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In the School of Architecture, Planning and Geomatics
University of Cape Town, November 2016

Sponsored by the National Research Foundation:
Sustainable and Renewable Energy Scholorship

Author: Gaby, Bianca, Schmidbauer

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Acknowledgement

This thesis is dedicated to my late Father, who always wanted me to be part of such an incredible industry.

I would like to thank, my mother, my fiancé, my landlord, my family and supervisor for your commitment and support, without you, it would not be possible.

Lastly, thanks to Nicolas Lindenberg, Geomatics department for assisting me with GIS.

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If a Student	Your Degree: e.g., MSc, PhD, etc.,	MLA
	Name of Supervisor (if supervised):	Julian Raxworthy
If this is a researchcontract, indicate the source of funding/sponsorship		None
Project Title		Brown-Green Infrastructure in a semi-arid environment

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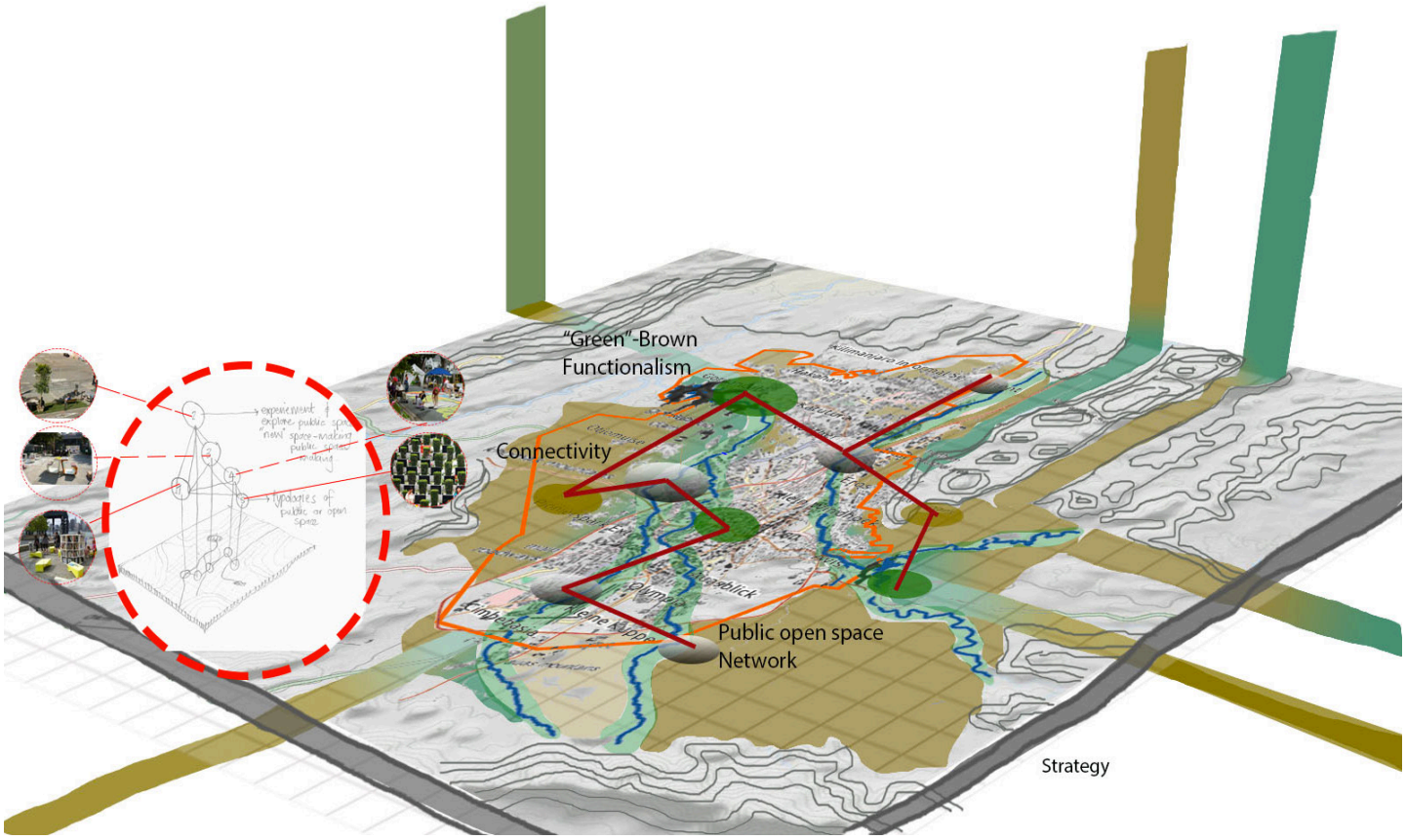
Chair : Faculty EIR Committee For applicants other than undergraduate students who have answered YES to any of the above questions.	Click here to enter text.		Click here to enter a date.



A CASE STUDY: BROWN-GREEN INFRASTRUCTURE IN A SEMI_ARID ENVIRONMENT!

Gaby Schmidbauer
SCHGAB005
MLA 2
2016

ABSTRACT

"Green infrastructure is defined as an interconnected network of "green" space that conserves natural ecosystem values and functions and provides related benefits to both human and non-human(Fauna & Flora) population.[1]

Green Infrastructure is therefore a new ecological (framework) model needed for considering spatial, environmental, social and economic sustainability in a bigger strategic context—in short it is an essential natural life sustaining system for our nation. The green infrastructure model provides a contemporary and innovative way to address this strategic absence in the urban environment.

Despite different definition of what constitute green infrastructure, most theorists agree that it comprises 3 things: connectivity, multi-functionality, and "green".[2]

River corridors are natural ecosystems considered as "Green" Infrastructure, which provide an interconnected network of "green" open spaces in cities.

In terms of connectivity, Windhoek, Namibia, has three major ecological corridors along the Klein Windhoek, Gammams and Arebbusch rivers, connecting suburbs, the city and two major dams known as Goreangab dam, North-West and Avis dam, South East of Windhoek. The rivers are ephemeral; it creates a contrast between a dominant dry season to a relative "wet" season i.e. due to water flow during a specific time of the year.

Over 200 hectares of river course space during both peak and non-peak events is underutilised. These existing open spaces are left unused, polluted and poorly managed reducing their potential for "multi-functionality". Most critically however, Windhoek is a semi-arid landscape and not necessarily "green".

This begs the question: Does "green" infrastructure have to be green? In semi-arid regions, many green infrastructure practices may not be "green" at all. [3] Windhoek, will therefore be used as a case study to test how green infrastructure might function in a different way when it is not entirely green, which is a key part of green infrastructure.

Would "brown-green" infrastructure be a better description for this context?

1 Neil Williamson, Jon Lovell, Green Infrastructure position statement (2009): 1-30.
2 Wright, Hannah. "Understanding green infrastructure: the development of a contested concept in England." Local Environment 16, no. 10 (2011): 1003-1019.
3 Green Infrastructure in Arid and Semi-Arid Climates

CONTENT

WINDHOEK, NAMIBIA

22.5609° S, 17.0658° E

1. INTRODUCTION

Green Infrastructure is a Euro-centric and North American model specifically developed due to water richness. "*"Green" is a more implicit idea in definition and usually represents the elements of green infrastructure that act as a basis for environmental improvements*."[1] For example the use of "green" varies, providing different assests that are **green in color** (green spaces, wetlands, forests).[2]

The primary question that developed out of the hypothesis is: Does green infrastructure have to be "green?" The focus of this study aims to address the "green" in green infrastructure, what it implies when it is green or not green and its performance as an element that act as a basis for environmental improvements to existing open space in a semi-arid region.

