butter and cosmetics. Higher up in the mountains, cherry, apple, walnut, prune, and pear trees grow. Some vegetables such as potatoes, tomatoes, zucchini, green beans, onions and some herbs, camille, mint, sage, and rosemary are grown there. As the Jebilet mountains are lower than the Atlas Mountains, the Berber predicted that only argan and citrus trees would grow there. In the mountains, the argan, fruit and vegetables are harvested for export. The vegetables are cultivated in very small amounts, for their own consumption. Only when there is a surplus, the vegetables are sold to the city. They established their local food supply. They live more minimalistic, as, for example, they share a hammam with two other families, and may only use it two or three times a week. The houses in the mountains are connected to septic tanks. Every five years or so, they replace the tanks.

A conversation with an inhabitant of Marrakech

The man lives just outside the old medina. He explained that tourists should not go to Tamansourt, as it was nothing more than an urban structure. He thought it was just a waste of time to visit.

A conversation with a Berber from Kelaat Mgouna

Another Berber, originating from the village of roses in the desert, had a different view on urbanisation. The 27-year-old man did move to Marrakech five years ago. He lives in Marrakech, where he shares an apartment with four friends not far from the city centre. He moved to the city because of the job opportunities. In Marrakech, he can make way more money. Although, he doesn't want much. He just wants a comfortable life and to be able to provide for his family. His family still lives in the desert.

The man does not own a car, although he would like to have one. Unfortunately, owning a car is quite expensive and according to him, taking the bus is not very comfortable in Morocco.

His uncle lives in Tamansourt. He explained that three years ago, it was not very safe in Tamansourt at night. For three years, the city is becoming safer. Furthermore, he explained that many people who live in Tamansourt moved there from Marrakech, as it is a less expensive place to live. He would not want to live there himself, as he thinks it is too quiet and boring for him.

A conversation with a shepherd in Tamansourt

As the shepherd was guiding his group of sheep and goats through the dried wadi beds, he explained that his sheep and goats eat the vegetation left in the wadi. More green can be found there, leaving a great spot to feed his livestock. He explained that the farmers live in the old urban settlements in Tamansourt. They don't live in the new town.

A conversation with a student in Marrakech

The philosophy student, another Berber from the Atlas mountains, explained that he moved to Marrakech for his studies and job opportunities. However, he enjoys visiting his family in the mountains. He takes pleasure in harvesting fresh vegetables from his family's garden every morning. He shared that there was this immense sense of serenity in the mountains, which he was quietly longing for.

4.2 EXPERT INTERVIEWS

The analysis showed several challenges that affect the comfortability and livability of Tamansourt, such as soil degradation and water scarcity. Some aspects of the aimed transformation of Tamansourt into an ecocity are outside the scope of urban design. The development must include knowledge across a range of disciplines. To gain knowledge in these fields, interviews were held with experts involved in two best practices. The goal is to be able to incorporate more aspects and disciplines into an integral vision, strategy and design for Tamansourt.

Africa Wood Grow
The spatial analysis showed the need for land conservation and soil restoration. As the vegetation cover is an important factor in this restoration process, the project Urban Arid Green could focus on ecosystem restoration via afforestation. One of the best practices in this field is Africa Wood Grow. Roeland Lelieveld, the co-founder of the initiative, shares his lessons learnt from the process of starting the initiative and he shares his knowledge. This best practice is landscape-oriented with socio-economic assets.

EcoShape
The wadis that enclose Tamansourt can flood aggressively, especially with intensifying conditions due to climate change. Water safety is one of the basic needs of a city. Also, leaving a buffer zone open is a very inefficient use of land. To gain knowledge in the field of hydraulic engineering and Building with Nature, Tom Wilms, Senior in Nature-based Solutions in Integrated Coastal Zone Management is interviewed. In the interview, Tom explains more about the natural system and aspects to include in a design to capture and slow down water. This best practice is landscape-oriented with a focus on water safety and societal issues.

< Figure 59: Photograph Berber from Atlas mountains transporting goods by mule.

4.2.1 AFRICA WOOD GROW

The Africa Wood Grow initiative focuses on reforestation in Kenya. Due to deforestation and erosion, the soil in the area the initiative is operating on is depleted and degraded. The ecological change Africa Wood Grow initiated is shown in the section in Figure 60 on the left below.

Africa Wood Grow is a community-driven initiative with a train-the-trainer approach. Farmers change their business operation into agroforestry and by this, they are regenerating the soil. The landscape is already starting to green, with socio-economic assets.

Figure 60: Left: section before and after Africa Wood Grow. Retrieved from (Africa Wood Grow Foundation, 2022). Right: image showing phasing of the ecological revival. Retrieved from (Africa Wood Grow Foundation, 2021).

A conversation with Roeland Lelieveld, co-founder of Africa Wood Grow and chairman of the Africa Wood Grow Foundation, on May 16, 2022.

Since the founding of the initiative, Roeland has been in close contact with the locals in Kenya. The stakeholders in the Africa Wood Grow initiative are all locals and the business operation is very low-profile, only local tools are used. The initiative's policy is very intrinsically oriented, everyone is equal. Instead of aiming for the most profit, they focus on contributing to the local economy and ecosystem fairly.

Daniel Muvali, Roeland's Kenyan companion, had a lot of knowledge and expertise on Kenyan vegetation. He provided the group with several options for vegetation. These options were all native species, as they add more to the biodiversity of the area. On top of this, they are more resilient to potential hazards and disruptions. The trees used for Africa Wood Grow are all grown from seeds, as this enriches the area with more genetic diversity. This vegetation is more resilient to for instance plagues.

Diseases and plagues only occur when there is an error in the natural system. This error is then naturally fixed by nature. Vegetation grown from seeds is more unique, farmers that grow vegetation from seeds are thus less selective. They are not only picking the most perfectly grown trees to clone, what is the case with planting from cuttings. Aiming for this variety is usually less interesting for a business operation, economic-wise.

The local farmers that participate in the initiative get the trees from the foundation and plant them in the rainy season. To avoid livestock from grazing the land, or gnawing the crack of the trees, the agroforestry land is completely fenced for the first 5 years. After 5 years, the fence can be removed. By then, the livestock cannot gnaw at the crack of the trees. Without a fence, the vegetation would be grazed within a day. Fencing livestock is another option, however, then you're depending on someone else's business operation. The local farmers participating in the foundation decide for themselves what they want to grow between the trees. By growing for instance sunflowers, corn and pumpkins, the foundation contributes to the local food economy. Planting the trees and placing the fences brings the farmers' salaries. These employees spend their money, and thus the local economy benefits from the project. In Figure 61 to the right, multiple photographs by the Africa Wood Grow are shown. They visualise the process and ecological change initiated by the initiative.

In Tamansourt, after overgrazing and mismanagement of the land, it is indeed time to bring back the sponge function of the area. The landscape and vegetation look quite similar to Europe's. In the mountains, you can even see the paths the goats graze via Google Earth!

When aiming for a community-driven approach to restore the landscape in Tamansourt, the focus could be more upstream. Here, smaller communities live and results might be made faster. For the restoration of the natural system with a landscape like this, one should aim to retain organic matter as much as possible. One should focus on less erosion, creating wadis and using relief in the landscape to retain organic matter.

It is important to know what native species used to grow on-site before Tamansourt was founded. Try talking to older inhabitants. In the middle of the city, there is a little park located. Finding out what went wrong here is very important, you can learn a lot from this. Furthermore, it is essential to know how the city retains and collects rainwater and how the residual flows of all organic material go. The way of fertilizing the ground, with animal manure or chemical fertilizer is essential to understand as well.

A suggestion for a tree specie could be the Cork oak. There is a shortage of this tree, and it can be harvested for use with economic value. It is a long-term vision, as you can only harvest the cork after 25 years. ***But a long-term vision is exactly what you need for a project like this.***

If you would start a pilot project, try to connect to the local government. Maybe they can provide subsidies.

If the landscape of Tamansourt would be restored, it would be a much more pleasant place to live. In that sense, the project can even contribute to solving the migration problem. Reforestation is much cheaper than the current EU anti-migration policy.

Figure 61: Photography Africa Wood Grow Foundation. Retrieved from (Africa Wood Grow Foundation, n.d.).

4.2.2 ECOSHAPE

EcoShape is a network of organizations and individuals that operate at the nexus of nature, engineering and society. They work together to advance the application of Building with Nature in water related societal issues. Witteveen+Bos is one of the engineering firms in the EcoShape consortium.

A conversation with Tom Wilms, Senior in Nature-based Solutions in Integrated Coastal Zone Management at Witteveen+Bos, on July 19, 2022.

Tom lived in Indonesia from 2014 to 2018 where he was project manager for Witteveen+Bos of the Building with Nature project in Central Java. The project focused on the restoration of the mangrove coast, aquaculture revitalisation and replication of the Building with Nature approach in Indonesia. The project was mainly related to the coastline. The degradation of the coastline had various causes, one of them was that the population wanted to earn more money there and shifted from rice farming to fish and shrimp farms. Mangroves were cut to make way for the aquaculture ponds until there was no mangrove left. Natural coastal protection disappeared, at some locations along 10 km of coast has been swallowed up and the coastline has shifted 2 to 3 km inland. In Indonesia, Tom learned that the locals often already have the solutions, by talking with them you learn the most. The problems there do not have to be solved in a western way, most of the time, a local solution can be better. The locals have been living there for years, they know much better what is going on and what is possible. ***Before formulating a vision or design, it is important to analyze the natural, socio-economic and institutional system.*** It is important to know what kind of people live in the area and how they live. Legislation, regulations and political ambitions are also crucial. This should always be considered for the project area and beyond.

The natural system of the wadis does not start at Tamansourt, the water comes from upstream, and continues to flow after Tamansourt. The whole system should be considered to make sure the part at Tamansourt floods less aggressively. To design for this, you first have to map the entire system. The solution is always area specific, but the principle is more general. ***Make sure you understand the principle and include this in your vision for urban development.***

To reduce the flashfloods you need to lower the water levels. Walls can be built along the edges of the wadi, but it would be more helpful to ensure that there is enough space in the wadi. Upstream, water must be collected and retained. By this, less water flows down to the wadi. The water that does flow down, is spread in time. By starting as high in the system as possible, the infiltration starts earliest. This can be done in various ways, such as through vegetation, reservoirs or pits. The type of suitable vegetation depends on the local situation (like soil and weather) and this affects the flow velocity of the water. Reservoirs can be temporary, underground, or multiple in stepped form, depending on the peak of the water discharge. Pits allow you to retain water, wherein vegetation grows. This way you can combat desertification and if the area is large enough even adjust rain patterns. Downstream, space must be created for the water, this also has an effect upstream. Downstream obstacles, such as vegetation, might be removed. The wadi can also be deepened there, or a secondary channel can be dug. There are many options.

To make the wadi greener, the conditions must be created so that the wadi can recover itself. This can be done by making dams, terraces, or basins near Tamansourt. It becomes more attractive to recreate here. A first thought is to construct every 500 meters, a 1-meter high dam with large stones. These large stones will halt more stones and sediment coming from upstream and in that way nature creates a terrace. It will be more humid there, water will infiltrate and vegetation will develop there.

For the number of trees needed, the original situation and comparable projects worldwide can be considered. There are limits to every system and economic value can be lost when other activities are sacrificed, however a forest can add economic value as well. It is valuable to define the area's ecosystem services. A forest can do without maintenance, but for this, you first need start-up management. You have to create the conditions in which nature can sustain itself. These should be kept good enough for 5-10 years so that the forest can develop further. Also, think of permaculture. As soon as the forest is formed, products can be taken from the forest, with reason and common sense of course. The vegetation often picks itself, hopefully, there are still enough seeds in the ground. It might be necessary to grow seeds, to speed up and strengthen the process. People then start earning money from growing them, and selling the plants becomes a business. Once the forest has been formed, it is no longer necessary to grow plants in this area, but this business can no longer be taken away from them, it is their income. Be aware of this.

Thrive for local vegetation and natural processes so that the seeds of the trees are spreading in the right direction, probably wild animals/plants do this naturally. It is important to involve a local university or NGO about the suitable local vegetation. Find out how much water the system needs and where you can get this from.

All sustainable urban development needs to get everyone involved. It is necessary that the vision already fits all parties, including nomads, farmers, residents, tourists, investors, the government, etc. Make sure that nobody's situation deteriorates. Behavioural changes of the various parties require education, rewards and enforcement. For example, investors need to understand that their real estate increases in value when the urban landscape is greener, that green brings cooling and food, stores CO_2, and can take out the flashfloods. Population growth leads to a higher demand for food, which means more livestock and thus more fodder. Therefore, more vegetation is eaten by goats and sheep and the soil in the wadi becomes too hard, water no longer infiltrates. This can lead to desertification. The farmers must understand why they are not allowed to go into nature with their herd. Show the farmer a short-term alternative and long-term goal. The inhabitants must be explained that they have to treat nature right. All this must also be asserted, to ensure human activities do not disturb nature and that the system can recover.

Sustainability involves short and long-term thinking. Long-term-only is not enough. In the short term, the challenge is to achieve success. This stimulates donators and governments. After the end of the project, you have to ensure that it is taken over by the local population. You have to educate them and make them understand that they have to take good care of nature.

Figure 62: Photography from Building with Nature Indonesia newsflash 2016, (Building with Nature Indonesia, 2016).

4.3 AL OMRANE TAMANSOURT

A conversation with the Senior Manager at the state company Al Omrane Tamansourt, on May 31, 2022.
After presenting the vision for Tamansourt and the developments undertook, it seems that the aims of the Al Omrane Tamansourt group and the Urban Arid Green project match. Both aim to design for an (ecologically) healthier Tamansourt and a more pleasant living environment. Crucial input is discussed below.

Wadis
The wadis that enclose the city are most of the time dried waterbeds only. Only with extreme amounts of precipitation, approximately once every ten years, the wadis are filled with water. The manager had not once seen water in those wadis since 2009 when he started working in Tamansourt. However, the company created a 3D model of the city, showing the desired outcome of the project. In this model, which is shown in figure 64 on page 70, the wadis are visualised as clear blue structures.

Soil condition
Tamansourt was chosen as a Villes Nouvelles site, as the soil was not suitable for agriculture. The soil is too rocky, hard and barren to use as agricultural land. The area surrounding Marrakech is suitable for agriculture. To avoid Marrakech from expanding into this agricultural landscape, Tamansourt was founded on this unsuitable land. The quality of the soil of the other first-generation new towns is better than Tamansourt's.
At the borders of the city, there are some agricultural fields located. The farmers who work there don't own the land, they may use it. As soon as the university campus, industrial site and residential area are developed on these sites, the farmers have to leave.

Finance
The Al Omrane Tamansourt group aims for a wastewater treatment plant for Tamansourt. With 70.000 people living there already, they need it. However, it is too expensive.

Collecting garbage, developing the electricity infrastructure, electricity costs, and watering plants was all part of Al Omrane's tasks for the first ten years after the founding of the city. Now, the municipality is becoming more self-sufficient and they will take over these tasks.

Construction
The developers are not the only ones working on construction in Tamansourt. There are some districts where inhabitants can build their own homes. This way, they can build their ideal homes, exactly the way they want. Al Omrane developed several guidelines which must be taken into account by those builders. As Tamansourt resembles Marrakech, the red city, the colours used for façades in Tamansourt are all reddish. This self-construction boosts a micro-economy. People arrange everything themselves, they buy materials and create jobs for local firms.

Accessibility to fundamental services
To improve the accessibility of Tamansourt, the highway between Marrakech and Tamansourt was widened over 12 kilometres. Al Omrane furthermore aims to stimulate the use of public transport by creating a separate bus lane. In this way, public transport always has priority and because of a shorter travel time, they hope to stimulate its use.

Concerning healthcare, Tamansourt is still a bit dependent on Marrakech. There are only two smaller healthcare centres located in Tamansourt at the moment. These centres include general practitioners. However, with 70.000 inhabitants, this is too little.

Seven mosques and several schools are located in Tamansourt already. On these essential aspects, Tamansourt is independent.

The original vision for Tamansourt as formulated by Al Omrane is visualised in Figure 63 on the next page.

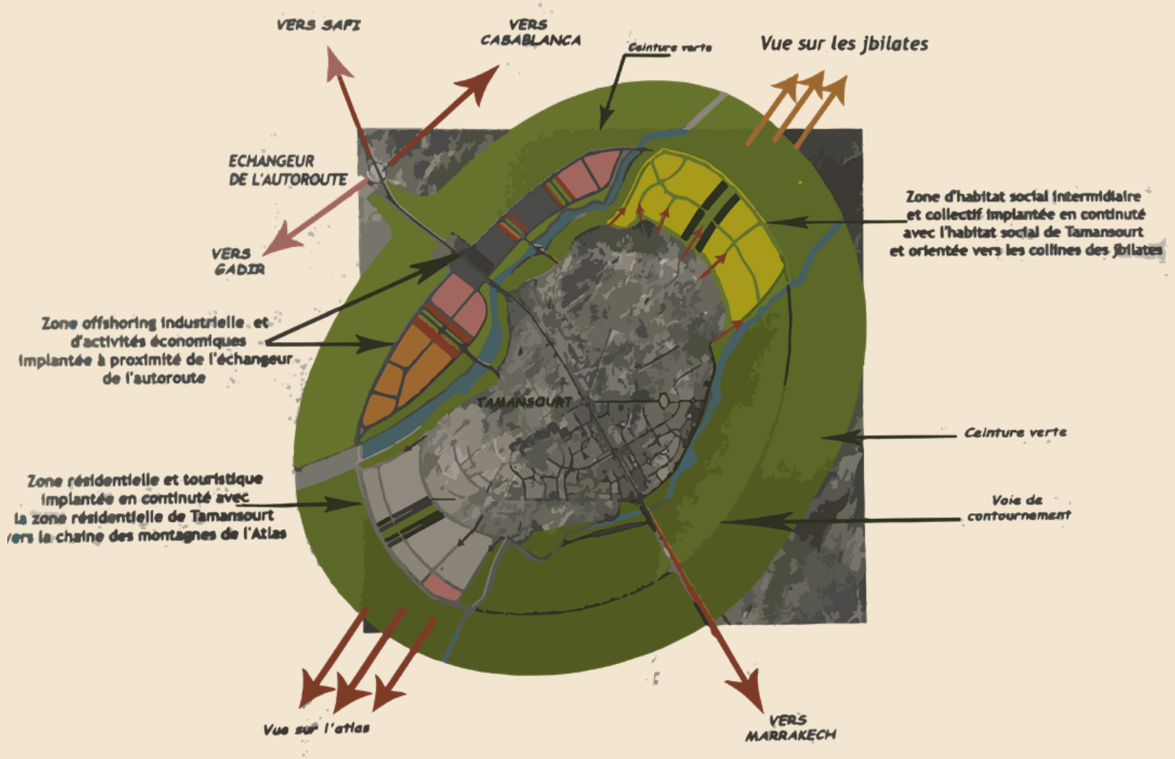


Figure 63: Vision map Tamansourt by Al Omrane. (Al Omrane Marrakech, 2008. p-182)

Figure 64: Photograph 3D model showing urban vision Tamansourt by Al Omrane. >

VISION

In chapter 5 'Vision', the vision statement for Tamansourt is explained and visualised. The vision builds on the concepts of Al Omrane and the Ecocity Builders.