METHODOLOGY

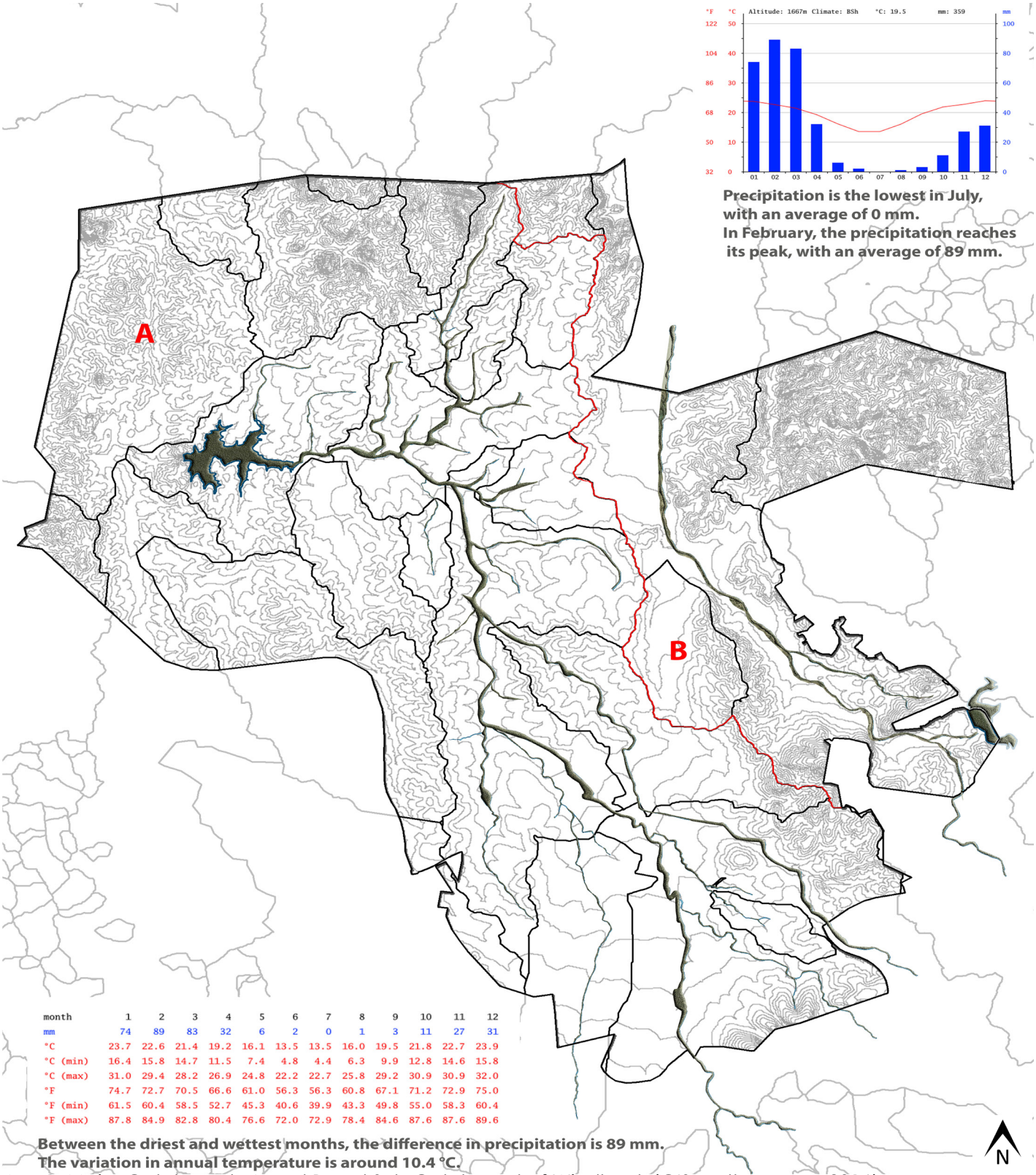
The study is conducted through a series of analytical maps of Windhoek, to investigate the green infrastructure premise. The mapping firstly introduces the Hydrological system of Windhoek, as this forms the structural ecological backbone to any green infrastructure. The maps that follow explores the performance of green (wet): flood risk areas, run-off co-efficiency of streets/roads (bitumen) vs soil/natural earth. The green as a functional element to deal with floods and excessive heat. Lastly, which is very important to the study is the green to brown/ brown to green gradient due to seasonal change.

Most importantly the objective of this report in the process of investigation, attempts to use "brown-green" as a substitute for "green" in green infrastructure in a semi-arid region.

1 Understanding green infrastructure: the development of a contested concept in England, p.1007

2 Green infrastructure: Smart conservation for the 21st century.

2. ANALYSIS OF WINDHOEK



month	1	2	3	4	5	6	7	8	9	10	11	12
mm	74	89	83	32	6	2	0	1	3	11	27	31
°C	23.7	22.6	21.4	19.2	16.1	13.5	13.5	16.0	19.5	21.8	22.7	23.9
°C (min)	16.4	15.8	14.7	11.5	7.4	4.8	4.4	6.3	9.9	12.8	14.6	15.8
°C (max)	31.0	29.4	28.2	26.9	24.8	22.2	22.7	25.8	29.2	30.9	30.9	32.0
°F	74.7	72.7	70.5	66.6	61.0	56.3	56.3	60.8	67.1	71.2	72.9	75.0
°F (min)	61.5	60.4	58.5	52.7	45.3	40.6	39.9	43.3	49.8	55.0	58.3	60.4
°F (max)	87.8	84.9	82.8	80.4	76.6	72.0	72.9	78.4	84.6	87.6	87.6	89.6

Between the driest and wettest months, the difference in precipitation is 89 mm.
The variation in annual temperature is around 10.4 °C.

Map 1: Major Catchments A and B and Sub Catchment of Windhoek (GIS, authors own, 2016)

Hydrology is the major determined system in green infrastructure. It is a natural ecological system whether green or brown, connecting spaces.

Analysis:
Catchments:
A: Arebbusch - Supply 100% of the water.
B: Klein Windhoek - Supply 80% of water

Finding:
Green = wet = water in rivers = 20%
Brown = dry = no water in rivers = 80%

Map 2: Permeability: Run-off coefficiency (GIS, authors own, 2016)

Street/Roads ar secondary engineered spaces that connect cities.

Analysis:
Grey- Built form: roads and buildings = impermeable = 40%
Brown- Ground = Permeable = 60%

Finding:
Street/Road/buildings: non- impervious surfaces = high volume of stormwater runoff, especially in the urban areas (CBD) = no infiltration =blockage in storm events = run off require storm water management.
Ground: impervious = run-off immediately absorbed = inflitrated into ground/plants

Map 3: Flood and flood risk areas (GIS, authors own, 2016)

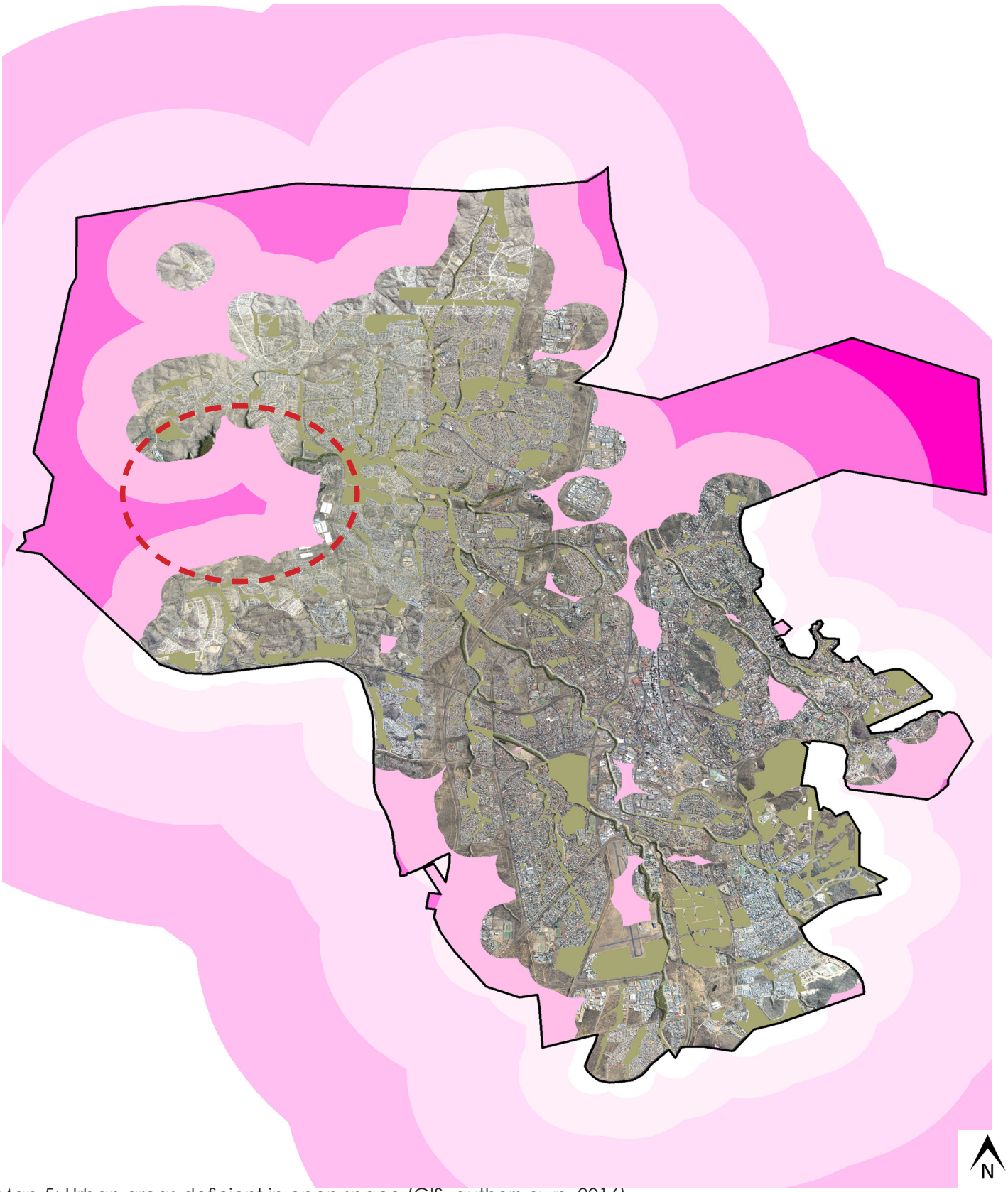
Analysis:
Grey/Black - Indicative Floods (Flash/fluvial)= 50 and 100 year
Orange: Developed areas affected

Finding:
While most parts of Windhoek is currently adequately protected from floodwaters, climate change will increase the probability of flooding from fluvial, surface and sewer sources. Existing open spaces network are potential green infrastructure mitigation measures.

Map 4: Open space Network flood mitigation management(GIS, authors own, 2016)

Analysis:
Grey/Black - Indicative Floods (Flash/fluvial)= 50 and 100 year
Orange: Developed areas affected
Green/Brown: Open space network

Finding:
Open spaces are not used to full potential to assist in flood mitigation. Open space network can mitigate fluvial flooding by absorbing stormwater/ runoff. Floodwater/runoff can be temporally stored in the "brown-green"open space system. and released into streams, rivers, canals slowly.



Map 5: Urban areas deficient in open space (GIS, authors own, 2016)

Analysis:

+ Urban area deficient in open space

-

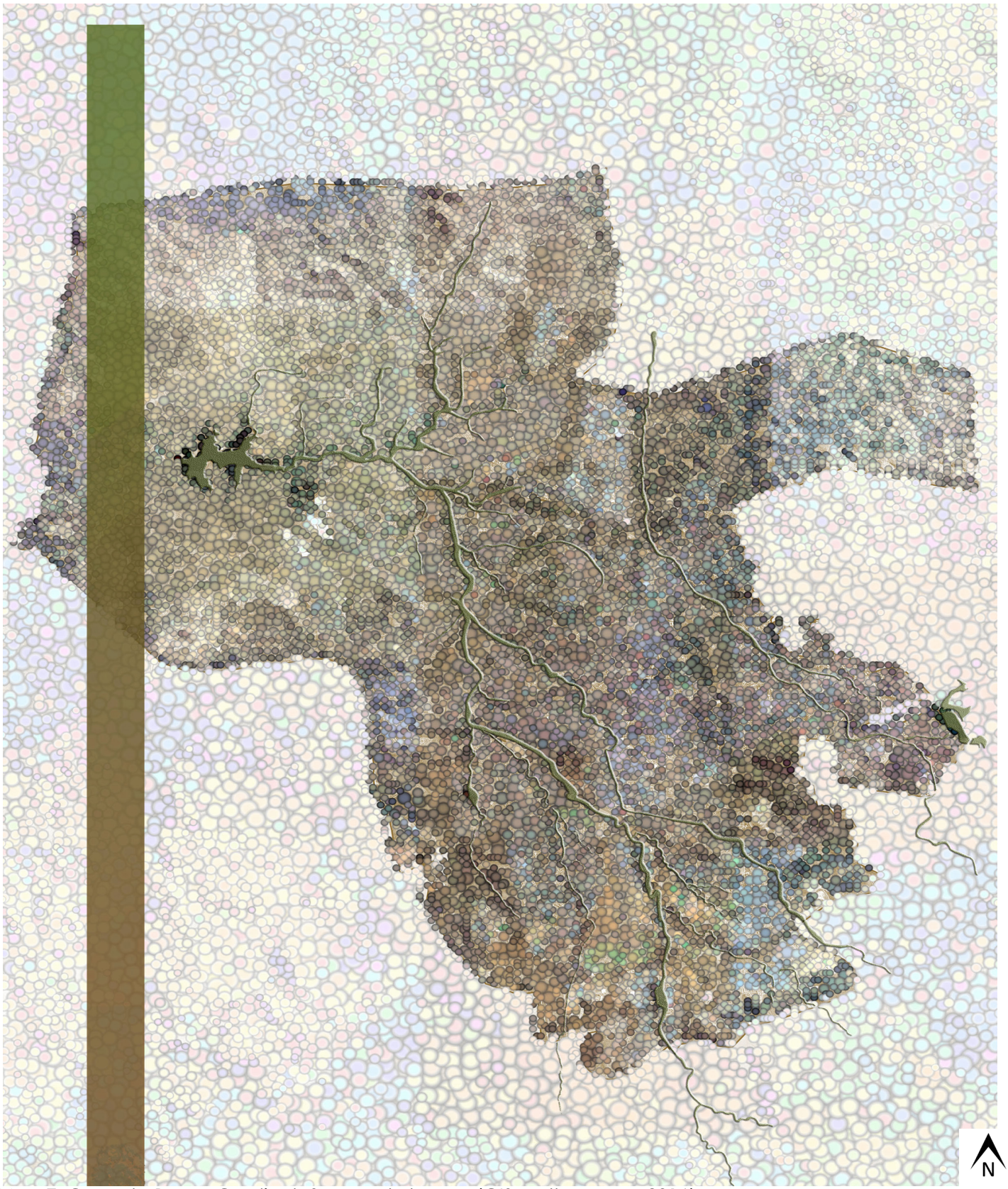
Finding:

Windhoek does have adequate open space however, over 200 hectares of open space along river corridors are underutilised, therefore potential to develop these spaces that are green and brown in nature. At a regional scale the North Eastern part of Windhoek, Goreangab dam (wet and "green"space has the potential to develop into a regional park. A portion of Goreangab dam is already a recreational space.

Map 6: Green, Brown and Grey Spatial Detection (GIS, authors own, 2016)

Analysis:
Green= vegetation
Brown = ground/soil
Grey = built form

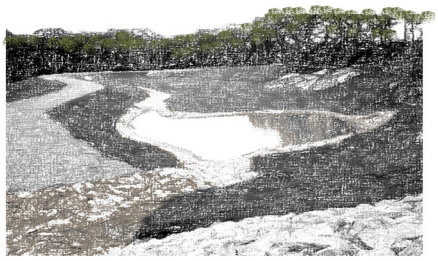
Finding:
During the wet season rivers and open spaces are green however during the dry season which is 80% of the time, the open spaces are "green"(tree presence), the periphery of rivers are green but the river itself is dry. Open spaces therefore are Brown-Green = dry-wet.