CHAPTER'S CONTENT

5

ANALYSIS		VISION	STRATEGY	DESIGN	CONCLUSION
How are population growth and urbanisation addressed in Morocco?	What is the current spatial quality of Tamansourt?	What are the goals and aims for Tamansourt?	How can Tamansourt systemically transition into an ecocity?	How can the ecocity principles be translated to a spatial design?	How can population growth and urbanisation be sustainably addressed in and regions?

5.1 REGREEN TO REWILD: TAMANSOURT ECOCITY 2040

In 2040, Tamansourt is an ecocity; an ecologically healthy city. In 17 years, a shift in the development paradigm from destruction to construction of the natural system takes place.

By utilizing nature, Tamansourt will strengthen it, making innovative use of the system development. After the first vegetation is restored by active regreening, the landscape gains the capacity to regenerate itself. The circumstances are created for nature to rewild.

A regenerative urban landscape is created wherein nature and agriculture are in balance with the human system. The resilient city and its inhabitants contribute to a healthy biosphere. This gives people a new purpose and job opportunities.

Plant nurseries in and around the city feed the landscape by growing seedlings. The restoration process is made visible to visitors as ecotourism and agrotourism arise in Tamansourt.

The Tamansourt ecocity creates financial and social independence for the inhabitants by training, educating and employing them in the activities undertaken in the transition. A socially, culturally, environmentally, and economically sustainable economy is created for the inhabitants of Tamansourt.

The idea of the ecocity is lifted to the territorial level as nature rewilds over city borders, and thus adds to the identity of Tamansourt and the Marrakech region. The landscape is allowed to continue to be regreened and rewild in the region, contributing to the reversal of desertification. With its transition, Tamansourt can spark other urbanised arid landscapes, especially the Moroccan Villes Nouvelles, to start their transition.

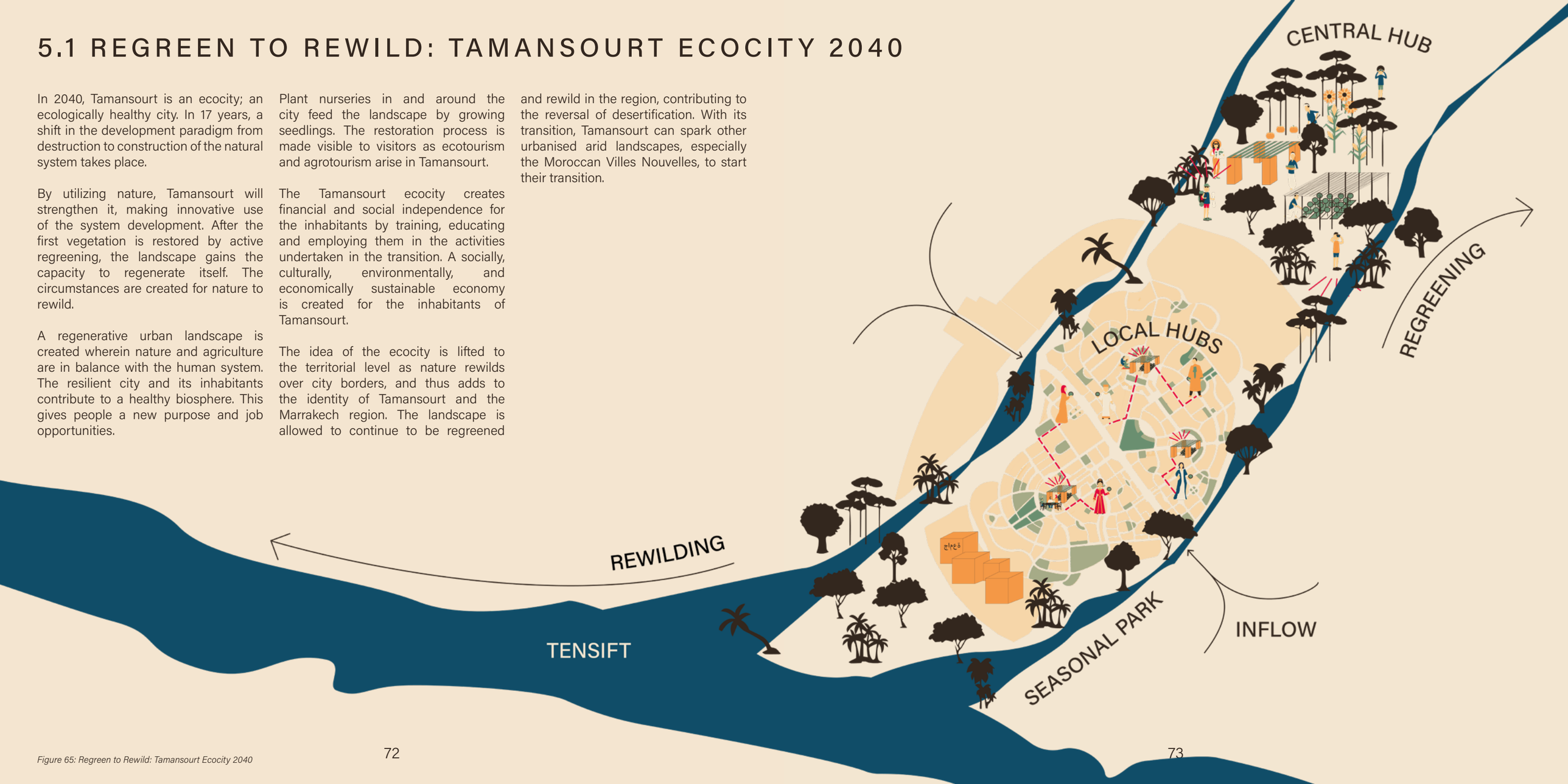


Figure 65: Regreen to Rewild: Tamansourt Ecocity 2040

5.2 CLOSE THE LOOPS

The closing of several loops is needed for the transition towards an ecocity. It will improve the quality of life and space in Tamansourt.

Water
Water is a prerequisite for the transition of Tamansourt. Water will be captured, however, rainwater is unpredictive whilst wastewater is produced daily. To make optimal use of the scarce natural resource, a circular water system is established. For this, the sanitation system of the urban area is rethought. Via water reuse and storage, the urban area and its human activities themselves become the city's new source of water.

Local food chain
Treated wastewater helps to actively bring back nature and restore soil quality. By choosing the right vegetation species, maintenance and watering are limited.

Recovered nutrients and organic household waste are used to organically fertilize the soil. By including sustainably managed agricultural activities in the ecocity, the second circular system is established: a local food chain. The landscape is regenerated by active regreening, and the locals play a crucial role in this process by providing the resources.

Knowledge
Tamansourt will experiment with different species and practices. By this, Tamansourt acts as a testing ground for other urban arid areas. The city itself will function as a botanical garden. By adding tourist facilities, people can learn about Moroccan agriculture and gardening. Knowledge is being shared between the university campus and the central hub.

Vegetation
To cope with the high demand for seedlings and to make the process visible to its inhabitants, the central hub will be in constant exchange with smaller, local, hubs in the three city centres. Here, more vivid community centres with common interests are created.

The plant nurseries in the hubs produce seedlings. Inhabitants can collect their free plants and trees to green the city themselves in these local hubs. By this, the locals are acting as a very important stakeholder and the city is greened from the bottom up.

Secondly, the nurseries in the central hub grow the vegetation to start regreening the wadis and the agroforest. For these locations, only native species are grown whilst the species for the urban area can be more exotic, naturalized and introduced. This is because the inhabitants, individually, can spend more time taking care of them. And due to the urban heat island effect. This will show some sort of gradient in species throughout the city.

Wadis
The regreened wadis will retain the water in the wadis and therefore, they spark the second source of water. Eventually, they do not have to be watered anymore. By landscape design, these wadis will create recreational value for the whole city, as they are accessible by every inhabitant within a 1,5 km distance from their homes. They function as linear, seasonal parks and they form clear guiding points throughout the whole city. They enclose the new ecocity as old Moroccan walls enclose the medinas.

Quality of life and space
The hubs and parks add value to the financial system and prosperity of the city. The transition of Tamansourt into an ecocity generates new economic sectors for Tamansourt. In 2040, Tamansourt does not rely on the construction sector only anymore. Examples are tourism, agroforestry, nurseries, logistics, maintenance, research and education.

When these key locations succeed, the restoration of the landscape will spread into the buffer zone between Marrakech and Tamansourt, starting to spark a systemic change on the regional level.

In chapter 8, design proposals for these key locations are made.

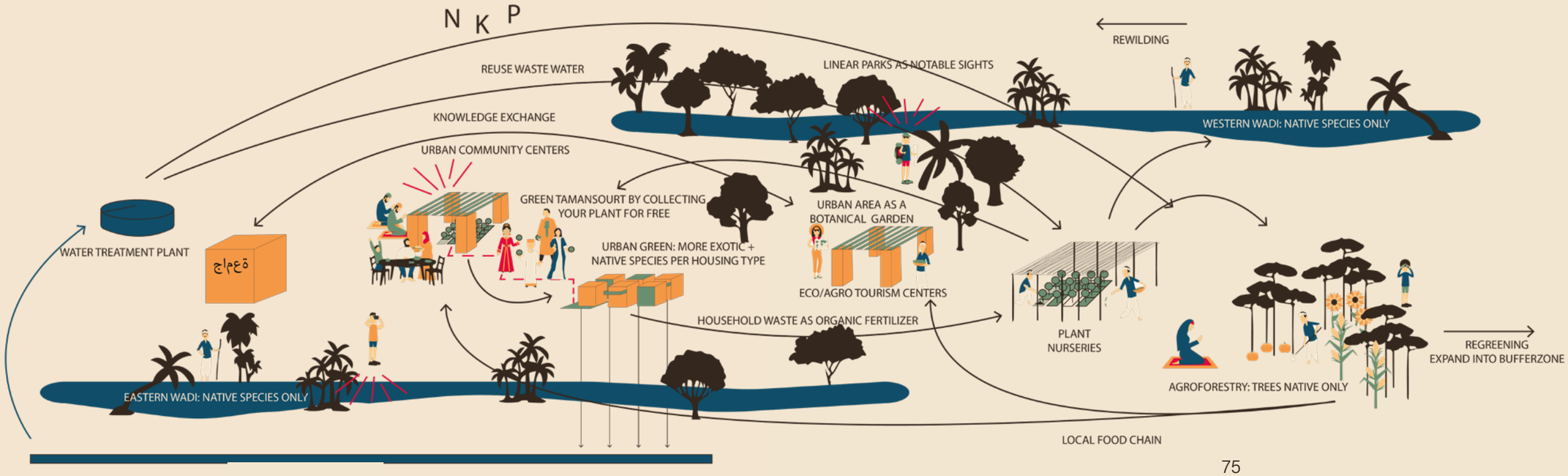


Figure 66: Close the Loops

SYSTEMIC CHANGE

In Chapter 6: 'Systemic Change,' the systemic change needed to transition Tamansourt into an ecocity is defined. This includes environmental, policy and behavioural change.

6

CHAPTER'S CONTENT

6.1 HARNASSING THE NATURAL SYSTEM

For Tamansourt to get out of the downward spiral, and to create a more sustainable and comfortable living environment, environmental change is needed. As the access to natural resources is already scarce, the resources that are present here should be used as circularly as possible.

Two periods a year, during the rainy season there is additional access to water in the area. By rethinking the interaction with nature, the area could benefit from this. The environmental change, therefore, proposes a system where water is kept within the area via vegetation.

The vegetation focuses on four main principles.

1. Slow down and infiltrate the water in the wadis.
2. Protect the urban area from floods.
3. Lower the usage of water. The usage of water is threefold: individual usage, agricultural, and maintenance of vegetation.
4. Improve the quality of life and space within the urban area.

Water is needed to grow vegetation. A circular water system is created in which wastewater is filtered and reused for watering.

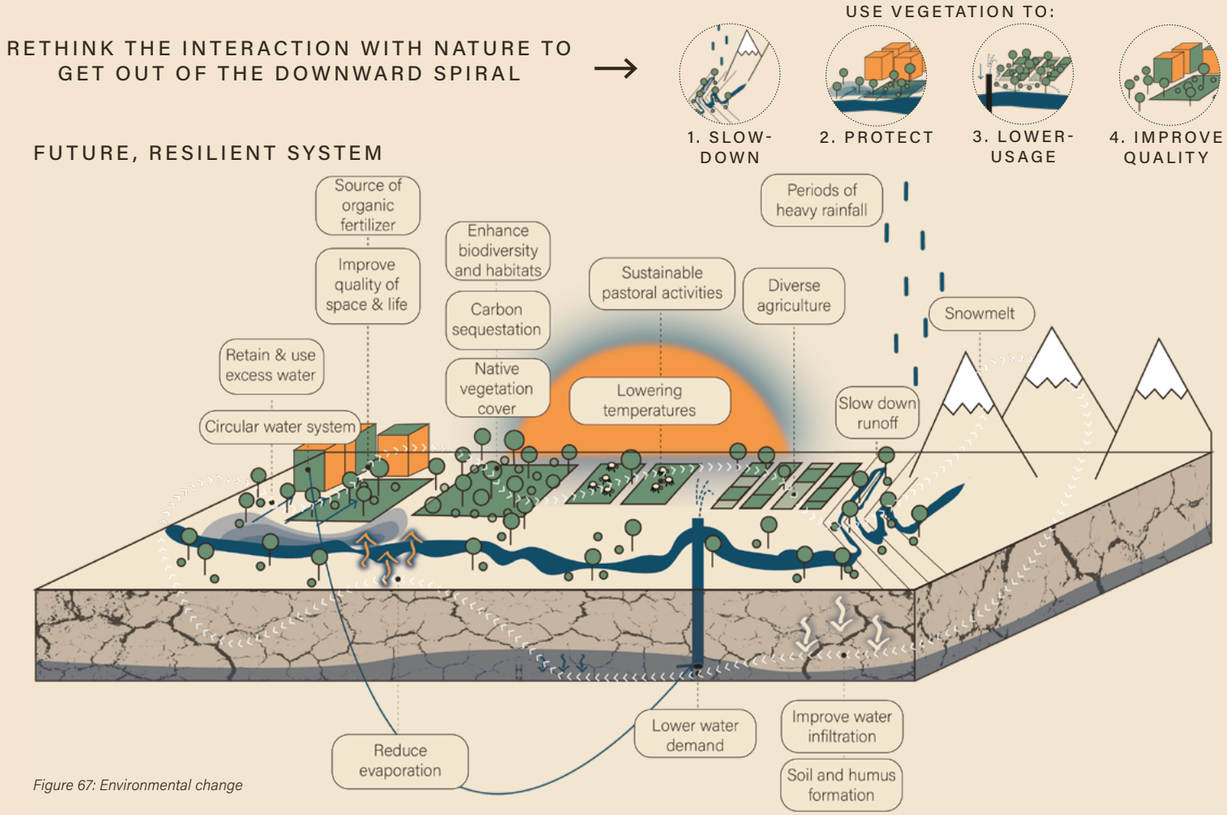


Figure 67: Environmental change

6.2 BUILDING PARTNERSHIPS

The state company Al Omrane and the Ecocity Builders are already involved in Tamansourt's transition into an ecocity. Relevant ministries that might not have been involved in the foundation of Tamansourt before, can still become involved now.

The ministerial departments concerning agriculture, water, nature, education, transport and healthcare must become involved in the development of Tamansourt. Not only to show top-down support but also to take notice of the process, for other projects in the country.

By transforming into an ecocity, certain tasks, such as green maintenance will intensify. The municipality must take care of this job and therefore, this actor should be involved in the transition as well.

The analysis presented the potential of the site when inhabitants take the initiative to green their environment. The dialogues showed that people living in rural areas are more used to living in harmony with nature. As urbanisation is one of the drivers behind the Villes Nouvelles Strategy, some of these people moved to urban areas for job opportunities and urban amenities.

For the transition of the city, Tamansourt should not count on governmental support only. It should become more self-sufficient and financially sustainable by empowering private actors and locals. When aiming for a future-proof living environment, locals must become key stakeholders in the transition. Engaged decision-making is needed. Ministries might change hands every 4-5 years. Locals don't move every period. They are the most consistent stakeholder involved. The local farmers must become advocators for the transition as well, instead of relegating them from the environment.

To share and gain knowledge, universities, students and researchers must be involved.

Other private actors, such as developers and investors have to be taken along in the process. When they understand that the change will safeguard their investments and work, they might want to invest further. Design and planning offices must be included to design for this.

Concluding, policy-driven, top-down interventions should balance bottom-up initiatives to harness the natural system. Although the promise of a green city has not come through yet, a trust-based partnership must be formed.

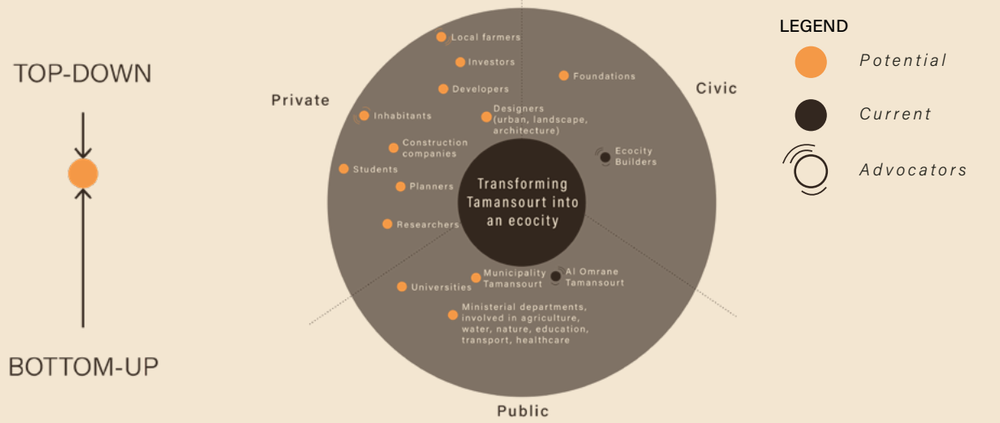


Figure 68: Policy change

6.3 EDUCATE TO CO-CREATE

The local context and community are important to the development. The historical layering of the city is missing in Tamansourt. People are living there for 18 years maximum. No family has been living there for centuries.