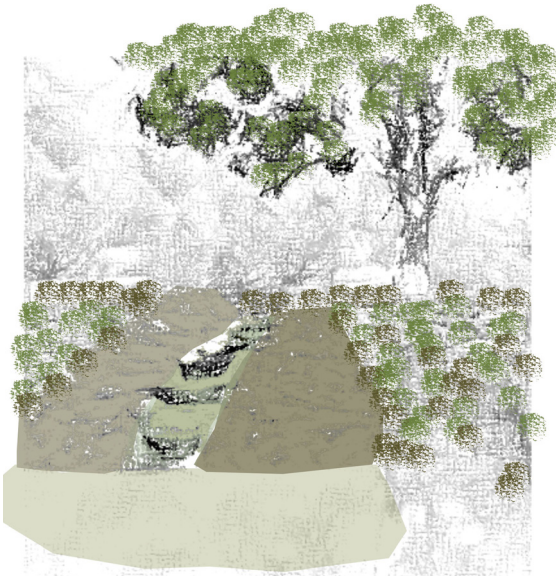
Map 7: Green to Brown Gradient- Seasonal change (GIS, authors own, 2016)

Analysis:
Green= greenness due to water = wet
Brown = brownness due to lack of water = dry

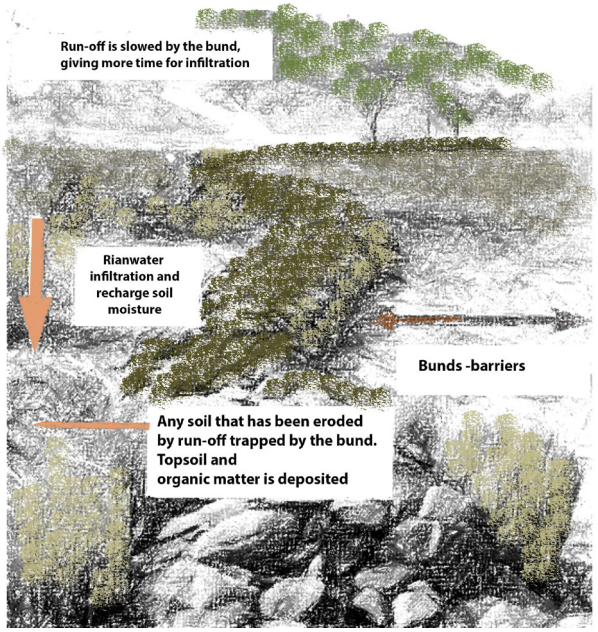
Finding:
The result show both a green and brown infrastructure.



Retention



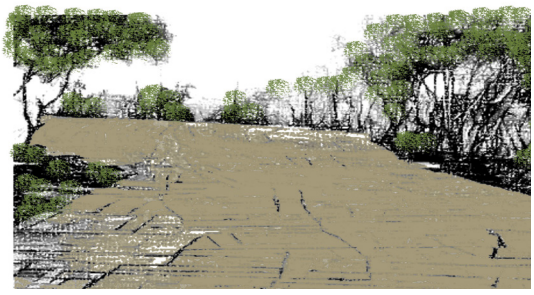
Drainage



Barrier

Retention -

Shade and Path



Path

Map 8: Characteristics or interplay of green and brown in spaces.(GIS, authors own, 2016)

Analysis:
Green = Wet = Water = Quality
Brown = Dry = no Water = Quantity

Finding:
Due to lack of water presence, the absence of water allows for somewhat of a greenery. Greenery is a compliment to the dryness!

4. CONCLUSION

"Green" is a more implicit idea in definition and usually represents the elements of green infrastructure which are **green in color** (green spaces, wetlands, forests). People associate with the color green, to describe a landscape or space in a region.

Hydrology is the determinant factor for "green" infrastructure to function as "green", which provide green corridors and open spaces. In this particular context, green (wet) is periodical, whereas brown (dry) is permanent, it takes the hydrological function and also provide an impart for public open space to develop.

The analysis reveal an analogy of **green and brown**. The brown (dry) is more dominant, can be seen as a quality when it is seen from a different perspective to green, for example; a Oasis space, were the brown creates the scene or illusion that its still green and wet. Even though most spaces are dry in nature, it still represents the color green.

"Brown-Green" Infrastructure is therefore an appropriate description for Windhoek in a semi-arid environment, which provides for both a green and brown multi-functionalism of open spaces to address environmental issues in similar ways. A dry and resilient environment capable to adopt to change, especially in the current climate change phenomenon.

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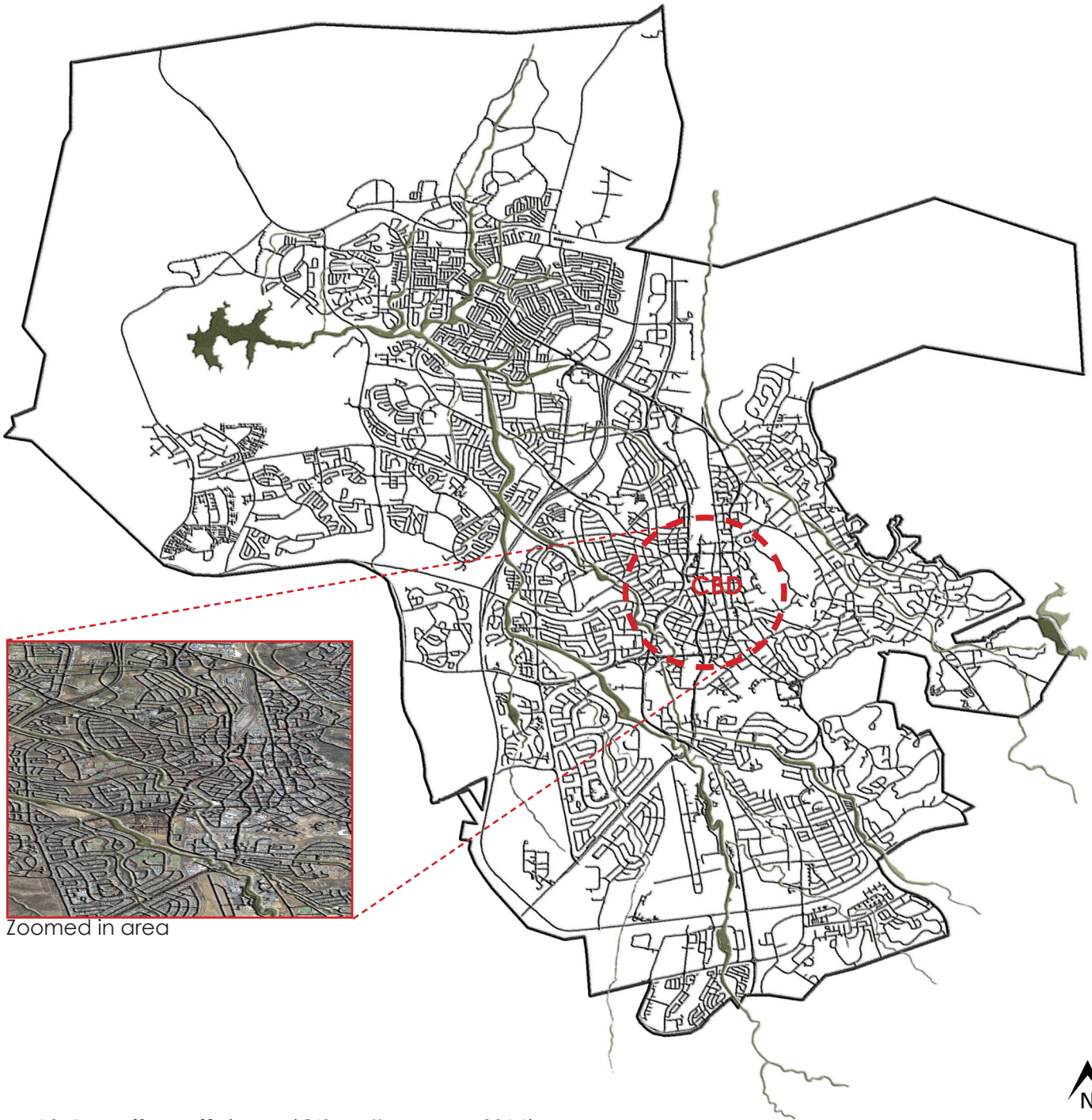
APPENDIX I

Map 9: Infrared map: Red, Brown and Grey Spatial Detection (GIS, authors own, 2016)

Analysis:
Red= green vegetation
Brown = ground/soil
Grey = built form

Finding:
The map show both a green and brown infrastructure.