The inhabitants fulfil an important role in the Tamansourt ecocity vision. For this vision to succeed, it is important that the community feels involved in the transition and starts to appropriate their 'new' city.

Via education, recognition and awareness can be created. For example, inhabitants must be educated on the use of chemicals, gardening and waste separation. This will affect people's daily lives. The locals must understand that they have to take good care of nature, otherwise the transformation might fail. By educating the community, they can co-create Tamansourt ecocity together.

The local community could form Community Based Organisations (CBOs), similar to how Africa Wood Grow is operating.

A CBO works on the local level only and is services oriented. CBOs are non-profit organisations (Chechetto-Salles, Geyer, & Tyler, 2006).

The local farmers must be trained in agroforestry activities. The community must compose a tourist programme when eco- and agro-tourism arises. Besides training in these fields, people need to be employed in these activities.

As explained by Wilms in paragraph 4.2.2, long-term and short-term successes are needed for sustainable urban development. The long-term reward for the locals is that in 2040, they will live in an ecologically healthy city. Their livability and comfort will increase.

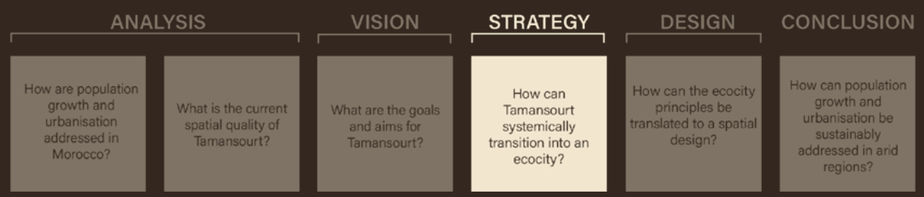
In the short term, rewards are needed as well. This will be income or greenery. In the first phases, a combination of rewarding and asserting might be needed. This is to ensure human activities do not disturb nature, and that the system can recover.

STRATEGY

In Chapter 7 'Strategy', new urban design guidelines are designed to support the Tamansourt Ecocity 2040 vision. Together, the patterns form the pathways towards an Urban Arid Green pattern language.

CHAPTER'S CONTENT

7



7.1 A PATTERN LANGUAGE

In 'A pattern language: Towns, Buildings, Construction' (1977), Alexander explains the method of a pattern language.

The book describes a set of patterns, developed to be able to work together. The set is designed to be understandable for all, all stakeholders where a town, building or construction is involved.

The patterns are formulated in such a way that they can be used unlimitedly, without the spatial outcome being the same.

The patterns include a form of instruction. Every pattern can be used on a certain scale, such as the scale of the building or city.

Each pattern is connected to another pattern. This connection of patterns creates a pattern language.

The Urban Arid Green project searches for a sustainable approach to address population growth and urbanisation in arid areas. This is done via a case study of Tamansourt. To implement the systemic change proposed in the Urban Arid Green report, all relevant stakeholders must be involved from the start of the process.

Therefore, the issues that manifested themselves, and the solutions presented for these issues, must be understandable for all.

As the overall aim of the study is larger than Tamansourt only, a new pattern language is formulated to sustainably address population growth and urbanisation in arid regions. This is the Urban Arid Green language.

Figure 69: All stakeholders must be involved at the start of the transition process.

7.2 PATTERNS & PATHWAYS

The Al Omrane Development Holding Company formulated 41 design guidelines for the development of new towns in 2010, as mentioned in the Analysis (chapter 3.2). The analysis concluded that the guidelines were not focused on the biosphere. To transition Tamansourt into an ecocity, socio-spatial design guidelines focused on the biosphere are formulated. These guidelines are presented in this paragraph. In the Urban Arid Green Pattern Atlas, the design guidelines by Al Omrane and the Urban Arid Green patterns are discussed more in detail.

The Urban Arid Green patterns are all based on the spatial analysis, interviews, vision and systemic change presented in this report. The patterns touch upon several scales:

- Organism
- Building
- District
- City
- Region
- Multi-scalar

The patterns form four pathways:

- Al Omrane
- Circularity & Ecology
- Supportive lifestyles
- Facillitating Fabric.

Pattern B.2 to the right is used to illustrate the method of the Pattern Language. In the title of the pattern, the first letter resembles the scale, followed by a number to specify the pattern. The colour indicates the pathway the pattern belongs to.

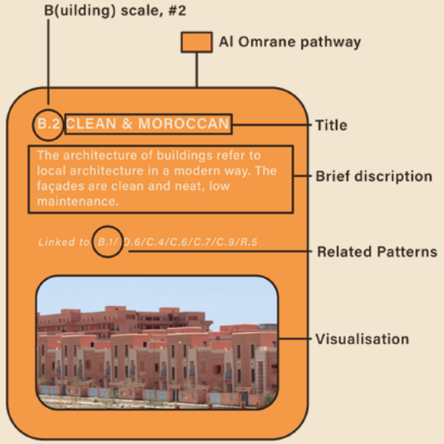


Figure 70: Examplary pattern

Al Omrane pathway

The guidelines by Al Omrane are reformulated into four patterns, together forming the Al Omrane pathway. The pathway ensures that the urban fabric remains clean and Moroccan. The pathway stimulates interaction between buildings and emphasizes a clear structure. The town is integrated into its context. As this pathway is based on the design guidelines for Moroccan new towns, this pathway is useful for other Moroccan new towns as well. The pathway must be altered when used in other countries.

Figure 71: Al Omrane Pathway

Circularity & Ecology pathway

By transitioning into an ecocity, the city will lower its usage of natural resources and it will produce renewably. It will reduce waste by reusing it as much as possible. A self-sustaining, resilient system is established, that can adapt to a changing climate and does not take natural resources for granted.

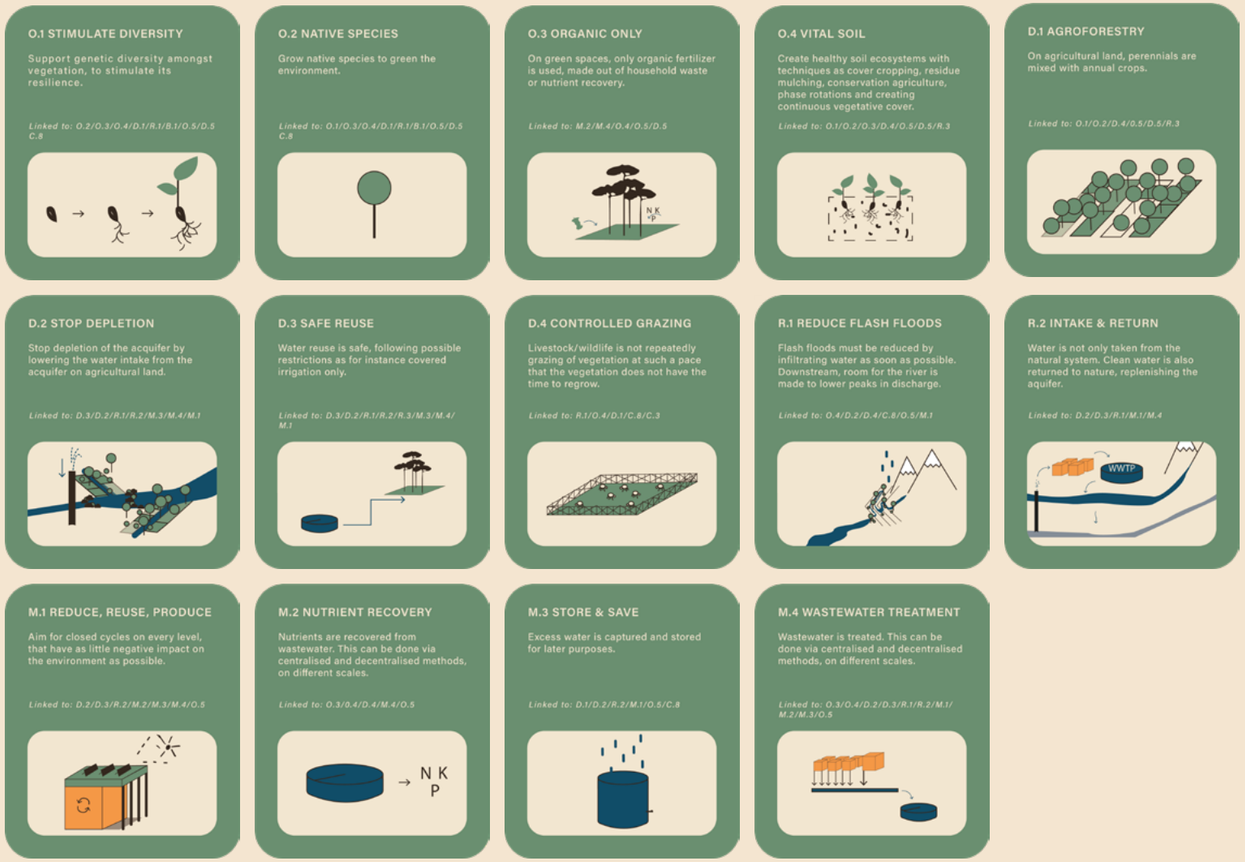


Figure 72: Circularity & Ecology Pathway

Supportive Lifestyles pathway

Following the ecocity definition of the Ecocity Builders (2010), the social order of the city reflects on fundamental principles of fairness, justice and reasonable equity.

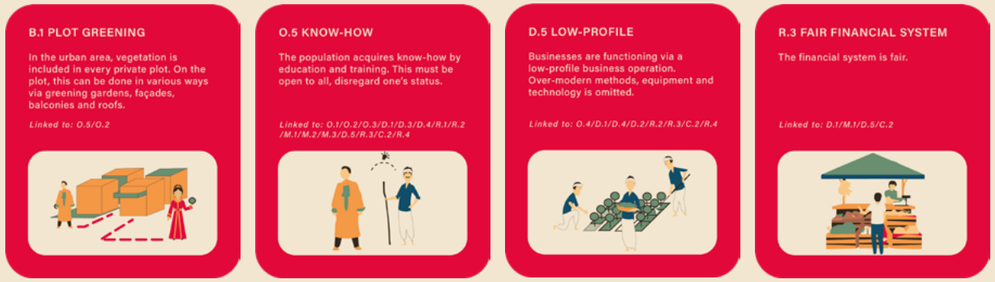


Figure 73: Supportive Lifestyles Pathway

Facilitating Fabric pathway

The urban structure forms a clear spatial framework and a safe and comfortable place to live. It provides the city with room to exceed the target population, to a certain limit. The urban fabric facilitates a sustainable interaction between human and natural systems.

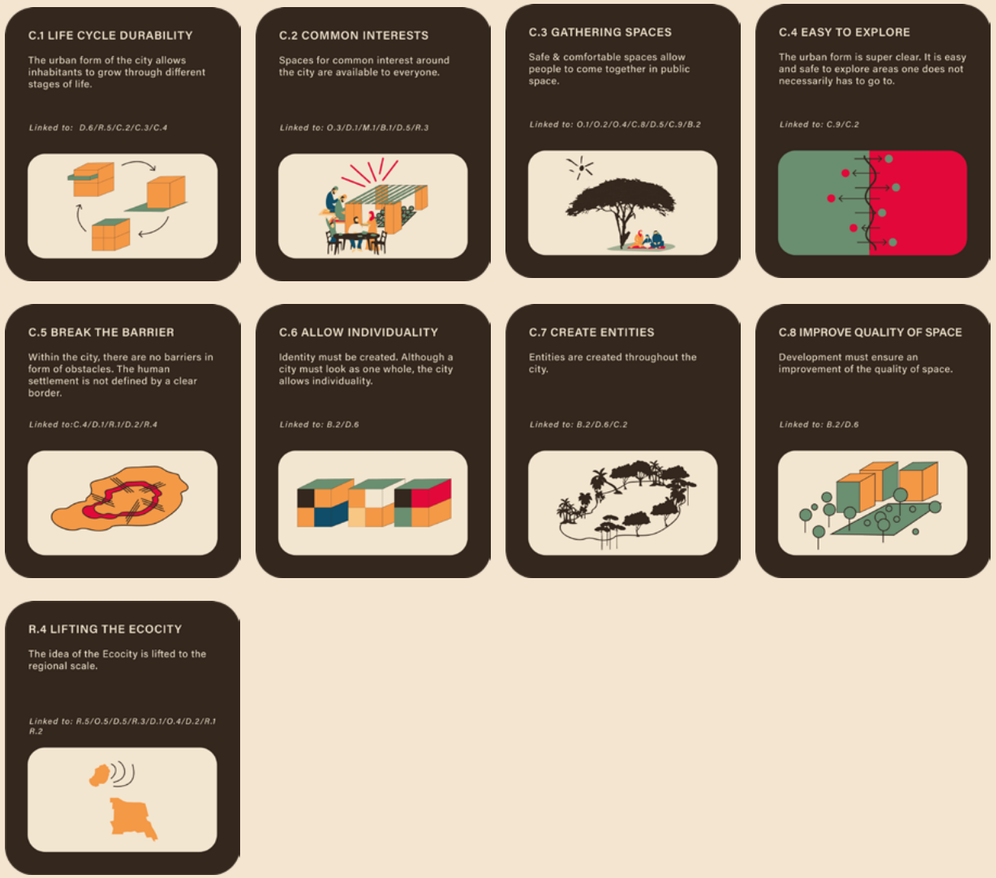


Figure 74: Facilitating Fabric Pathway

Figure 75: All stakeholders speak the same language, they understand each other and work together on the transition towards an ecocity.

7.3 THE URBAN ARID GREEN LANGUAGE

Below, the Urban Arid Green Language is displayed as a possible sequences of patterns, showing the biosphere as the foundation of the ecocity.

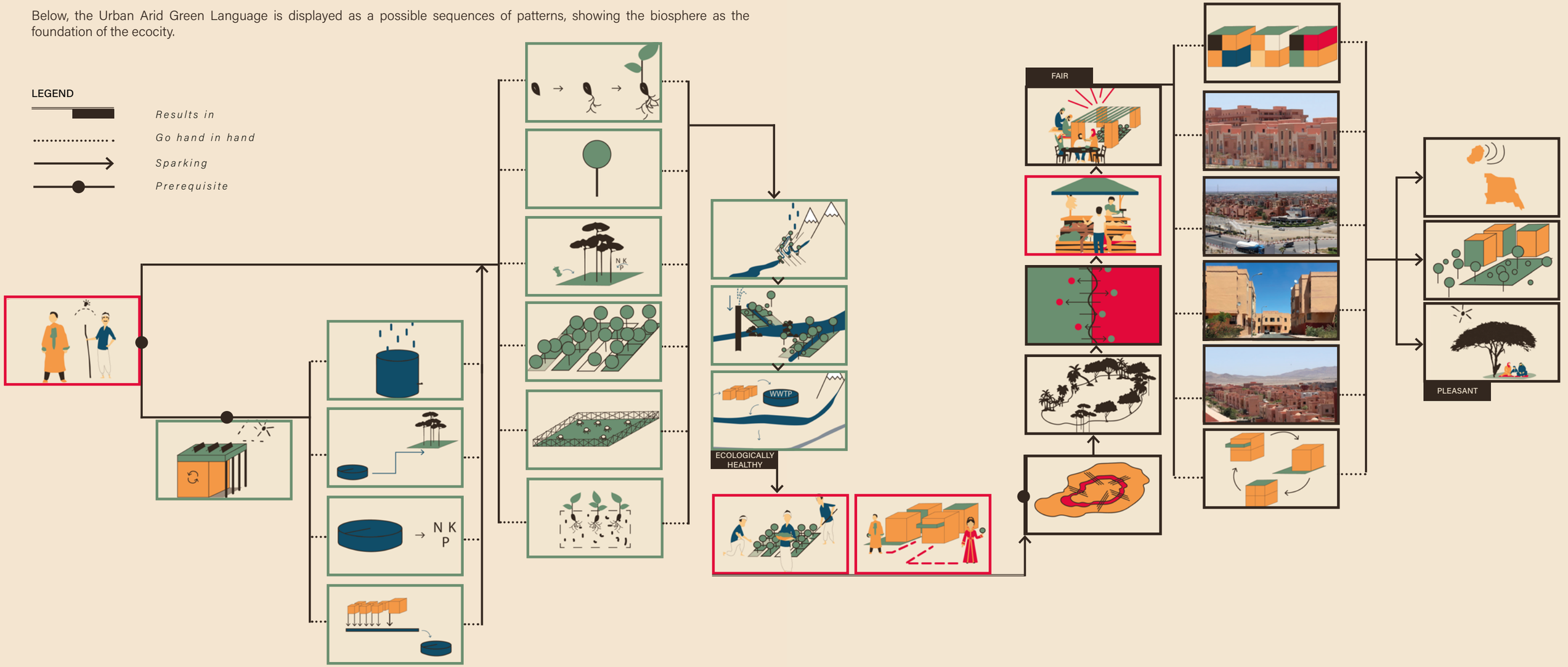


Figure 76: Urban Arid Green Pattern Language

DESIGN

8

In this chapter, the ecocity principles are translated into a landscape-driven design. The chapter demonstrates how the method of the Urban Arid Green language can be applied. It illustrates a potential spatial outcome of the community-driven vision.

The design does not touch the form of the planned built volumes in Tamansourt, to fit into the plan by Al Omrane.

Locations key to the Tamansourt Ecocity 2040 vision are zoomed in on. This is done on diverse scales, the city, neighbourhood and building/plant scale.

Next to visualising a potential spatial outcome, the chapter aims to explain what to do and why.

CHAPTER'S CONTENT

The previous chapters highlighted the importance of involving the community in the design process. Their input in this is extremely valuable and should be used to design an ecologically, socially and economically healthy city.

This did not happen during the Urban Arid Green graduation project, among others because the expectations of the locals must be considered.

The Urban Arid Green project aims to design a spatial framework for the community to appropriate. Designing the city top-down is explicitly not the goal of this research.

8.1 TAMANSOURT-ORIENTED

The analysis showed that Tamansourt is perceived as a dormitory city, which is lacking sufficient urban amenities and job opportunities. The urban fabric of Tamansourt supports this, it is Marrakech-oriented. For Tamansourt to lose this image, its structure must shift from being Marrakech-oriented to Tamansourt-oriented. The vision for Tamansourt as designed by Al Omrane Marrakech (2008, p. 182), and shown on page 69, is altered to the Tamansourt-oriented plan shown in Figure 77 below. The following paragraphs explain key aspects of this plan more in detail.

8.2 Mobility shift
As Tamansourt is built to be dense, the transition focuses on the urban fabric in between buildings and its interaction with buildings. As the open public space mainly includes infrastructure, a mobility shift is needed.

8.3 Local hubs
To activate the urban area, spaces for common interest are created in the three, by Al Omrane appointed, centres.

8.4 Central hub
The central hub is located on the northeast side of Tamansourt, outside the outer road. Here, food production, education, research and touristic activities synergize.

8.5 Seasonal parks
The greened wadis enclose the ecocity, translating old Moroccan medina walls into those of a new ecocity. Creating two linear parks for the inhabitants to enjoy.

8.6 Sanitation system
To close the loops, a circular water system is designed. Mainly due to odour nuisance, the wastewater treatment plant is located in the South-East of the city.

8.7 Appropriation
To activate the framework, spaces for social gathering are created. These are located within the seasonal parks and central hub on the activity strip, on the continuation of the main axis in the city.

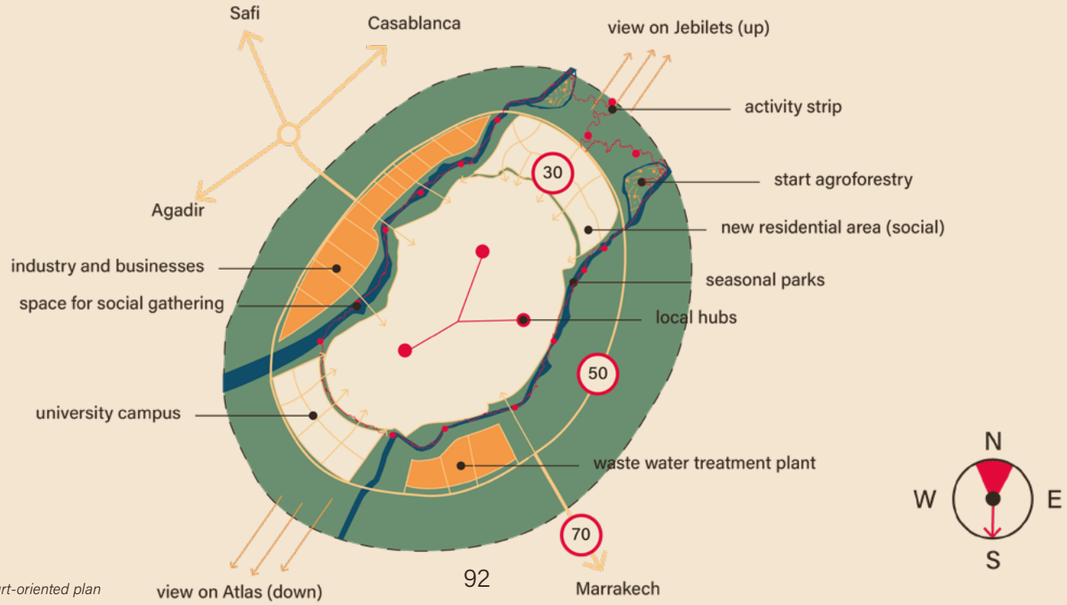


Figure 77: Tamansourt-oriented plan

8.2 MOBILITY SHIFT

Rethinking the infrastructure will support the shift in the urban form of Tamansourt from Marrakech-oriented (out) to Tamansourt-oriented (in).

The Marrakech-Safi highway now crosses Tamansourt through the core of the city. Slow traffic goes over this fast traffic via pedestrian bridges. The highway splits into avenues of 14-meter-wide asphalt. This is dividing the city into parts and forming physical and non-physical barriers.

By prioritising the outer road to enter Tamansourt or cross Tamansourt, slow traffic within the city is prioritised and comforted. The infrastructure will form less of a barrier throughout the urban layout. Slow traffic and shared mobility will facilitate more safe, healthy and social mobility.

Due to this shift, the grand avenues within the city become more than traffic arteries. They have the potential to become urban axes of activity that connect the centres.

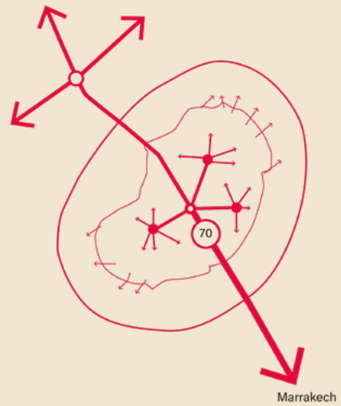


Figure 78: Current mobility vision, based on vision map Tamansourt by Al Omrane. (Al Omrane Marrakech, 2008. p. 182)

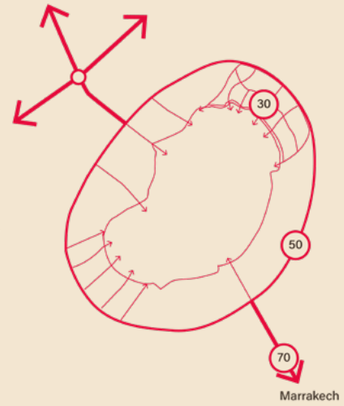


Figure 79: Rethought mobility vision

Figure 80: Principle rethought main infrastructure / outer road

The outer road will connect the rewilded natural landscape or agroforestry to industry, businesses, the university campus or housing with retail.

The principle for the outer road is focused on creating a safe road. Here, slow traffic and fast traffic are separated. There is enough lightning, pedestrians are prioritised and bus stops are located on a strategic location.

The outer road is not built yet during the Urban Arid Green project. Therefore, the layout of this road can be rethought.

8.3 LOCAL HUBS

The mobility shift allows the local hubs to spark active, multifunctional centres. By only rethinking the infrastructure, the grand avenues and urban form are kept intact. The local hubs are located in the three by Al Omrane-appointed city centres, they fit within the future urban layout.* The location ensures proximity to all residents.

In every centre, the secondary avenues split into tertiary avenues. On these points, where flows come together, large open areas are located. These spaces are similarly sized to Jemaa el-Fna in Marrakech (see Urban Arid Green Photo book, p.31). The hierarchy in urban form automatically guides flows towards these centres. Adding the local hubs to these spaces activates them.

The avenues connecting these centres already include space for activities in the plint, with housing on top. By slowing down the 10-15m-wide asphalt and transitioning it into wide, active, boulevards, a pleasant multi-functional strip is created.

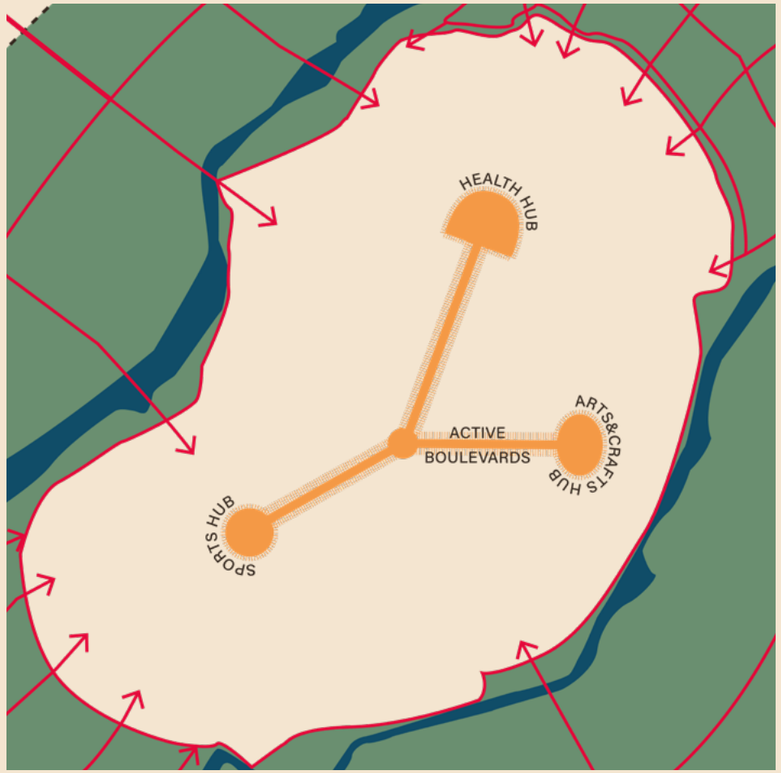


Figure 81: Rethought mobility activate centres.

The local hubs in the centres include a mix of functions. Every hub includes general functions; a nursery, shop, restaurant/café and supporting facilities, as well as hub-specific functions. Common daily activities, such as doing groceries are mixed with more occasional activities, like sports/arts/health, or collecting green. By this, a common use is stimulated.

General functions

In the shop, among others, food grown in the central hub is sold to the population. The nurseries grow urban green for the residents to collect and green the city from the bottom up. In cafes and restaurants, food and drinks are prepared using local products. The activities provide locals with job opportunities and emphasize the interaction between different locals. The centres will give new purpose to its inhabitants.

Hub-specific

The fundamental amenities that were lacking, as presented in the analysis, are added to the hub. By this, the functions in Tamansourt will be more adequate for its population. The amenities added depend on the already present functions surrounding the hub. Each centre will have different characteristics.

** The design for the local hubs is based on the visionary model at the Al Omrane Tamansourt office, shown on page 70. In some cases, the already-built blocks differ from the visionary model. In these cases, the model is altered to the present situation.*

The analysis showed that the main infrastructure already includes green avenues. This green must remain to create comfortable boulevards.

In the Tamansourt Ecocity 2040 vision, the locals will regreen the urban landscape further. The zoning plan by Al Omrane is used as a basis. The villas and apartment buildings with shared courtyards need to maximise the amount of ground bounded green. The residential buildings with balconies must maximise the amount of green in pots. All other typologies without (suitable) outdoor space should include wall and roof greening.

Figure 82: Different types of greening per typology.

This diversity in green is displayed in the green zoning plan in Figure 83 below.

Greening up the built environment from the bottom up has a positive effect on mental health. The production of these seedlings provides work and income, giving the locals a new purpose. It improves the urban climate and quality of life and space. In this strategy, the locals take the lead in greening their living environment. Whilst being responsible for the process, they must be supported by the system.

The species that may be used in the built environment of Tamansourt are presented in Table 5 to the right. This palette includes more exotic species than agroforestry and seasonal parks, because of the urban heat island effect and because people can individually take better care of their vegetation. Added to this palette are the palettes of the seasonal parks and the agroforestry, as both include native, drought-resistant species. The selection process of these species is explained in the Urban Arid Green Species Catalogue.

Figure 83: Green zoning plan for Tamansourt's built environment.

Scientific name	Origin
Washingtonia robusta	naturalized
Chamaerops humilis	not native
Cupressus sempervirens	not fully native
Jacaranda mimosifolia	naturalized
Melia azedarach	naturalized
Schinus molle	naturalized
Gazania sp.	naturalized
Agave americana 'Variegata'	naturalized
Plumbago auriculate	introduced
Washingtonia robusta	naturalized
Jacaranda mimosifolia	introduced
Cenchrus setaceus	native

Table 5: Proposed vegetation palette to grow in the local hubs.

Sports hub

On the southwest avenue, leading towards to only hub South to the former highway, some public football courts are located. On some side streets, tennis courts are located. Adding sports facilities to the southern hub will strengthen the sportive scene. This hub is described more in-depth on the next page. Close to the hub, a park and mosque are located.

Arts & Crafts hub

In the East centre, a movie theatre is already located. By adding arts and crafts activities to this hub, a scene of leisure is created.

Health hub

Along the centre in the North, a pharmacy and general practitioner are located. As a hospital is missing in Tamansourt, these activities provide the city with the opportunity to form a health centre.

LEGEND

- *Local hub - added buildings*
- *Local hub - added nursery*
- *Residential buildings*
- *Public functions*
- *Park*
- *Main flows to hub*

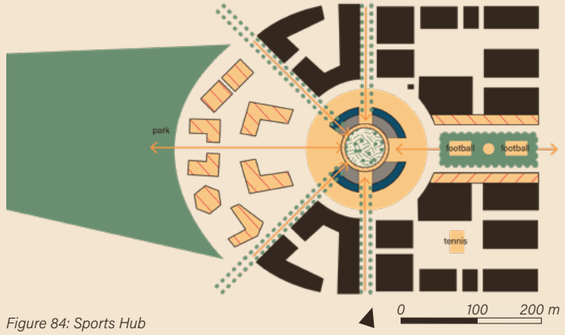


Figure 84: Sports Hub

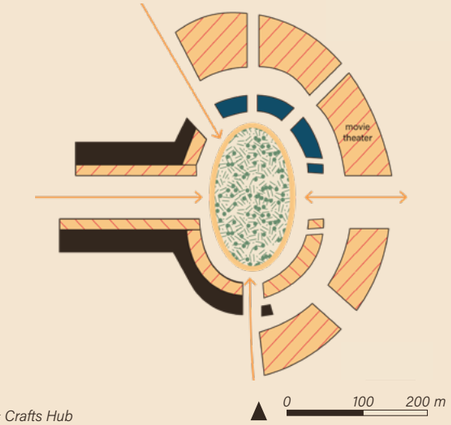


Figure 85: Arts & Crafts Hub

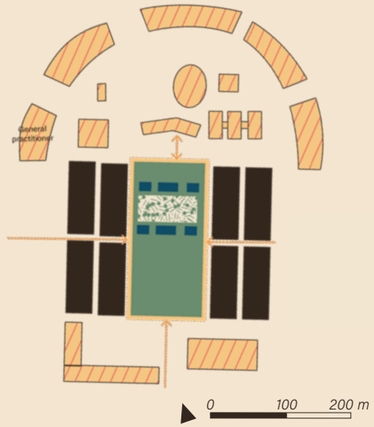


Figure 86: Health Hub

In Figure 87 below, the design process of the Sports hub is visualised. Below, this process is explained more in detail, to set an example for the other hubs.

1. The urban form is used to guide flows towards the large open space.

2. The mobility shift opens up the space to use, as it won't be enclosed by a 4-lane roundabout anymore.

3. Midst of the open space, the community centre is located.

4. The building volumes are based on the flows, opening up towards the public functions on the West side. The buildings interact with the volumes of Al Omrane, without seeking any symmetry.

5. The volumes are levelling up towards the Al Omrane-buildings to integrate into the urban form.

6. The nursery, the greening process, is the focal point of the centre and thus the city. The centres are the heart of the ecocity, in location and place in the transformation process. The volumes enclose the nursery, creating a more intimate atmosphere.

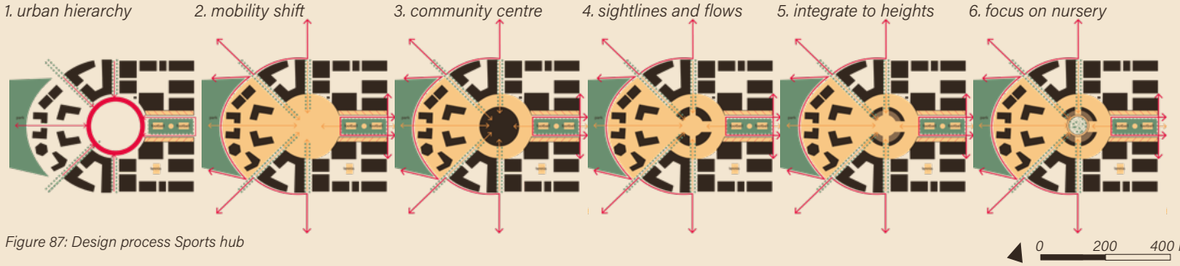


Figure 87: Design process Sports hub

Figure 88 to the right shows the possible area overview of the generic and specific function of the Sports hub.

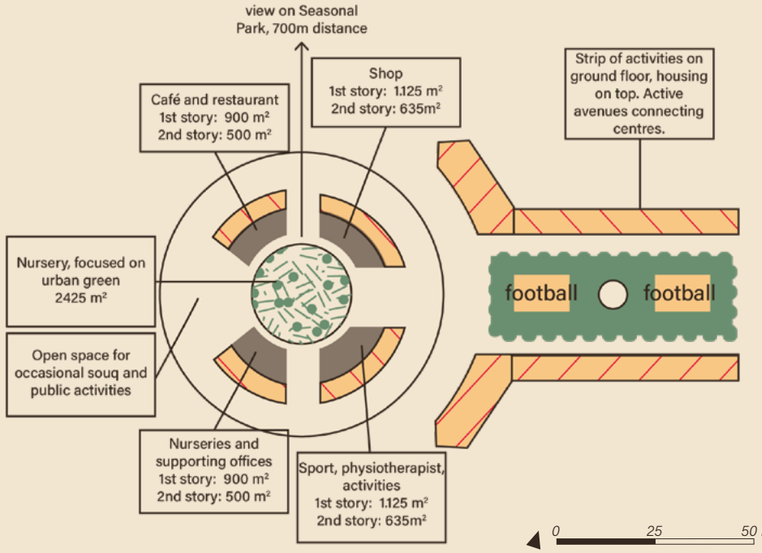


Figure 88: Area overview generic/specific functions Sports hub.

Learnt during the site visit, empty open spaces in Tamansourt are often used by the locals as a place to organise a souq. This is also the case for the empty roundabout, as shown in Figure 89 below.

Figure 89: Roundabout local hub Tamansourt, screenshot from (Morocco map satellite//Africa, n.d.).

The centre still facilitates this by reserving open space for a souq or other local activities, as shown in Figure 89.

The local hubs' structure is made out of rammed earth, similar to the smaller canopies spread over the activity strip (see chapter 8.7). This creates entities and a clear, recognizable structure.

Different locals come to the community centres for different purposes. They all benefit from it and there is a certain level of social safety. People get to know each other.

Based on the demographics of Tamansourt (chapter 3.1) four main characters are used to envision the use of the community centres on the next page.

The impression in Figure 92 on pages 100-101 shows the small-scale atmosphere in the local hub. The ten most important applied patterns of the Urban Arid Green language in this location are highlighted.