Zoomed in area

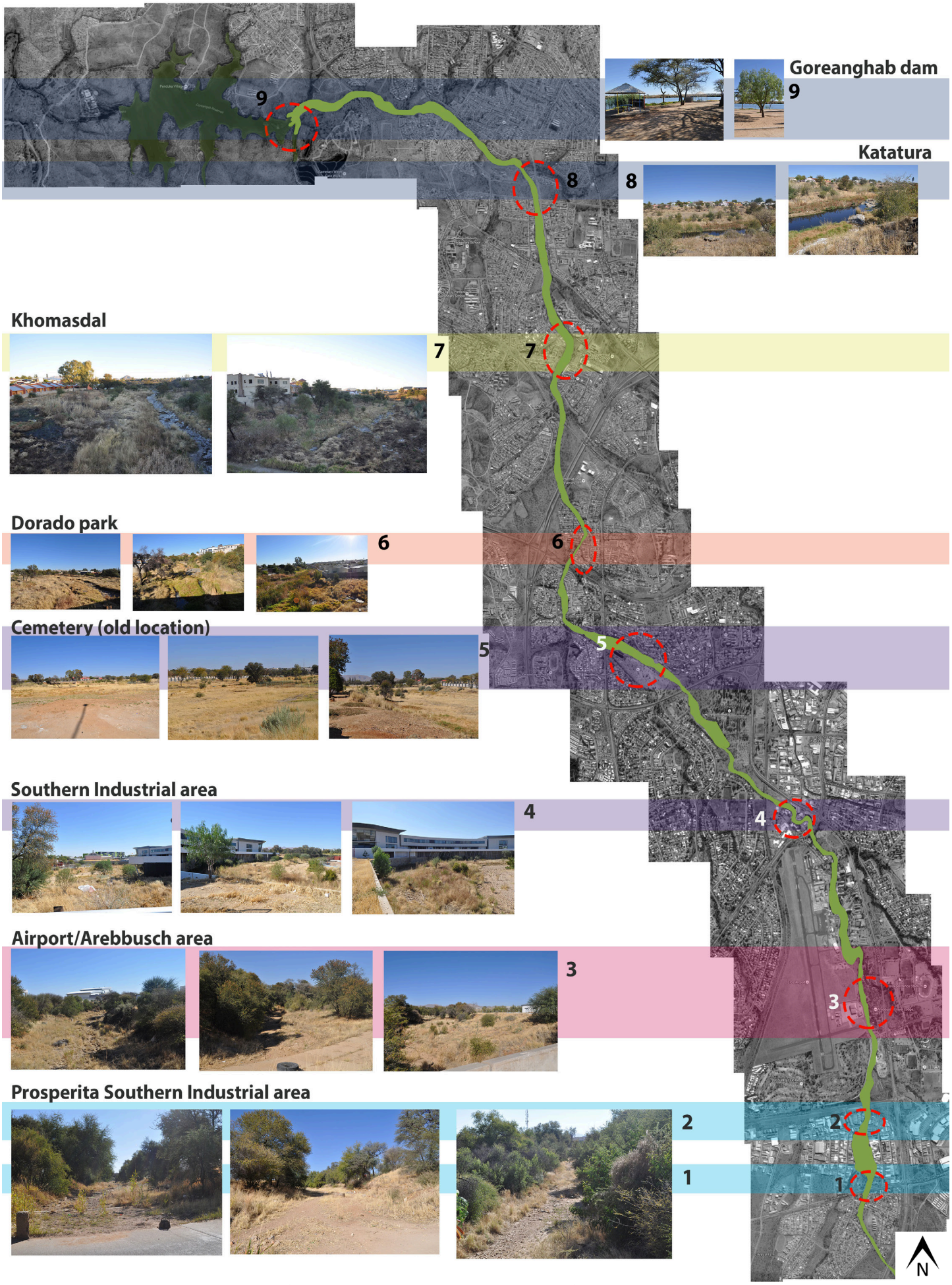
Map 10: Run-off co-efficiency (GIS, authors own, 2016)

Street/Roads are secondary engineered spaces that connect cities.

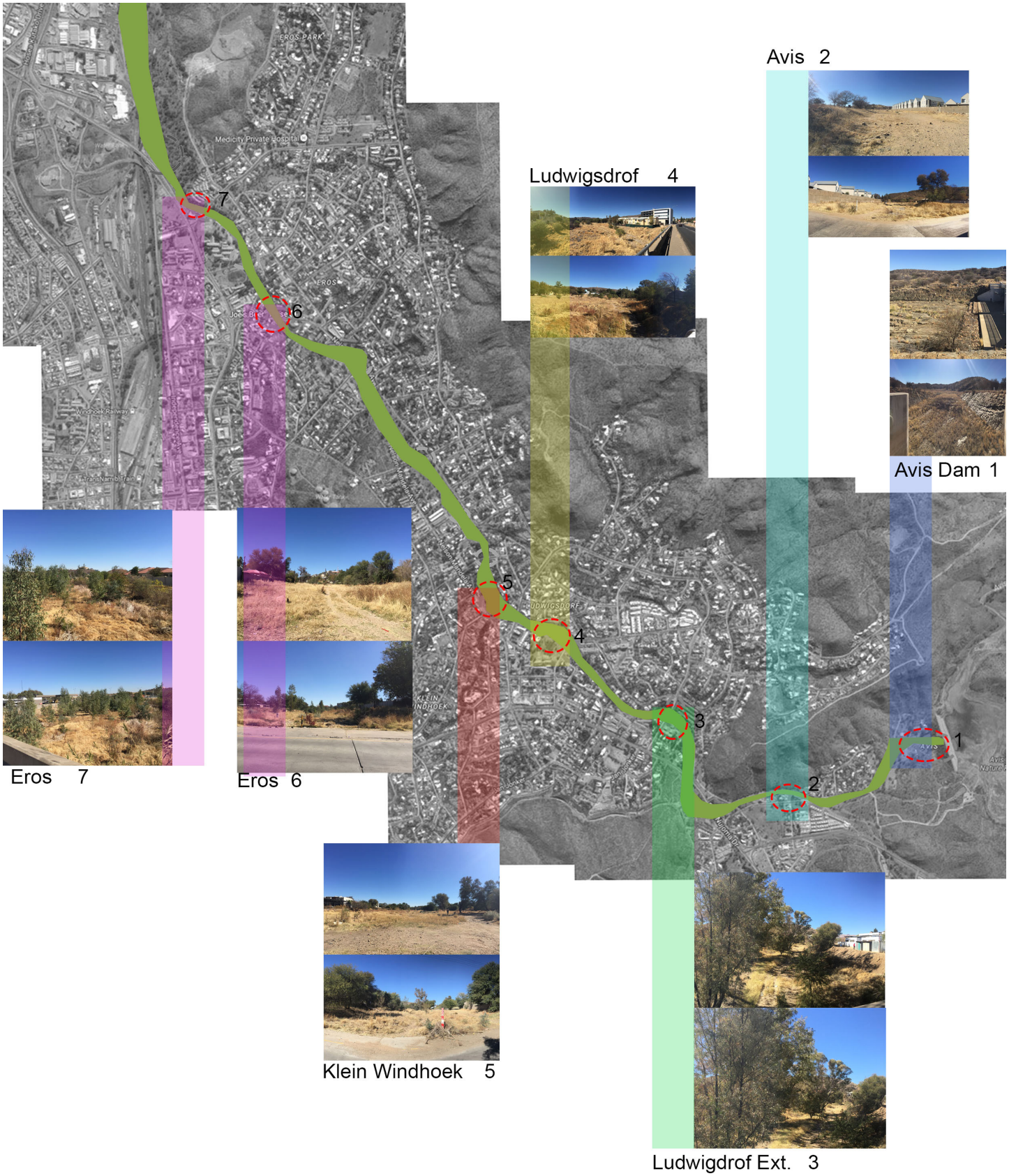
Analysis:
Grey - Street/road: mostly asphalt/non impervious = 30%
White - Soil: Lithosol, thin layer impervious = 70%