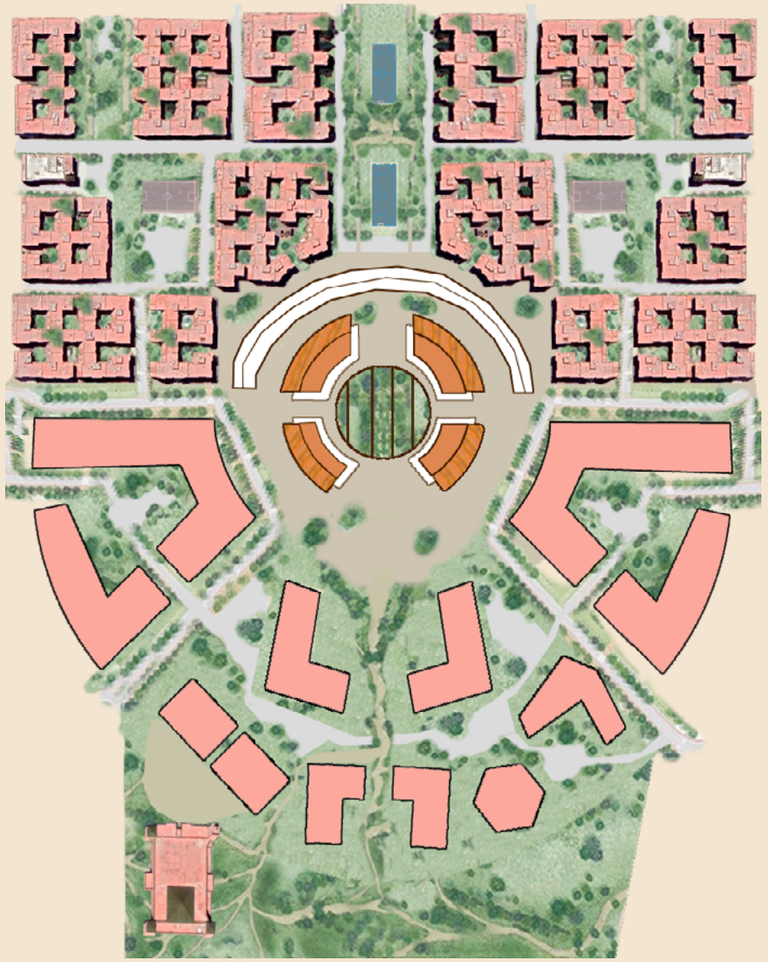


Figure 89: Plan Sports Centre

Figure 91: Impression from active boulevard to Sports hub, including the different users.

Fatima, 42 years old mother of five. While her kids are in the daycare and at school, she works in the nursery. Here, she spends her day taking care of the seedlings and working in the restaurant. She visits the agroforestry site once a day to collect fresh vegetables for the shop and restaurants. She meets many fellow locals during her days.

Yassin, 63 year old retired man. He worked his entire life but still takes great joy from working for the community. During the day, he coordinates the nursery and works on administration. He visits the nearby mosque three times a day and coaches the youth on the football courts to the next world cup.

Layla, 21 year old student. She lives and studies on the university campus. After her day of studying, she visits the city centre to buy fresh vegetables. She buys some additional food in the markets along the boulevard, and walks back home via the calming Eastern seasonal park to clear her mind.

Jamal, 16 year old boy. After his school day, he plays football on the public football court with his friends. Afterwards, they work out in the gym in the city centre before he goes home for dinner. After dinner, he visits the park to enjoy time with his family.

Figure 90: Section Spots hub and surroundings

Figure 92: Impression small-scale atmosphere in local hub. Interior from (den Heeten, 2022).

MOST IMPORTANT APPLIED PATTERNS

D.6 INTERACTION

B.2 CLEAN & MOROCCAN

C.9 CLEAR STRUCTURE

O.2 NATIVE SPECIES

B.1 PLOT GREENING

O.5 KNOW-HOW

D.5 LOW-PROFILE

R.3 FAIR FINANCIAL

C.2 COMMON INTERESTS

8.4 THE CENTRAL HUB

The central hub is linked to the new residential area on the northeast side of Tamansourt. *

In the central hub, extra channels are dug to provide the wadis with room for the water and reduce flash floods. The extra channels follow the elevation of the landscape. When the wadis fill up in the rainy season, water flows into the extra channels naturally. The extra channels are less deep. A weir downstream to the extra channels allows catching water in the new system. The active greening of the wadis will start upstream.

The land in between the water bodies is the first target location for the agroforest, as most water will infiltrate this land. Both regreening actions benefit from each other. The green will spread naturally from these starting points as the soil's quality is restored. Within this first target zone, the exact starting point for the agroforest lies along the activity strip. The activity strip runs through the central hub, over the 5m elevation line for a more organic feel. Tourist, agricultural and educational functions are attached to the strip. The forest feeds on the nurseries, while tourists, students and researchers can learn from the activities.

The route starts at the crossing with the main avenue coming from the new neighbourhood. Here, a parking lot is located. Except for logistics, the hub will be pedestrian-only. The central hub is in constant exchange with the local hubs, where local products are sold to the community.

On the places where the extension of the other avenues crosses the activity strip, additional built volumes are located. Here, research, education, and tourist activities are housed. As the central hub is elevated to the city, there will be a clear sightline towards these buildings.

Along the seasonal park and on the North side of the hub, thorny bushes ensure the absence of livestock, to prevent the land from being overgrazed. As seeds spread over this, nature will rewild over these borders. In the central hub, fenced livestock farms are located. By providing the farmers with a place to keep the livestock, the thorny bushes will be respected.

The activity strip continues through the seasonal parks. By adding recognition points for people to come together in strategic locations, outdoor activity increases and functions mix.

The central hub brings a circular and local food chain and it creates jobs. Via agroforestry, the area is regreened actively. This creates the conditions within which the landscape can rewild. The soil's quality is restored and therefore water can infiltrate more easily, lowering the pressure on the aquifer and even replenishing it.

** During the period of this research project, February 2022 - January 2023, this area was not constructed yet. The design for the central hub is based on the visionary model at the Al Omrane Tamansourt office, shown on page 70. Urban Arid Green aims for an adaptive approach. If the visionary model does not correspond to the final built output, the design must be altered following the guidelines.*

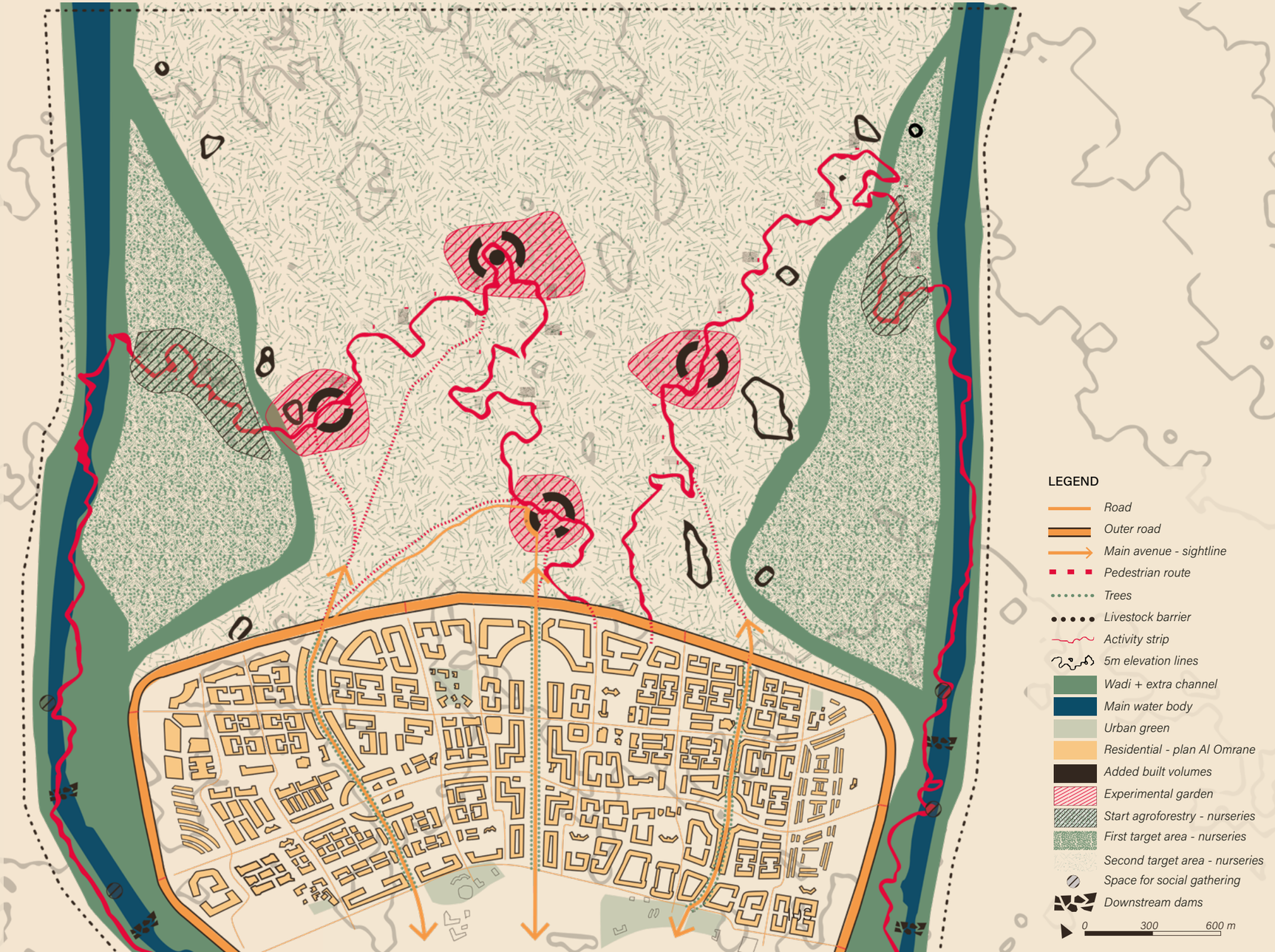


Figure 93: Plan Central Hub >

The link between the central hub and the city is shown in Figure 94 below.

The central hub is linked to the new residential neighbourhood. The outer road in between both allows public transport and prioritises safe and slow traffic. From the outer road, visitors from the central hub can take an exit and park their cars at the tourist centre. From that point, the activity strip starts. This runs through an agroforestry site. Within this landscape, the locals test different ways of food production, soil formation and restoring degraded areas.

As the central hub is located outside the city, they won't block the sightlines towards the mosques in the city. One of the buildings in the hub functions as a watchtower. From this, visitors will have a beautiful view over the seasonal parks, agroforest and city. From here, the restoration process will show.

Within the tower, research, tourist and educational functions are stacked. The largest tree in the forest will be up to 30 meters. The watchtower will be a bit lower. By this, a view is will be interesting, looking, on, up and through the forest. A staggered façade uses the tree as a metaphor.

The nurseries and storage space are located along the activity strip, to feed the forest. Within the storage space, the low-profile equipment and products from the forest are kept.

Figure 94: Section Central Hub

Urban Agroforestry
Perennial ecosystemic agriculture will be established in the central hub. This contributes to converting the desertified landscape into a productive ecology.

The agroforestry site is a new economic driver for the ecocity, though the goal is to create a system where humans and nature are in harmony.

The tree species that may be used in the Tamansourt agroforestry are presented in Table 6 to the right. The selection process of these species is explained in the Urban Arid Green Species Catalogue. In conclusion: a mix of native, drought-resistant tree species is used, growing either edible or economically valued products. These trees are combined with crops. The locals must select which crops they grow in between the trees, taking into account the demands on water, humidity, soil and sun. Crop and phase rotations must be included, as explained in the analysis.

The most important is to search for food varieties that thrive in the local conditions (Trainer, 2019). As this is an experimental site, this might be a process of trial and error.

The not-so-site-specific challenge here is that harvest might fail, due to climate change or hazards. The governmental policies should support the conversion of the land into agroforestry. For example, providing subsidies whenever the harvest is failed or the land is disrupted. Or to provide local farmers with start-up capital. Locals should take initiative to form Community Based Organisations. Through this, the stakeholders complete and stimulate each other. Bottom-up initiatives, education and research are crucial to this site.

By creating a planting scheme to harvest throughout the year, the workflow is more evenly distributed. It provides a more reliable, sustainable food chain.

The goal for Tamansourt is to have a closed local food chain. The Dutch Nutrition Centre advises eating 200 g of vegetables and 200 g of fruit per person per day (Rijksinstituut voor Volksgezondheid en Milieu, n.d.). This is 146 kg per year. When the soil is intensively used and rotated all year round, with two harvests a year, an average yield of 2kg per m^2 can be taken from the forest, with a variety of vegetable productivity.

When aiming for a complete local food chain, approximately 73m^2 of space is required per person. Tamansourt's target population is 450.000, Tamansourt now counts 70.000 inhabitants. To feed the population, the agroforest needs 5,11 km^2 now and 32,85 km^2 in the future*. With 19,5 km^2 of total surface in Tamansourt, this is one-fifth to one-and-a-half time the surface of Tamansourt. This is for vegetables and fruit production only, nutrition for livestock and space for livestock are not included in this calculation. The calculation shows that the space for agroforestry must be sufficiently large to expand over time.

** Calculations might differ due to different circumstances, different (Islamic) diets and testing different methods of food production.*

Scientific name	Origin
Quercus ilex	native
Quercus coccifera	native
Quercus faginea	native
Quercus rotundifolia	native
Quercus suber	native
Olea europea sylvestris	native
Olea europaea maroccana	native
Pinus halepensis	native
Pinus pinea	native
Pinus pinaster	native
Tetraclinis articulata	native
Argania spinosa	native
Ziziphus lotus	native
Pistacia atlantica	native
Pistacia lentiscus	native
Ceratonia silicua	native
Phillyrea angustifolia	native
Cupressus atlantica	native
Olea europea	native
Ziziphus jujube	naturalized
Eucalyptus camaldulensis	introduced
Argania spinosa	native
Citrus aurantium	native
Phoenix dactylifera	native
Verbena officinalis	native
Lavandula (multifida)	native
Nerium oleaner	native

Table 6: Proposed vegetation palette to grow in the central hub.


START: 2023


PHASE 1: MICROCLIMATE


PHASE 2: SOIL FORMATION


PHASE 3: AGROAFFORESTATION

Figure 95: Formation Agroforest

Formation Agroforestry
In Figure 95, the formation of the Agroforest is visualised. To transform the barren landscape into a healthy food forest, planting trees and making trenches is the first step. The trees will provide shade and the microclimate will start to adapt. Next, a phase of humus/soil formation starts, using organic waste and recovered nutrients which close loops. By intense pruning, and leaving the branches afterwards, this process is fastened.

When the conditions are met, crops can be grown between the trees and the phase of agrofforestation begins. When the forest is stabilized, products can be taken from it as well.

Not every tree or crop can be harvested during the year of the plantation. Quercus suber (Cork oak) for example can only be harvested after 25 years and every nine years. A harvesting schedule must be drawn up to keep track of this workflow.

On pages 107-110, impressions of the agroforestry site are shown. Within the visualisations, the applied patterns are highlighted. By this, the design shows one of the many spatial outcomes of the patterns used.

Figure 96: Impression Agroforestry Central Hub. One additional image used: Blue Diversion Autarky - ANSI Sanitation. (n.d.). https://sanitation.ansi.org/DiversionAutarky. >
Figure 97: Impression Agroforestry Central Hub. >

MOST IMPORTANT APPLIED PATTERNS

M.4 WASTEWATER TREATMENT

M.2 NUTRIENT RECOVERY

N K P

D.4 CONTROLLED GRAZING

O.2 NATIVE SPECIES

D.1 AGROFORESTRY

O.5 KNOW-HOW

D.5 LOW-PROFILE

R.3 FAIR FINANCIAL

C.2 COMMON INTERESTS

MOST IMPORTANT APPLIED PATTERNS

D.4 CONTROLLED GRAZING

O.4 VITAL SOIL

D.1 AGROFORESTRY

O.2 NATIVE SPECIES

D.2 STOP DEPLETION

O.5 KNOW-HOW

D.5 LOW-PROFILE

R.3 FAIR FINANCIAL

C.2 COMMON INTERESTS

8.5 URBAN SEASONAL PARKS

Water safety
The new seasonal parks prevent the urban area from flooding. It is a more efficient use of the wadis and adds to the livability of Tamansourt. The wadis cannot flood aggressively anymore. The hydraulic-oriented nature-based solutions presented on the right below, in Figure 99, are prerequisites for a safe urban redesign of the erosion gulls. To mitigate flash floods, prevent water erosion and thus restore the soil quality in Tamansourt, interventions upstream and downstream are needed. Communities that live around the erosion gulls along the whole stream, visualised in Figure 99, are important stakeholders for Tamansourt.

From erosion gull to park
When the natural system is harnessed, the flash floods that used to erode the soil will seep into the soil and replenish reserves. Water that used to be wasted during flash floods will then increase the water resources. In the rainy season, parts of the parks might be too wet to use comfortably. Nevertheless, the space is used more efficiently throughout the year.

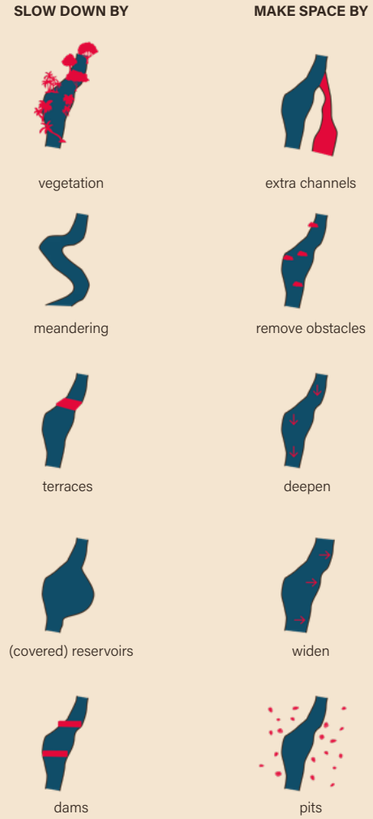


Figure 98: Measures for Water Safety.

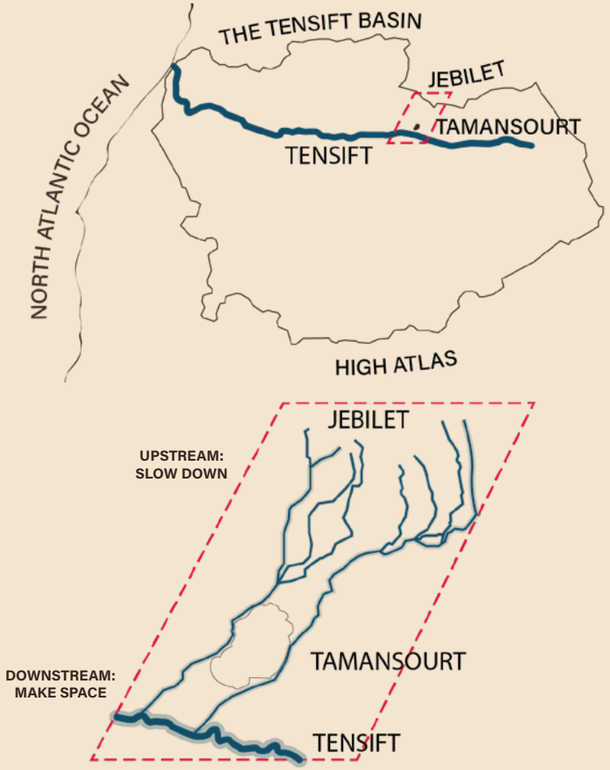


Figure 99: Location Waterbodies Linked to Tamansourt in Tensift Basin.