Finding:
Street/Road: non- impervious surfaces = high volume of stormwater runoff, especially in the urban areas (CBD) = no infiltration =blockage in storm events = run off require storm water management.
Soil: impervious = run-off immediately absorbed = infiltrated into ground/plants

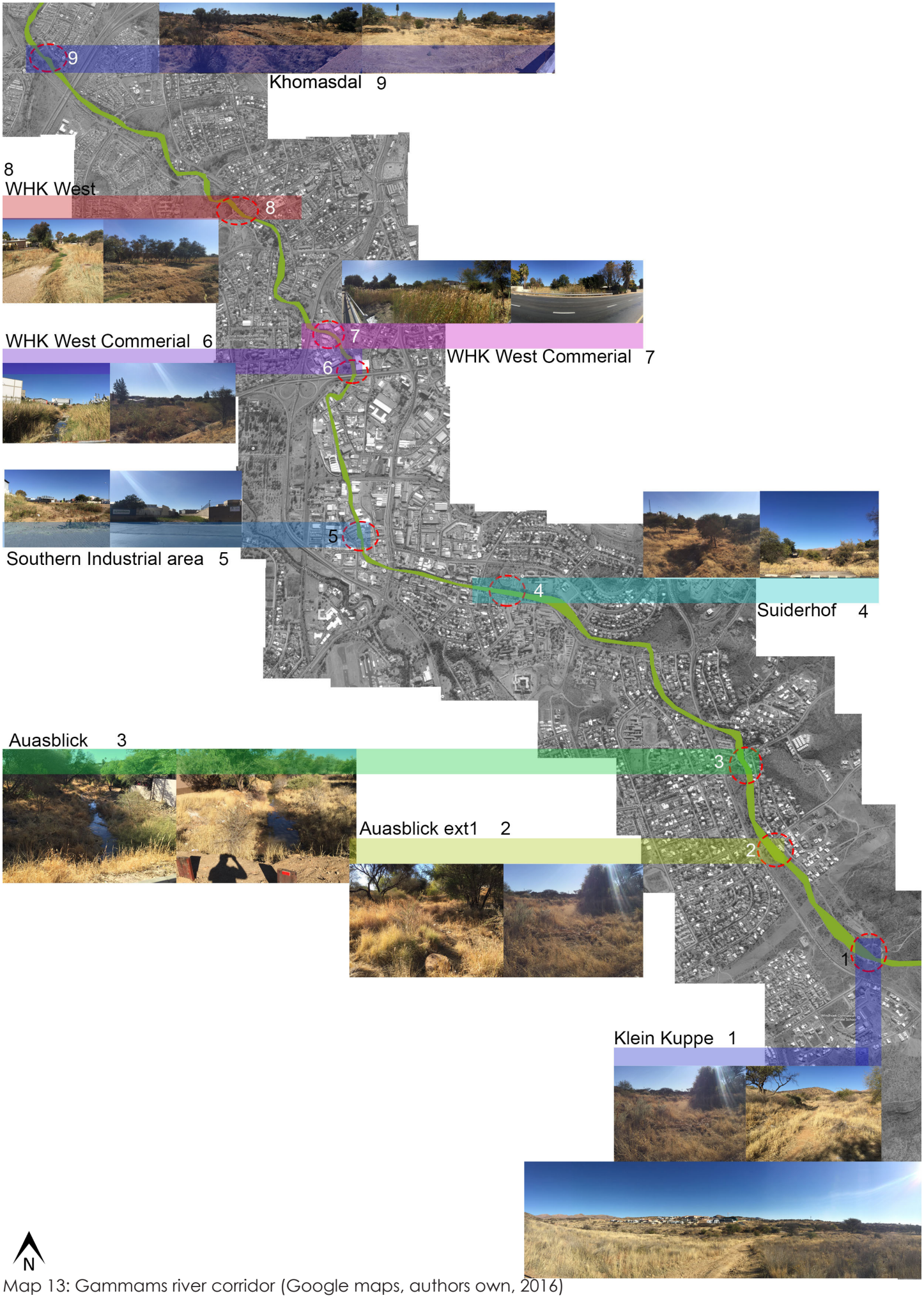
APPENDIX 1: INVENTORY OF WINDHOEK'S RIVER CORRIDORS



Map 11: Arebbusch river corridor (Google maps, authors own, 2016)



Map 12: Klein Windhoek river corridor (Google maps, authors own, 2016)



Map 13: Gammams river corridor (Google maps, authors own, 2016)

Gaby Schmidbauer

Embracing Dryness: a performative public open space system for Windhoek

Windhoek is a "young" capital city of Namibia, with a population of ± 415000 people, and is experiencing rapid urbanization. Intensive redevelopment and densification that is under catered for in open space terms. Due to both apartheid and current spatial planning practices, Windhoek does not have a coherent public open space system nor a formal landscape architecture industry that might create one. The rivers of Windhoek are the major connectors in the city, mostly dry, in order to manage floods, open spaces perform as temporary "basins" to hold water.

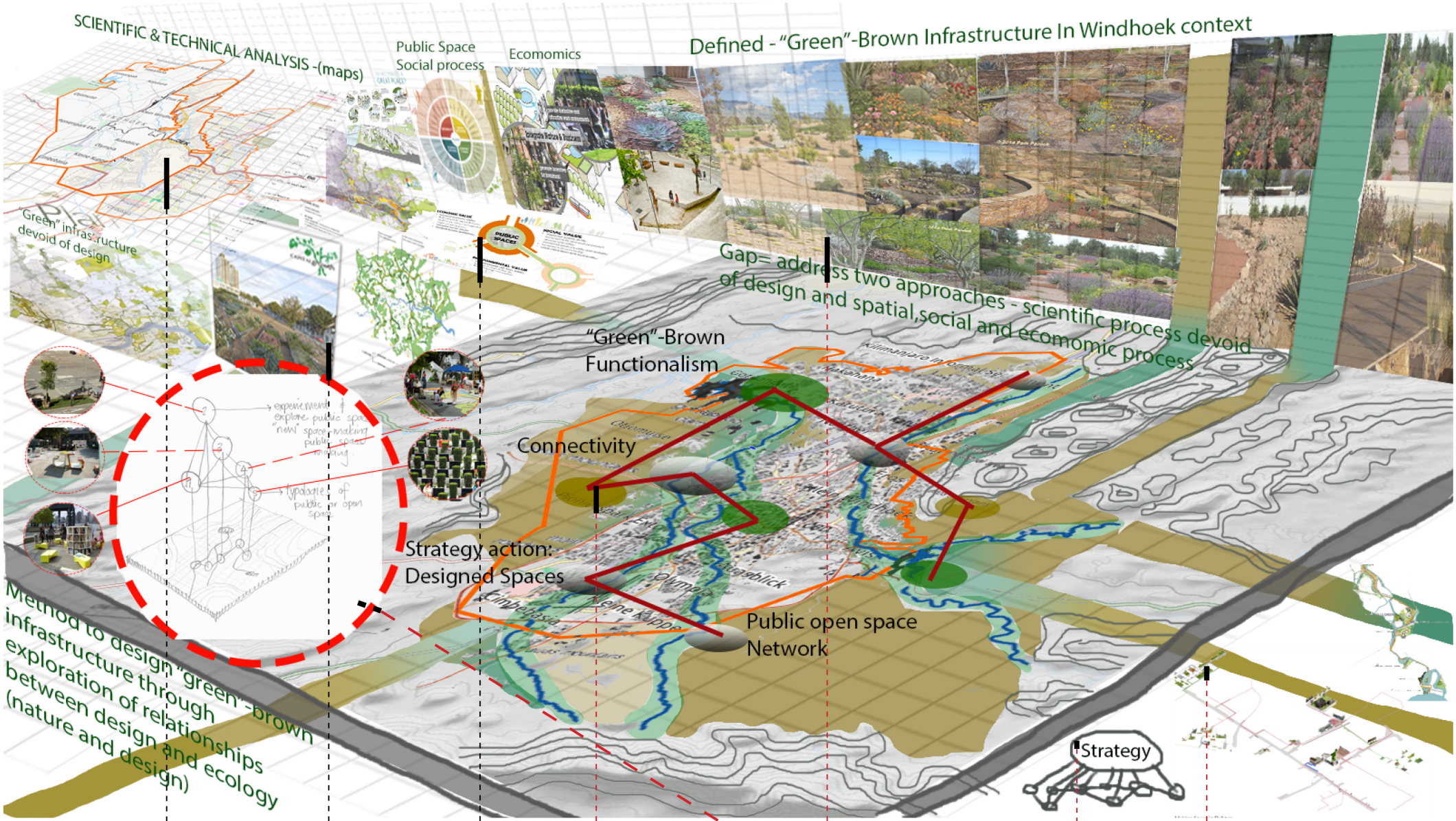
In the last 10 years the model of "Green Infrastructure" has developed internationally to provide a strategic framework to address environmental issues, enhance the environment and support socio-economic policy, balancing environmental performance and recreational development of public open spaces. However Windhoek is not green; it is brown."Brown Infrastructure" has the potential to provide a network of interconnected, multifunctional, attractive "brown-green" public open spaces system, enhancing the environment, for all inhabitants in Windhoek. Reflecting the inherent dry nature of Windhoek, Brown Infrastructure embraces dryness as an identifiable material specific of the place that should be appreciated.

The landscape infrastructure approach of the project first develops a network of interconnected, multifunctional, "brown-green" public open space system identified through a mapping process. Each public open space system has been classified by a proposed typology, which sets up the performance of the brown infrastructure and the types public open space function and use. This typology seeks to create diverse and distinctive spaces using a material language building on Windhoek's character, using different natural landscaping techniques, including use of rock, sand and indigenous vegetation. Each of the ten different types is then demonstrated on a specific site to test how the type works with specific site qualities and quantity, wetness and dryness to establish a landscape identity that also performs ecologically. In doing so, the project explores how landscape architects can design with the presence and absence of water.

RUBRIC

CRITERIA	RESPONSE	DELIVERABLE
Context	Infrastructure and public open space system is non existent in Windhoek, investigating Windhoek through the lense of "brown "infrastructure and public open spaces network. Dryness is also a quality associated with Windhoek open spaces. Project therefore focuses on establishing a performative opens spaces system and embracing dryness	A series of maps unpacks the geomorphology, hydrological and open space systems of Windhoek, followed by establishing a brown infrastructure and open public space network. Photographs of the river context.
Landscape Architecture	Landscape Architecture industry does not exist in Windhoek. It challenges landscape infrastructure/ green infrastructure and sets a "new" infrastructure and open spaces system for this particular context. Project explores how landscape architects can design with the presence and absence of water	Maps of Windhoek's Landscape characteristics and identifying a new Infrastructure, open space system and types
Namibia	Due to apartheid planning the project address the spatial inequality. Infrastructure connects and provide access to open public spaces. Considers open space distribution	Indication of distribution and deficiency of open spaces are mapped.
Site	The sites depend on a hydrological system, its either wet or dry or a gradient from wet to dry. The dryness is an identifiable material specific to the place and embraces the brownness.	Existing context, Plans and Photomontages describe new proposal
Scale	Landscape and Human scale: Landscape - Brown Infrastructure address the ecological, socio-economical role and the open space system address the human scale according to a type criteria	Brown Infrastructure maps address the landscape scale and the typology criteria sheet address the hierarchy of types
Form	Configuration of various types. Form is determined by the physical quality of site	Each type has been designed according to the typology criteria.
Ecology	Brown Infrastructure address the ecological role - connects and provide access, manage flood risks and overheating	Analytical diagram, maps and considering micro climatic conditions
Representation	Brown represents the dryness of Windhoek and how brown can be appreciated as a design technique	Seen throughout presentation
Idea	Project focus is primarily about Windhoek's public open spaces that are not designed nor coherent. The brown as a technique /infrastructure address the idea that landscape architects can design with brown.	Referring to study: the analytical maps and sketches. Addressing the hypothesis question and to conclude what the study suggest about the topic
Physicality	Brown/Rock Palette, "Oasis "spaces (wetness) micro climatic conditions. - Natural landscape materiality	How the rock pallete can be used as material and the different use and effect of materiality - site specific and /or type specific
Process	The project follows a series of analytical maps from the study addressing dryness (brown) and wetness (green) developing a brown infrastructure, rock palette and addressing the green as a " secondary" element.	The brown as a colour pallete used to explain each typology
Innovation	The critique of green infrastructure and open space systems does not suit Windhoek's climate. Windhoek is not green , it is Brown. Brown infrastructure is seen as an appropriate landscape intervention and offers landscape architects new ideas as to how to work/ design in the presence and absence of water	The project discuss and demonstrate how an old idea can differ, seen from a different design perspective
Experience	Each type has a different role and hierarchy within the open public space system that address the needs for both Humans, Fauna and Flora. Each type also address the physical quality of the site enhancing and embracing the dryness	Each site shows a different experience according to the typology sheet. Shows brownness spatialy. Explains how brownnes is used within each design - material and use

Embracing dryness, by Gaby Schmidbauer (MLA 2016)



STUDY

"Machine" Landscape - Scientific and Technical mapping, survey, analysis to understand the environmental and social attributes:
Geology
Topography
Hydrology
Soil
Vegetation
Floodplains
Open spaces
Transport system
Amenities - Facilities
Land - use

STUDY

Theories to test "green" infrastructure Evidence
Identify and Interogate case studies or models/examples
1. Understanding green infrastructure
2. The East London Green Grid

STUDY/PROJECT

Address Social and Economic issues - Making/designing- Public space

PROJECT

Develop a public open space framework.
Identify open spaces network to bring out the spirit of experimentation, innovation and optimism
Identify an area as a catalyst for other open spaces to develop.
Identified network can be a model or example that explores or address the social and environmental challenges currently experienced, towards a healthy and humane neighbourhood or environment

PROJECT

Celebrate and use of Namibian Materiality

PROJECT

Develop a public open space framework.