In Figure 100 below, the most important hydraulic-oriented measures to transition the erosion gullies into seasonal parks are visualised on the waterbody west of Tamansourt. Slowing down the water and preventing overgrazing are the most important measures to restore the water bodies. The location of the sections is shown in Figure 101 to the right.

Figure 101: Locations of longitude sections and cross sections. Image from (Google Earth Pro, 7.3.4.8642, 2022).

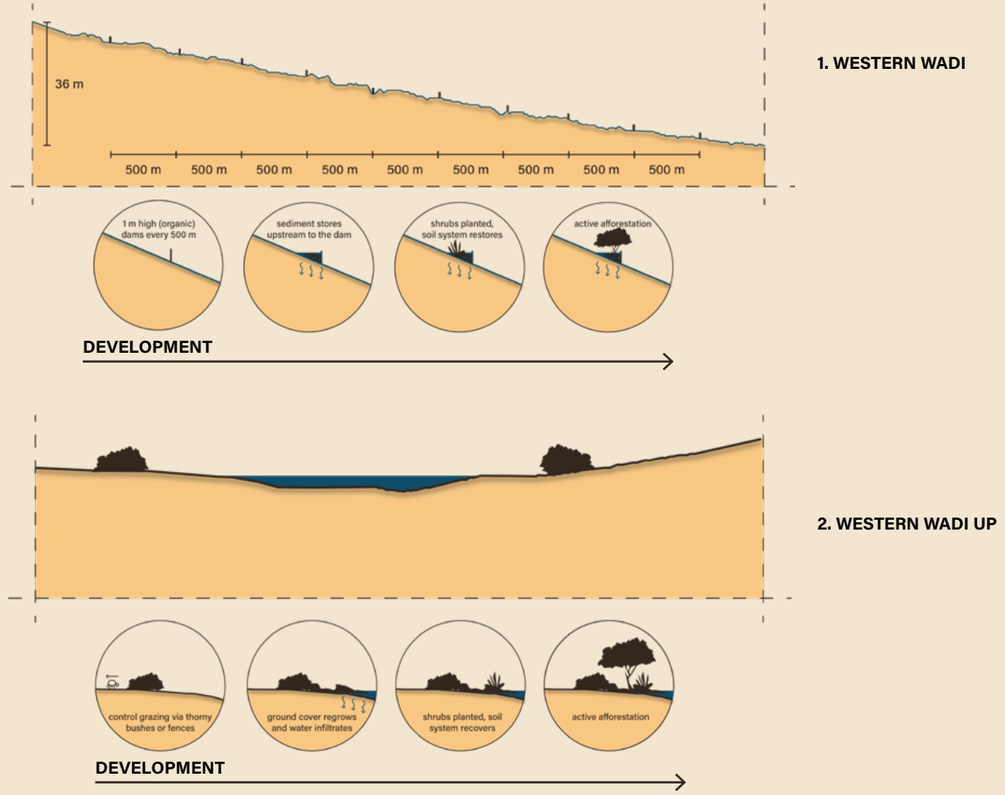


Figure 100: Measures to slow down water in Western wadi in longitude and cross-section.

Nativeness
The seasonal park is a different take on a tidal park. In Marrakech, the famous Jardin Majorelle is located (see Urban Arid Green Photo Book p.30). The Marrakech and Tamansourt parks differ in species, as within the Tamansourt parks, only native species will be used. This is to prevent high watering and maintenance costs. The parks in Tamansourt will exhibit the beauty of the Moroccon flora and fauna, creating tourism and cultural value.

A mix of native, drought-resistant species that could be used in the park is presented in Table 7 to the right. The selection process of these species is explained in the Urban Arid Green Species Catalogue.

The species that can be used on this site highly depend on the amount of water and the flow velocity, which depends on the exact location along the water body. As this is an experiment, this might be a trial-and-error process to see what species suit the landscape best.

Scientific name	Origin
Quercus ilex	native
Quercus faginea	native
Quercus suber	native
Olea europaea maroccana	native
Pinus halepensis	native
Pinus pinea	native
Pinus pinaster	native
Tetraclinis articulata	native
Argania spinosa	native
Ziziphus lotus	native
Pistacia atlantica	native
Pistacia lentiscus	native
Arbutus unedo	native
Teucrium fruticans	native
Chamaerops humilis	native
Rosmarinus officinalis	native
Myrtus communis	native
Phillyrea angustifolia	native
Olea europea	native
Argania spinosa	native
Citrus aurantium	native
Nerium oleaner	native
Phoenix dactylifera	native
Citrus aurantium	native
Myrtus communis	native
Dracaena draco	native
Lavandula (multifida)	native
Rosa (canina)	native
Pennisetum setaceum	native
Nerium oleaner	native
Hedera helix	native

Table 7: Proposed vegetation palette to grow in the Seasonal Parks.

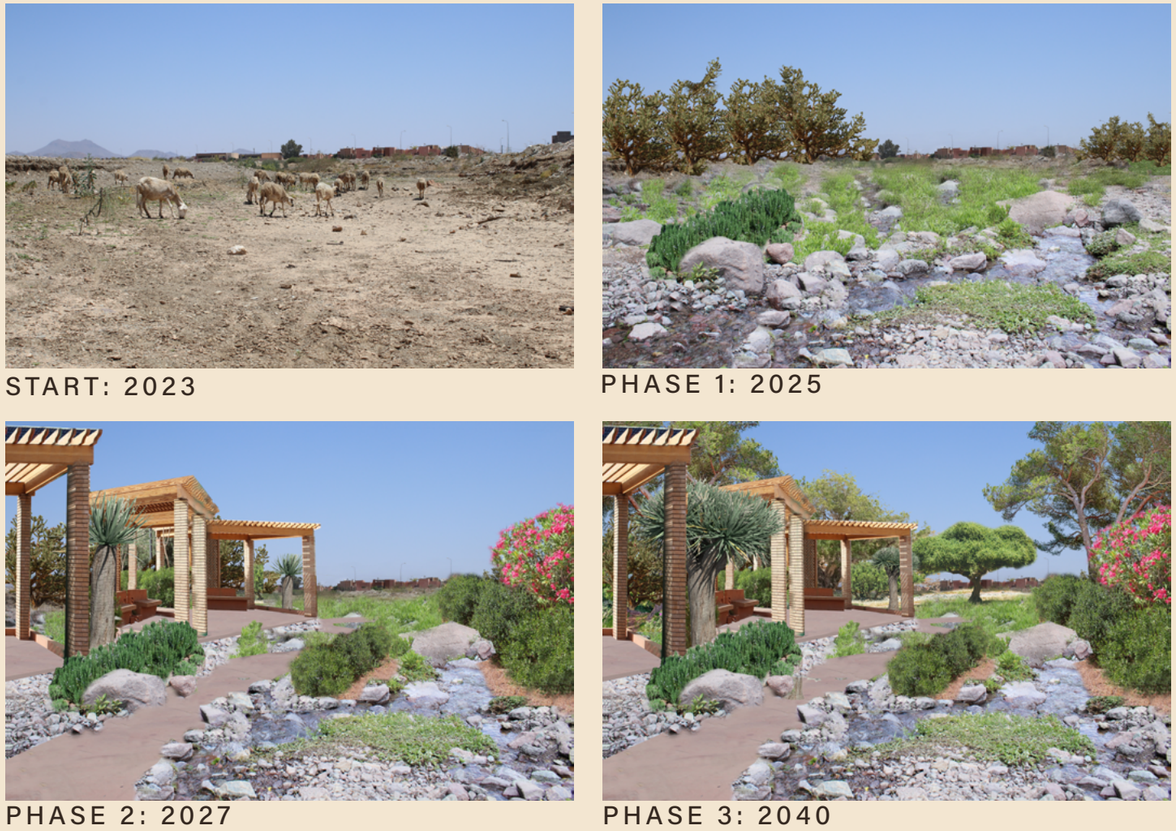


Figure 102: Phasing Seasonal Park.

Phasing to seasonal park
In Figure 102, the phasing of the Seasonal Parks is visualised. First, the prerequisite is needed: water. Slowing down the water upstream and creating room for the water downstream. By using organic material, the water will be captured. The absence of livestock is another prerequisite as the wadi cannot be overgrazed anymore. In this first phase, the conditions for the wadi the regreen are created. Ground cover can grow back naturally. In the second phase, the vegetation needs to be planted actively, to create the conditions for the park to be rewild further. Due to the restored ground cover, the water can infiltrate better and shrubs can be planted. As the water is slowed down, it is safer to recreate in the wadis. In the third phase, the afforestation begins. Especially in the earlier phases, after intenser rainfall from November to March, more maintenance may be needed. However, this is also creating job opportunities and a community feeling for locals to tidy the park.

On pages 118-119, the final visualisation of the park is shown together with the applied patterns. The visualisation shows one of the many potential outcomes of the patterns used.

Improve the quality of life and space
The urban seasonal parks will enclose the Tamansourt ecocity, as the old walls enclose historic Moroccan medinas.

By adding several canopies in strategic locations, the seasonal parks will facilitate social gatherings. The rammed-earth canopies arise out of the arid soil, just like the wildered Moroccan landscape will. While respecting the natural system, people may use the parks.

Following the study by Van den Berg et al. (2016), the seasonal parks will have a positive effect on the mental and physical health of their visitors.

As the landscape rewilds, it grows high and new sightlines are created. The parks will form a new green decor, as visualised via the impression in Figure 104 on the next page. The restored wadis improve the quality of life and space as every inhabitant lives within a 1,5 km distance of the linear parks.

Section Western wadi
On the west side of Tamansourt, the seasonal park is located between the newly built industrial/business area and the residential area. The link between the urban area and the seasonal park is visualised in Figure 103 below.

The road linked to the residential area is more slow-traffic oriented, to provide safe and healthy mobility, lowering the barrier to visiting the park.

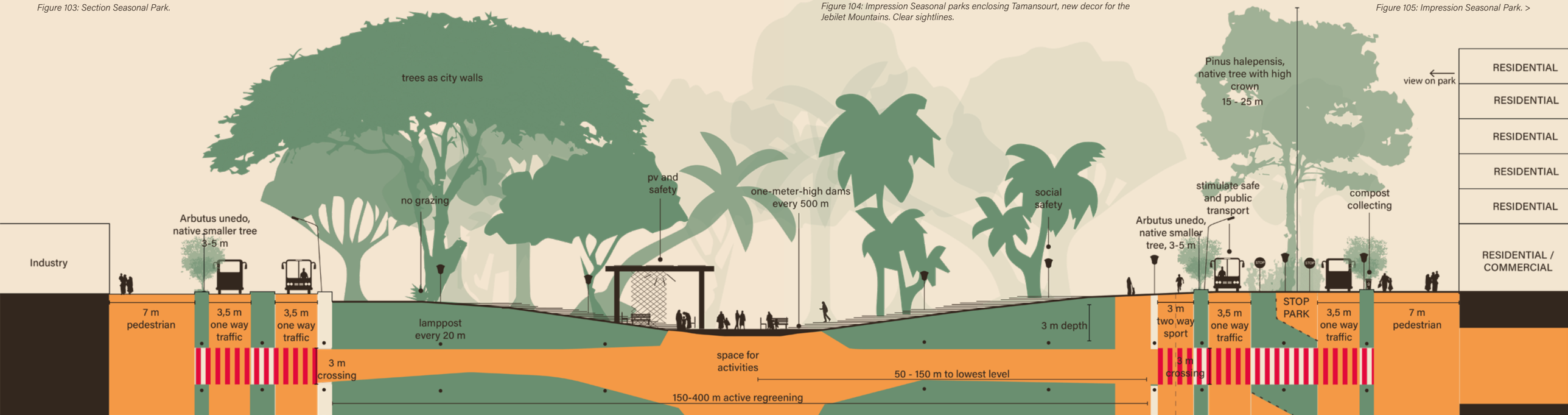
The wadi is three meters deep maximum. Via a slow slope, everyone can visit the park. The activities are located amid the wadi, as the surface there is horizontal and more comfortable. The width of the park varies from 150 to 400 meters.

The road linked to the business/ industrial area is more car-oriented, as the area will mainly be visited by car. As it is close to the highway exchanger, visitors will enter via the West side. Inhabitants from Tamansourt, who might work there, will visit the area via safe slow traffic and the seasonal parks. The employees who walk to work, start their day with a lovely, calming scene. At the end of the day, they might run into fellow locals who are enjoying the park.

Figure 104: Impression Seasonal parks enclosing Tamansourt, new decor for the Jebilet Mountains. Clear sightlines.

Figure 105: Impression Seasonal Park. >

Figure 103: Section Seasonal Park.



MOST IMPORTANT APPLIED PATTERNS

D.4 CONTROLLED GRAZING

O.2 NATIVE SPECIES

R.1 REDUCE FLASH FLOODS

O.4 VITAL SOIL

C.8 IMPROVE QUALITY OF SPACE

C.3 GATHERING SPACES

C.5 BREAK THE BARRIER

C.4 EASY TO EXPLORE

M.1 REDUCE, REUSE, PRODUCE

NEW RESIDENTIAL DISTRICT

8.6 SANITATION SYSTEM

Centralised wastewater treatment
As water is limited in the Maghreb, water should be reused as much as possible. At the moment a wastewater treatment plant is too expensive for Tamansourt, however, it is aimed to be developed and therefore included in this long-term vision.

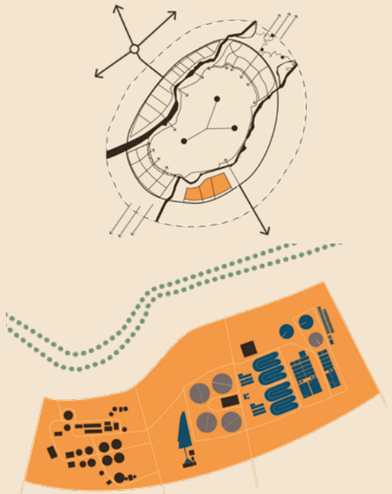


Figure 107: Zoom-in WWTP

The surface of the wastewater treatment plant (WWTP) is copied from the recently built WWTP in Marrakech. As it is so nearby, wastewater numbers per person are likely similar. The Marrakech WWTP has a project size of 263.000m3 water/day. In Morocco, 62% of the urban dwellers are connected to a water treatment plant (Alhamed, Biad, Saad, & Masaki, 2018). The goal for Tamansourt is to have 100% connected.

Marrakech counts 1.033.050 inhabitants (Worldpopulationreview.com, 2022). 62% of this number is 640.500. As with a target population for Tamansourt of 450.000 inhabitants, only 70,3% of the treatment capacity will be in use, 184.900 m3 of water can be cleaned.

The wastewater treatment plant in Tamansourt thus allows extra population growth on top of the target population, however, there is a limit. The situation of the WWTP limits the urban expansion to the southeast, due to odour nuisance.

As noticed on the site visit in May 2022, wastewater treatment plants can be smelly. The WWTP is therefore positioned south of the city. As the main wind direction in Tamansourt is north-northwest to north-northeast, Tamansourt will not be disturbed by the odour.

Figure 108: Main wind direction Tamansourt

When occasionally the wind blows towards the city, the seasonal park will function as a natural shelterbelt, as Vegetative Environmental Buffers can mitigate odour (Tyndall, 2008).

The treatment capacity and odour nuisance of the WWTP both mark a clear limit to Tamansourt's growth.

Via the centralised infrastructure of the WWTP, grey and black water are treated. The output of this plant can be fertilizer and clean water (Eawag, n.d.-b).

Fertilizers will be used in the hubs. Ultimately, the conditions are met in which nature is a self-sustaining system, and the seasonal parks won't have to be watered actively. Clean, drinkable, water is then only reused in nurseries and the city.

Tamansourt's sewage system must be (re-)constructed for this WWTP, as wastewater coming from the buildings must be brought to the WWTP.

Treating wastewater takes a lot of energy and depends on access to significant quantities of water (Eawag, n.d.-a).

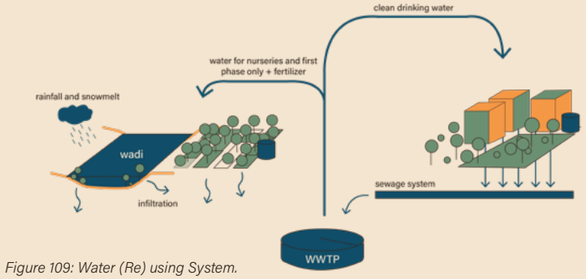


Figure 109: Water (Re) using System.

< Figure 106: Overview impressions Central Hub, Parks, Agroforestry, Local Hub and planned Built Environment by Al Omrane

This makes the WWTP very expensive. Decentralised options for wastewater treatment are therefore explored.

Decentralised wastewater treatment
One of these options is de Blue Diversion Autarky toilet and hand washing station (Method A below). This is a modular, safe, off-the-grid and affordable principle of wastewater treatment. The end product is fertiliser, water for toilet flushing/ hand washing and pellets (Sutherland, Reynaert, Sindall, Riechmann, Magwaza, Lienert &Udert, 2021).

Another option, or an additional one, is the Ray Hay system to treat wastewater. This start-up developed different prototypes. One prototype treats wastewater through a green facade/ balcony gardens (Method B below). Via this method, water can be reused for covered irrigation. Another prototype treats water via planted soil filtration and UV disinfection. Via this method, water can be reused for washing machines, toilet flushing and open irrigation (Method C below) (Riechelman, 2019).

These modular options could work very well in addition to the WWTP, for on-site irrigation and reducing the water demand within the city.

Integrating these options in the plan for Tamansourt makes the treatment process visible as well, it makes people more aware of the process. This integration is visualised via the impressions in Figures 111 and 114 below.

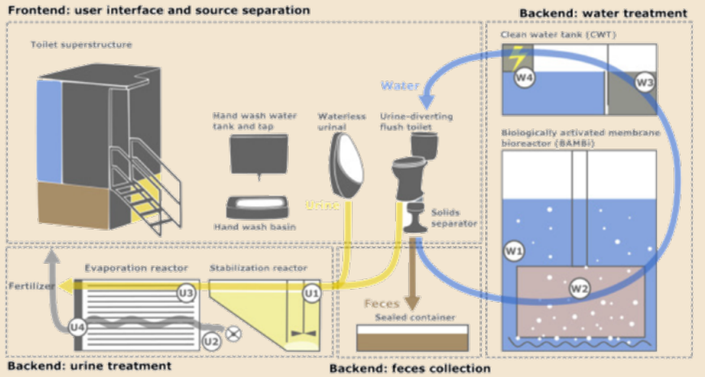


Figure 110: Method A, Blue Diversion Autarky toilet. (Sutherland et al., 2021, p5)

Figure 111: Impression Blue Diversion Autarky toilet in central hub Tamansourt. One additional image used to create this impression: Blue Diversion Autarky - ANSI Sanitation. (n.d.). https://sanitation.ansi.org/DiversionAutarky.

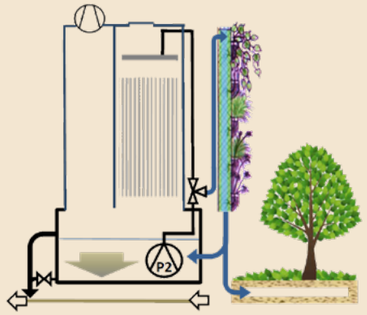


Figure 112 Method B, Ray Hay system through facade/balcony. (Riechelman, 2019, p24)

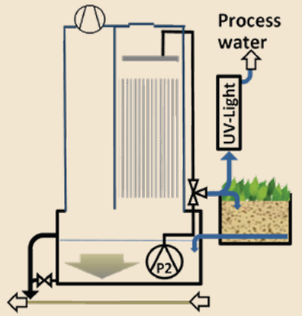


Figure 113: Method C, Ray Hay system through planted soil and UV. (Riechelman, 2019, p24)

Figure 114: Impression Ray Hay system method B in local hub Tamansourt. One additional image used to create this impression: Ray Hay system by (Riechelman, 2019, p.7).

8.7 APPROPRIATION

To activate the green framework of the ecocity, places for common interest within are needed. With the Moroccan sun and temperatures, shade is needed to gather comfortably outside. Many Moroccan canopies can be found in the Marrakech region, see Figure 115. They all have the same purpose; to provide shade and some intimacy.

By positioning these canopies in strategic locations in the design, recognition points can be created. Whenever one finds one along the activity strip and in the hubs, one knows they are welcomed beneath the canopy, it creates entities. In Figure 116, these strategic locations are highlighted.

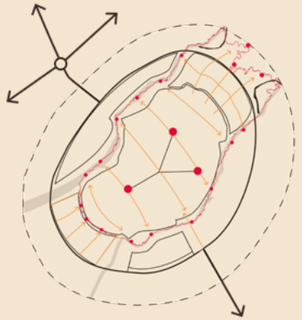


Figure 116: Proposed location 18 canopies along activity strip and three local hubs on city

Figure 115: Photographs Moroccan canopies in Marrakech region, by author.

To create recognition, the design of the canopies must be eye-catching. Rammed earth is an old construction technique used throughout Moroccan history. The old method can be seen in for instance the El Badi Palace in Marrakech, see Figure 117. For this technique, the arid, barren, rocky soil in Tamansourt and the desert landscape nearby can be used.

When building the canopies out of rammed-earth, they will arise out of the landscape, and built the social layer of the city. Every canopy will be slightly different and will provide shadow, together with the opportunity to produce solar energy. Cables can go in the structure while creating outputs for users.

Figure 117: Photographs El Badi Palace Marrakech (left) and soil Tamansourt (right).

To process of rammed earth is explained in Figure 118, to provide a framework for further design processes.

1. First a solid substructure is needed, to raise and protect the foundation. Then, a moist earth mixture can be poured into a mould on top of the structure. To ensure strength and durability, a percentage of cement should be added to the earth mixture. The strength should be tested with Tamansourt's earth, to form the right mixture.

2. Earth is 'rammed' in the mould.

3. A layer of earth is added and rammed.

4. This process repeats itself until the height of the mould is reached.

5. When the earth is dry, the mould can be removed.

The rammed-earth structure will show some signs of erosion due to rain over the first period. Small pits can easily be fixed via stucco.

Via this method, the energy used for construction is relatively low. Soil dug from the extra channels in the central hub can be used for this. The production method is low-profile. Making it a circular, sustainable and affordable construction method for the Moroccan ecocity.

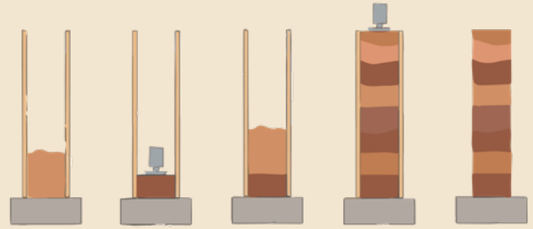


Figure 118: Building a rammed-earth construction. (First In Architecture, 2022).

IMPLEMENTATION

In chapter 9 'Implementation', the potential phasing to implement the Regreen to Rewild vision is explaind. Then, the need for patience is explained using an altered Adaptive Pathway Approach.

CHAPTER'S CONTENT

9

9.1 PHASING

Building with nature takes time as ecosystems adapt slowly (van Eekelen & Bouw, 2020, p.31).

As explained by Wilms, short-term successes and long-term goals are needed for sustainable urban development. Measures of success are needed to reflect on the development. This creates urgency, while a willingness to be patient is needed.

The phasing of the Urban Arid Green project is visualised in Figure 119 below. In 2023, the common goal must be clear; Tamansourt needs to transition into an ecocity. For this to happen, top-down support is needed. From this moment, data collection starts and knowledge is exchanged openly. Among stakeholders within Tamansourt, and with the other new towns. Via the top-down support, locals are activated and enthused. The locals form CBOs and all stakeholders together participate in the finalisation of the design of hubs, landscapes and infrastructure.

The locals can already start decentralised wastewater treatment. This will be continued and strengthened over time, especially when tourist facilities enter the site. In 2030, when the city becomes more self-sufficient, the design of the WWTP can start and as soon as finalised, the reconstruction of the sewage infrastructure starts. The WWTP must be built when the reconstruction is finalised so water can be recovered.

Midst this process, the building of nurseries and storage can already start, room for the wadis can be dug and barriers to control grazing must be set up. By this, seedlings

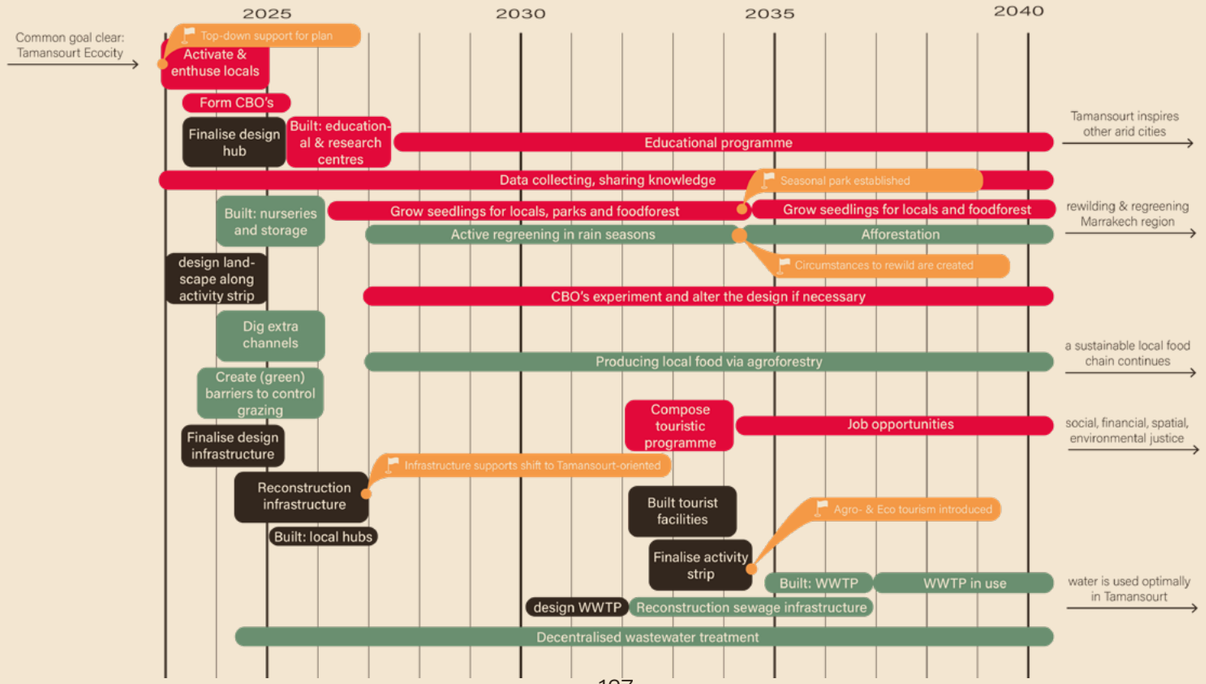


Figure 119: Phasing Transformation Tamansourt.

can be grown and the active regreening process can start during the rainy seasons. The production of a local food chain is started.

When the wadis and agroforestry sites are sufficiently regreened, the tourist facilities must be built, finalising the activity strip. Agro- and ecotourism will then be introduced to the site. At that moment, a tourist programme must be composed and new job opportunities are created.

As the design and reconstruction of infrastructure is a longer process, the reconstruction can also start during the design phase, per district or project. The local hub can be built simultaneously with the reconstruction of the infrastructure.

The educational and research centres can be built once the design for the central hub is completed. After this, the educational programme, with for instance a Faculty of Nature, Environment and Agroforestry can be settled in the hub, making use of the ongoing data collection.

This desired phasing, therefore, shows prerequisites for every next phase. Meaning that a certain phase can only start whenever the prerequisite goal is achieved.

The short-term successes, such as the building of a nursery, are goals to stimulate donators and governments. At the end of a project/reign, they can be proud, whilst it needs to be ensured that the project is taken over by locals.

9.2 PATIENCE

Addressing population growth and urbanisation in arid areas is a long-term process, no 'hit-and-run' project. Apart from the changing conditions envisioned in the proposed systemic change, the development might face other, unforeseen, changes. Such as extreme effects of climate change, changes in management and stakeholders involved or changing needs and trends. The approach to address population growth and urbanisation sustainably must be adaptive, to be able to deal with uncertainties.

Tamansourt aims to advance on the transformative framework towards an ecocity. For this, an adaptive pathway approach must be used. A pathways lens, as formulated by Fazey, Wise, Lyon, Câmpeanu, Moug & Davies (2016) could be used as a tool to provide a better understanding of the past and possible future developments. This is relevant to improving the development of the city.

As with many sustainable urban development projects, a lot of 'what if's can be pinpointed in the Urban Arid Green project. The adaptive pathway includes these 'what if's' as key decision points. After every decision point, paths to advance are presented. Paths can contribute to sustainable urban development, or lead the project in the so-called unsustainable space.

Figure 120 shows the method of using the pathways lens to formulate an adaptive approach for urban development. The orange lines show that there can be different sustainable scenarios to reach

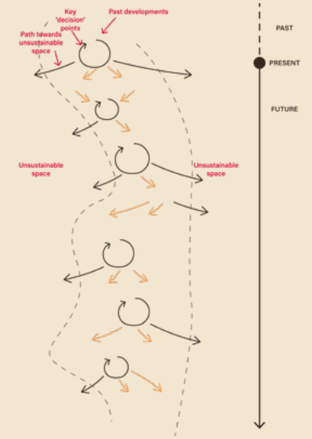


Figure 120: Using a pathway lens. By author based on (Fazey, Wise, Lyon, Câmpeanu, Moug & Davies, 2016)

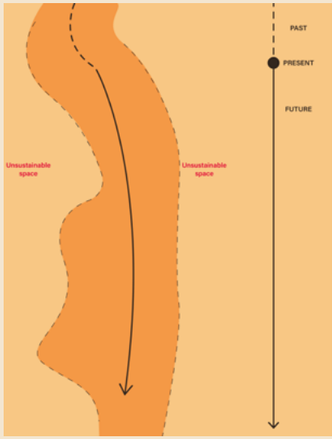


Figure 121: Visualising the pathway as a chronological process.

the ultimate goal, following the adaptive pathway.

However, this suggests that the development, with its key decision points, is a chronological process through time, as conceptualised in Figure 121. This is not the case for the uncertainties urban development might have to deal with. The timespan of Tamansourt Ecocity 2040 takes up to 17 years. Effects of climate change, such as more intense periods of drought or rainfall cannot be predicted exactly over a time span of 18 years. The same goes for financial and social challenges, as we can, unfortunately, state after seeing the results of the war in Ukraine and the COVID-19 pandemic.

The adaptive pathway approach for the sustainable urban development aimed at in Urban Arid Green is altered in Figure 122. Showing no clear borders between decision points, as they might affect each other. The route is no linear process, it is a process of constant reflection on the development. The zone between the sustainable and unsustainable space is not perfectly round, it's not a clear line between 'good' and 'bad.' All paths' intentions are sustainable, though must be guarded so they don't overshoot into the unsustainable space.

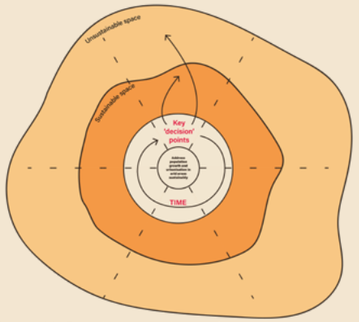


Figure 122: Showing the pathway of sustainable urban development as a process of constant reflection.

The developments of the past can already be assessed and given a place in the future pathway, together with some developments to be aware of. This is visualised in Figure 123 below. Going through the adaptive pathway approach with all stakeholders will ensure shared understanding and awareness. For this, workshops must be held. In a socially safe atmosphere, people can address and discuss certain actions. The sustainability of the development can be preserved if everyone commits to the common goal, despite any possible setbacks along the way.

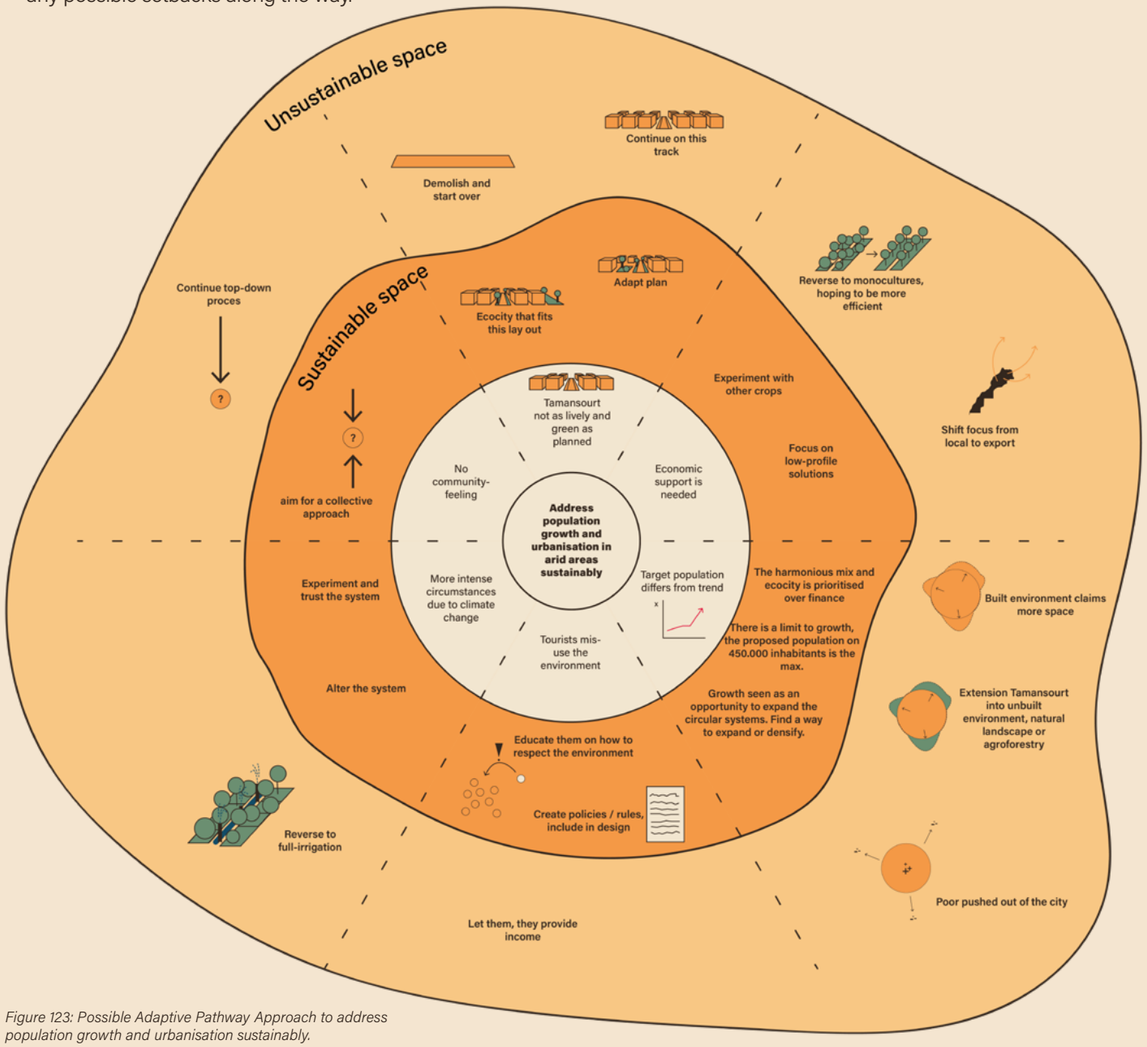


Figure 123: Possible Adaptive Pathway Approach to address population growth and urbanisation sustainably.

CONCLUSION AND REFLECTION

This chapter answers the research questions and reflects on the research by design process.

CHAPTER'S CONTENT

10

10.1 CONCLUSION

The objective of Urban Arid Green was to formulate an approach to address population growth and urbanisation in arid areas. To do this, a set of sub-questions were formulated. By answering these sub-questions, the main research question can be answered, as described in the Project Approach.

1. How are population growth and urbanisation addressed in Morocco?
In Morocco, population growth and urbanisation are addressed via the expansion of already existing cities and the development of new towns. Tamansourt is one of 19 Moroccan new towns founded under the Villes Nouvelles strategy. The government is the main stakeholder in the development of these new towns, it was a very top-down process.

2. What is the current spatial quality of Tamansourt?
The current spatial quality of Tamansourt is highly affected by its orientation towards Marrakech. The city is built to be a very dense satellite city to Marrakech. The lack of certain urban amenities and thus human activity in Tamansourt supports this, Tamansourt seems inferior to Marrakech. The built environment and human activities are seen as drivers behind the degradation of the natural system. Human activities and climate change are causing soil degradation and environmental issues in the city. The society living here is dealing with environmental as well as social injustices, due to the policy to mainly build affordable and social housing in Tamansourt.

3. What are the goals and aims for Tamansourt?
The goal is to transition Tamansourt into an ecocity by 2040, by restoring the soil quality. Urban Arid Green shows how the urban landscape can spark the restoration of the natural system. Advancing on the ecocity concept provides the urban fabric with a green framework to catalyse sustainable activities. By this, a sustainable interaction between human and natural systems can be achieved. The wide urban fabric of Tamansourt shows the potential to be activated and make the nickname *dormitory city* a thing of the past.

4. How can Tamansourt systemically transition into an ecocity?
To transition Tamansourt into an ecocity, systemic change is needed. Including environmental/physical, policy and behavioural change. The environment must be harnessed, the now degraded soil quality must be restored. This environmental change will be sparked by making optimal use of the limited amount of resources. By educating, training and employing the local community, the ecocity can be co-created, using bottom-up initiatives and top-down support. The community will be provided with the framework to create a regenerative productive urban landscape from the bottom up.

This systemic change is captured in the Urban Arid Green pattern language. The language is composed of a set of pathways; Al Omrane, Circularity & Ecology, Supportive Lifestyles and Facilitating Fabric. The pathways form a brief visual overview of all interventions included in the proposed development of Tamansourt. Via this language, the development guidelines are made understandable for all stakeholders. Together, the language addresses the Sustainable Development Goals of the UN, it takes the natural system as the basis for sustainability.

5. How can the ecocity principles be translated to a spatial design?
The Urban Arid Green project shows how to make the generic patterns in the Urban Arid Green language site-specific. With the patterns, a spatial framework is designed to catalyse the sustainable development in Tamansourt. The design shows what the spatial output of a pattern could look like, whilst one pattern won't ever have an identical spatial outcome to different sites. The Urban Arid Green project shows the translation process of the patterns.

How can population growth and urbanisation be sustainably addressed in arid regions?

There are limited resources, water, food, and energy, in arid areas. These resources are crucial to combat the challenges that current and future human societies living there are facing. Urban design could play a role in combatting these challenges, by designing to advance on the transformative framework towards an ecocity. This includes designing a circular system, to optimally use these scarce resources, together with a fair social and economic system. Furthermore, the (growing) human population in an ecocity must construct the system, instead of destruct it.

The generic principles of such a framework must be translated into a spatial design. The process of applying these patterns to the Tamansourt Ecocity 2040 project was a process of constantly adjusting, designing and testing. By testing the method, other landscapes can learn from this and use it as a tool to communicate with all different stakeholders involved. The translation of the generic principles must be shared openly to help and inspire similar cases.

A network of ecocities should be formed to take action, and together build towards global sustainability.

An ecocity is not only formed by its focus on circularity and ecology. The most important is to formulate a plan that everyone agrees upon. When developing a phasing, short-term successes and long-term goals must be included. This is to be of interest to different stakeholders. The locals should be empowered and engaged in the transition. They'll make or break the sustainable urban development aimed for. They have to co-create the ecocity.

As the Al Omrane pathway is based on the design guidelines for all Moroccan new towns, the Urban Arid Green language can be used in the development of other Moroccan new towns as well. However, the set can also be applied to other urban landscapes, including new towns and already-existing cities. Specifically, ones that are under the pressure of the scarcity of natural resources, population growth, urbanisation and climate change. Though, to some level, all cities are facing this, due to climate change and unequally divided resources and capital.

Every landscape might need to add its site-specific pathway, like the Urban Arid Green project developed the Al Omrane pathway. By this, the Urban Arid Green language allows unique dialects for different landscapes.

Though, time must tell whether or not population growth and urbanisation are sustainably addressed in Tamansourt, as sustainable urban development includes the unforeseen future situation as well.

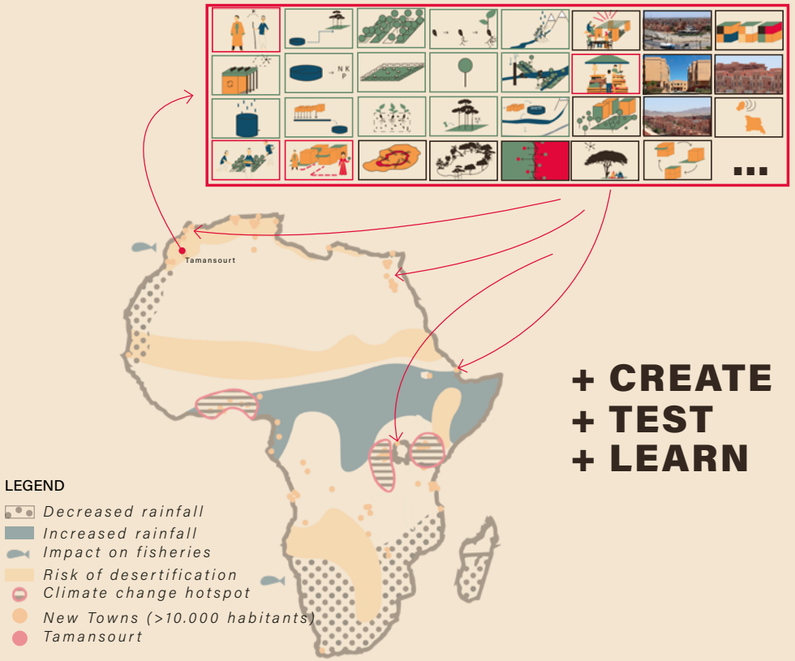


Figure 124: Urban Arid Green langague created and tested via Tamansourt, shared with other cities to formulate different dialects. Background from (Keeton, 2020).

A conversation with Kirstin Miller, Executive Director at Ecocity Builders, on August 12, 2022

A lot is overlapping between the Urban Arid Green project and the Ecocity Builders approach. It's a nice fit as far as the vision for Tamansourt and the way the Ecocity Builders created the smart codes. Therefore it seems logical to bring Urban Arid Green back into the project at the right moment, it is ready to go with all of the ideas. It is the same kind of thinking as how Ecocity Builders uses the smart code, with form-based codes, and patterns of design that can be replicated and customised. It is straightforward with easy-to-understand cues, where and at what time.

When proposing more affordable or nature-based solutions, there is a struggle. It is hard to make a profit out of low-cost eco-friendly, nature-based solutions. Investors want to make money and therefore more expensive projects are often favoured.

The issue should be reframed. The infrastructures that are built are vulnerable to the effects of climate change. The investments made must be protected. Nature-based solutions, lower cost green infrastructure, are the insurance prophecy that protects the investments that are already there.

We need international and global policies to mitigate climate change and be prepared for shocks and factors that are coming. People need to understand that a lot of the 'only in ... years'-events are all outdated information. The climate is changed so dramatically. It's hard to adapt to the real numbers but we need to. Therefore, we should argue for the need for green infrastructure.

10.2 REFLECTION

Design and research
The sustainable development in Urban Arid Green focuses on the challenges the urban fabric faces brought by climate change and demographic trends. With this project, knowledge and skills from design practice are blended and innovative ways to stimulate sustainable development are explored.

The project works through different scales. For instance, by formulating a regional strategy to use vegetation to slow down the water in the waterscape and improve the quality of life and space in the urban area. In this urban area, a (re-)development project on the neighbourhood scale envisions the spatial outcome of the strategy. Urban Arid Green thus aims to improve the quality of life, space and environmental performance through the lens of urban ecology, matching the topic of the cross-domain lab Urban Ecology & Ecocities.

It was a new experience for me to already re-design a not-yet fully developed design. For the design, I decided to base the Urban Arid Green project on the visionary model made by Al Omrane, which I noticed during the site visit in May 2022. When designing for the local hubs in the centres, I noticed the model, in Figure 125, differed from the few developments on site, Figure 126. The mega roundabout was being used as a souq, and there are football courts located on the grand avenue leading towards the roundabout. The built volumes connected to the roundabout, counter formed the roundabout.

For the local hubs, I decided to copy the already-built areas based on online images and add the unbuilt volumes based on the visionary model. This made the design outcome more realistic, however, it brings questions about the other sites as the city is still under construction. The building volumes in the central hub are located on the points crossing the sightlines of the new residential area, based on the visionary model. However, the design process of the local hubs shows there is room for alteration within that model. Therefore, I tried to explain the reasoning behind the design choices quite explicitly. This way, the design can easily be altered to the final built output, in case the Urban Arid Green project would be used in the actual transformation of Tamansourt.

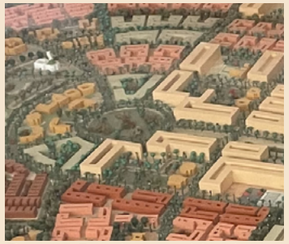


Figure 125: Zoom-in on roundabout in visionary model Al Omrane


Figure 126: Roundabout Tamansourt screenshot from (Morocco map satellite//Africa, n.d.).

This also shows the difficulty concerning data. This was the first time to work on a project abroad, where I did not receive information to base the design. Retrieving this data was quite a task, and in some cases, I did not fully succeed. For instance with the (waste)water numbers of Tamansourt. As I couldn't find the data for Tamansourt specifically, I made an educated guess based on the numbers of Marrakech. In many design exercises, using data that is a couple of years old is quite representative. For this new town, with extremely rapid development and population growth, even a small period makes a huge difference. As the city is built so recently, a lot is happening and data is outdated fast.

Methodology
In my previous educational projects, a site visit was self-evident, at least in the beginning phase of the project. During Urban Arid Green, I experienced this completely differently. I crossed continents (including climates and cultures) and I never visited Morocco before. Besides the literature and e-studies I did beforehand, I was not familiar with the Moroccan context at all. Apart from only visiting the site in Tamansourt, I needed to visit the region to get grip on this new context. Including the social, historical and cultural context. However, as a complete outsider, two weeks were probably not enough to do so. I tried to change my perspective during the project, and see things through a Moroccan lens. Hopefully, the fresh perspective provided the development with new ideas. It would have been great to visit the site again during the rainy season, as the strategy is based on a water cycle that includes a period of heavy rainfall. During the project, I gained contradictory information on the wadis enclosing Tamansourt. As the landscape shows clear erosion gullies, I chose to work with the most inconvenient situation where the wadis would flood aggressively. Therefore, the outcome is safe, which I consider the basic need for a city. It would have been great to experience the rainy season myself. Unfortunately, this was not feasible in the timeframe of the graduation year and the unpredictability of rainfall. The rainy season in Tamansourt runs from November - February. Sadly, if I had scheduled another trip to Tamansourt in November 2022, I would not have experienced any rain.

The vision for Tamansourt in Urban Arid Green was partly based on the experiences gained during the site visit. As I only went to Tamansourt once, my experience and therefore review of certain information is probably one-sided. I visited Tamansourt in May, it was quite warm. In cooler periods, it might have been more lively in public areas.

Systemic change
The Moroccan National priority programme to supply drinking water and irrigation 2020-2027 already set similar objectives to improve water security. In 2008, the Green Morocco Plan was launched to support the economy. The strategy dropped the number of undernourished. However, the strategy also strengthened social inequalities as big farmers are export-oriented and gained profit from the strategy while the traditional Moroccan farmers did not benefit from the modernization and relied on rainfall and aquifers. Generation Green 2020-2030 was set to favour traditional Moroccan farmers. A lot has been done on the issue of food and water security, as well as economic support. Many policies have been made. Hopefully, this thesis offers a new approach to facing these challenges and serves as a systemic solution.

Societal relevance and transferability
To increase the transferability, some issues in the project are generalised and simplified. For instance, the old human settlements within Tamansourt are not touched upon. This is done because the project always preconceived the plan of Al Omrane, in which some residents living in these settlements are bought-out. However, these locations are the only locations in the new town with any historical layering, social value, and appropriation of space. It would have been interesting to see how, although they don't fit in the new Tamansourt look and feel, they could fit in the Tamansourt ecocity. Probably, this is not the only new town with historic centres, so it could have set an even greater example. As things might have gotten a bit too political and unrealistic, as it interrupts the current developments, this topic is not touched upon. Looking back, this might be a missed opportunity.

The pattern language itself is generalised on purpose, so the unique outcomes are not part of the general language. Hopefully, this stimulates creativity while using the Urban Arid Green language. The patterns are all knowledge or experience-based, via research, interviews, design, and the site visit. The use of the pattern language makes the project more easily understandable and transferable. Reading the whole Urban Arid Green report would provide any potential users of the language with a common understanding, background and example.

The project results are easily shared with the stakeholders involved. I got familiar with the Ecocity Morocco project via the Ecocity Builders' team. Since the start of the Urban Arid Green project, I am in contact with Mr Abdelaziz, a Moroccan expert. The meeting in May 2022 with Al Omrane on site hopefully sparked their interest as well. The results will of course be shared openly.

Limitations and Ethical considerations
The Urban Arid Green project aims for an inclusive, low-profile systemic solution to the unsustainable growth of cities, focussing on arid regions. The project tried to fit into the current situation and include the existing plans. By this, it aims to be as realistic and practical as possible. Though, there are limitations to this approach.

Transforming Tamansourt into an ecocity is a common goal among actors. However, it must be financially feasible and interesting enough for business operations and people to invest in, to happen. According to the Living Planet Report 2022, formulated by WWF (2022), we are currently in a broken relationship with nature, and restoring this relationship is not only an issue of restoring the environment. We must also acknowledge the economic, development, security, social, moral and ethical sides of the problem. The project focuses on intensifying a sustainable interaction between the human system and the natural system while allowing growth in both. It focuses on how humans use the landscape most appropriately. While doing this, it prioritises environmental issues over others, such as financial challenges. Based on the integrated SDG model, the project sees the biosphere as the foundation for global sustainability, the foundation on which the society and economy depend. However, prioritising for instance finance over the environment would probably have a different outcome. The adaptive pathway approach tries to include future unforeseen changes or shifts in mindsets. However, top-down policymaking or financial setbacks can always easily overrule everything. The projects might rely a bit too much on the goodwill of communities and institutions, as sustainable urban development takes more than just that.

Urban Arid Green focuses on a co-creation approach that includes all stakeholders. While designing, I struggled as it felt as if I did the complete opposite of what was intended, that I was designing on my own, in the Netherlands, off-site. The dialogues with the residents were missing in the design phase of the project, whilst these dialogues would contribute to the systemic change. In the process, I figured that the design should only build a framework for the transition process.

As an outsider, I explicitly tried to not take on the position of a local, trying to do this did not feel just. The local community must be encouraged to appropriate and activate their city. Though, I would love to zoom in and design further. For this, one should be in Tamansourt, discuss with the locals, speak the Urban Arid Green language with them and experience the city throughout the year. This was unfortunately not possible during the period of the graduation project.

Greenwashing
Delmas & Burbano (2011) defined greenwashing as 'poor environmental performance and positive communication about environmental performance.' During the Urban Arid Green project, I tried to avoid greenwashing. However, there is a risk in designing for the regreening of a desertified landscape, and showing the potential spatial outcome of this. In the Urban Arid Green project, the visualisations, plans and sections made are a tool to communicate the designed framework.

Of course, a designer aims to visualise the results as beautifully and interesting as possible. The design must convince and enthuse people. This might not always be the most realistic result. The design in Urban Arid Green is landscape driven. It considers all layers of the landscape and it aims to tackle causes that drove the degradation. Therefore, I am convinced that Urban Arid Green can start the regreening process and I fully support the proposed outcomes. However, a total green environment might take more or less time to evolve. Also, as it aims for rewilding, the project only shows one out of many spatial outcomes.

Further research
During the Urban Arid Green project, I explored some other disciplines in addition to urban design. For instance agroforestry/food production, water management and sanitation. For these, more detailed plans are needed. The one-meter-heigh organic dams every 500 meters for instance, as discussed with Wilms, was just an indicative or experimental approach. The sanitary approach is only explored on the systemic level and macro scale.

For further research, it would also be interesting to do soil testings and find out how many seeds are still in the soil's seed bank, to calculate the amount of vegetation that needs to be planted actively. Soil testings are also needed to create the right mixture for the rammed-earth construction.

Personal growth
My objective for the graduation year was to contribute to an actual project and do a bit more than just a theoretical exercise. It was also to step outside my comfort zone. I value the experiences I gained during this cross-cultural project a lot. It was the first non-Dutch educational project I worked on. While stepping out of the safe bubble wherein all projects were pre-organised, I gained more than knowledge only. Presenting the project to a non-TU Delft-related, state-led Moroccan developer and the Executive Director of the Ecocity Builders was quite an educational experience. The project made me more explorative and curious, whilst it also made me appreciate things that were obvious to me before.

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CHAPTER'S CONTENT

11

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APPENDICES

CHAPTER'S CONTENT

12

APPENDIX I: NEW CITY DEVELOPMENT MOROCCO

	New city	Project manager	Urban form / concept	Area (km^2)	Launch date	Projected population
1	Tamansourt	Al Omrane Tamansourt	Satellite city	19,5	2004	450 000
2	Tamesna	Al Omrane Tamesna	Satellite city	8,4	2005	250 000
3	Ibn Batouta New City	Al Omrane Al Boughaz	Satellite city	1,20	2006	55 000
4	Chouiter	Alliances Darna	Satellite city	2,17	2007	60 000
5	Chrafate	Al Omrane Tanger-Tétouan-Al Hoceïma	Satellite city	13	2009	150 000
6	Lakhyayta	Al Omrane Sahel Lakhyayta	Industrial satellite city	12,9	2009	300 000
7	Riad Al Omrane	Al Omrane Meknès	Urban Pole	2,34	2009	80 000
8	Tagadirt	Al Omrane Agadir	Urban Pole	11,3	2009	200 000
9	Zaouite Sidi Othmane	Al Omrane Drâa-Tafilalet	Urban Pole	4,18	2009	80 000
10	Ras El Ma	Al Omrane Fès	Urban Pole	1,91	2010	50 000
11	Mohammed VI Green City	SADV, OCP	Green city/Knowledge city	10	2011	100 000
12	Green mine Khouribga	SACV, OCP	Knowledge city	2,94	2014	25 000
13	Forum El Oued Technology Cluster	Phosboucraâ Foundation, OCP	Technopole	1,26	2016	12 000
14	Mazagan	SAEDM, OCP	Urban Pole	13,0	2017	134 000
15	Aroui	CGI, Al Omrane	Urban Pole	14,0	2008	180 000
16	Casa-Anfa	AUDA, CDG Dev	Independent financial district	3,65	2010	100 000
17	Zenata Eco-City	SAZ, CDG, Dev	Eco-City	18,3	2012	300 000
18	Aïn Chkef (La cité du parc)	Jnane Saiss développement, CDG Dev	Urban Pole	10,54	2014	270 000
19	Mohammed VI Tanger Tech City	China-Morocco partnership (CCCC and SATI)	Smart City	20	2019	-

Table 1. New city development in Morocco. (Côté-Roy & Moser, 2022).