PROJECT

Identify open spaces network , a model/ example and catalyst

WINDHOEK CONTEXT

EMBRACING DRYNESS

PROCESS: DESIGN GENERATORS & MATERIALITY

STACKED/ MORTAR STONE WALLS

STACKED LOOSE ROCKS/ BOULDERS

CUT FLAGSTONE/LAYERED FLAGSTONE

BIOTITE MICA SCHIST

QUARTZITE

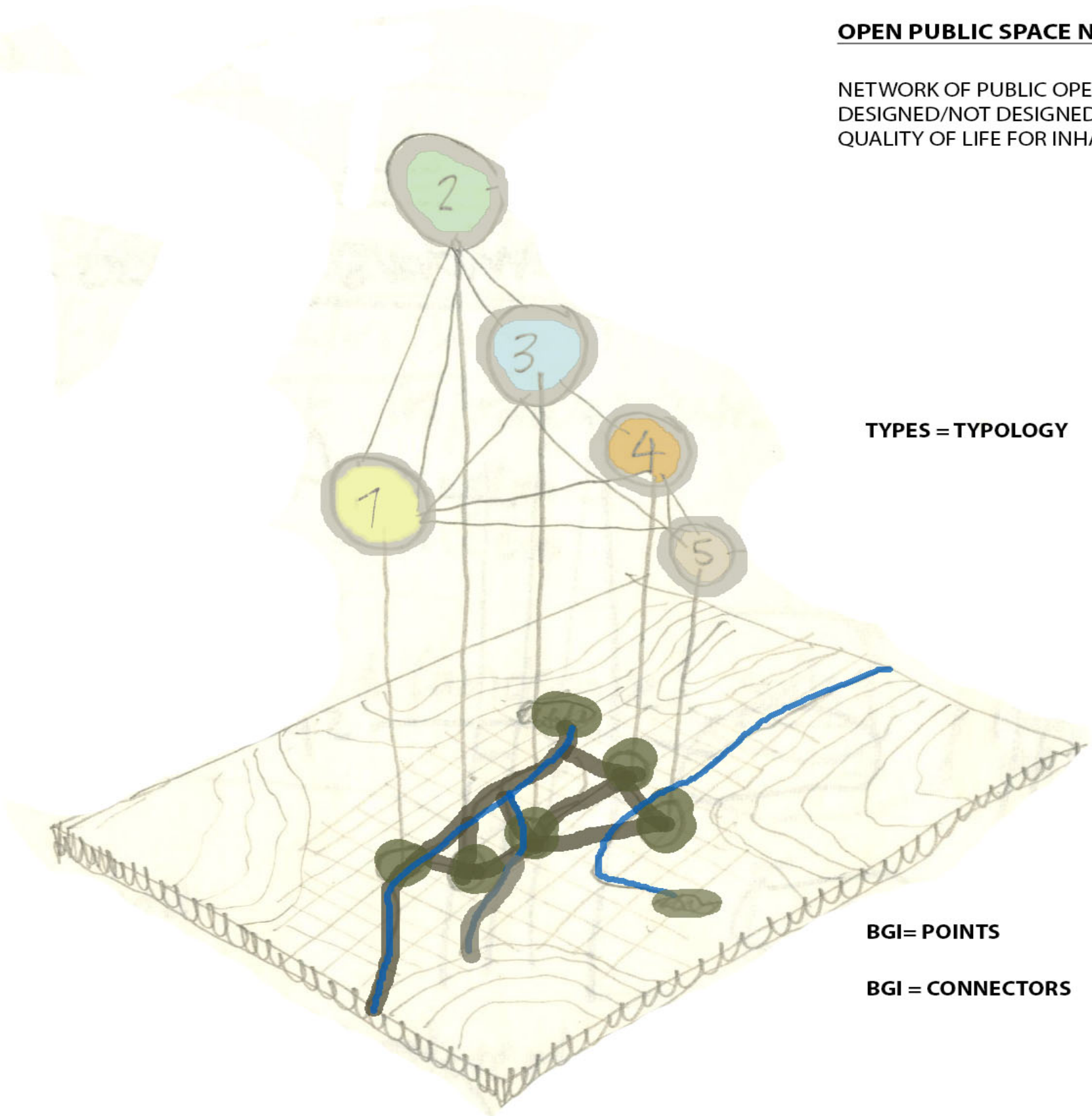
SLATE

Acacia mellifera

Acacia hereroensis

Aloe littoralis

PROJECT PRINCIPLES



OPEN PUBLIC SPACE NETWORK

NETWORK OF PUBLIC OPEN SPACE DESIGNED/NOT DESIGNED TO IMPROVE THE QUALITY OF LIFE FOR INHABITANTS

TYPES = TYPOLOGY

BGI= POINTS

BGI = CONNECTORS

BROWN INFRASTRUCTURE

BI = INTERCONNECTED , MULTIFUNCTIONAL NETWORK OF BROWN-GREEN OPEN SPACE

3 DESIGN PRINCIPLES

CONNECTIONS

MULTIFUNCTION

BROWN_GREEN

"A CONNECTED SYSTEM OF PARKS & GREENWAYS IS MANFESTLY FAR MORE COMPLETE & USEFUL THAN A SERIES OD ISOLATED PARKS." (JOHN OLMSTEAD & FREDERICK LAW OLMSTEAD JR, 1903)

ACTION

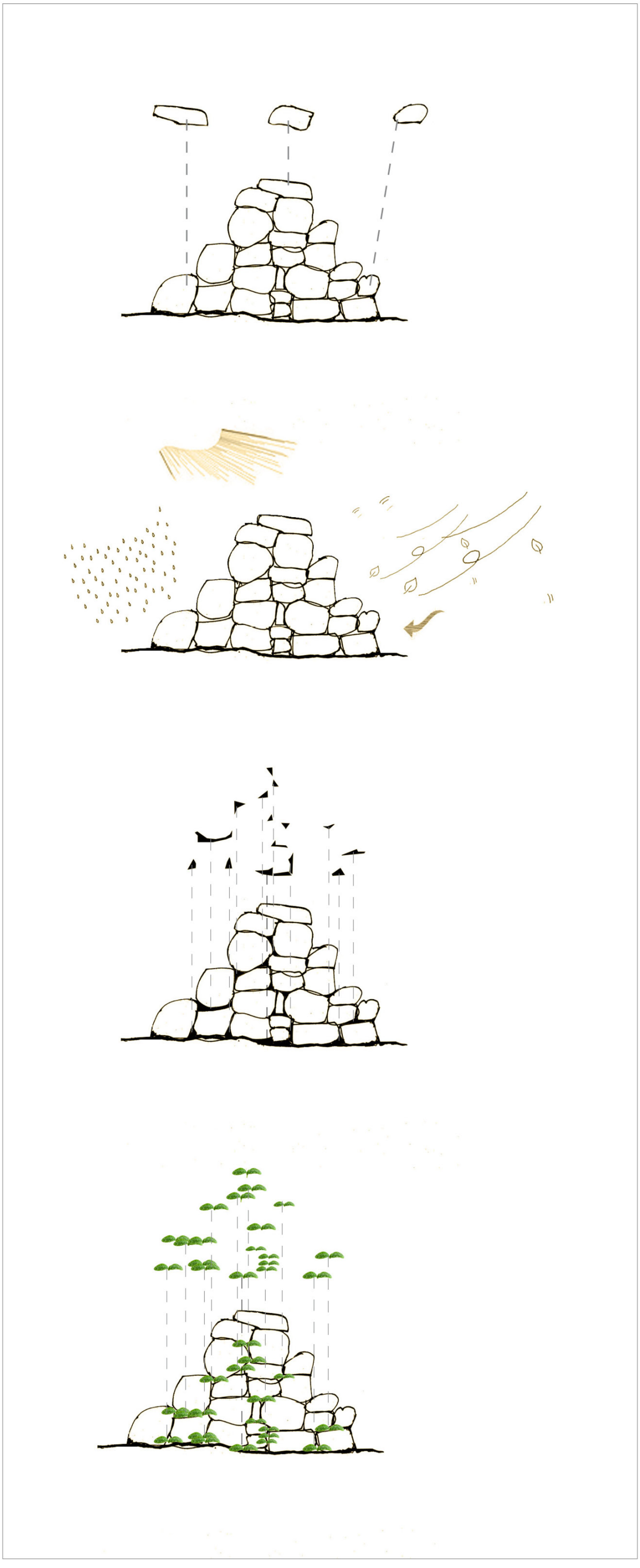
Material:
Stone/Rock Stacked

Context:
Exposed to environmental factors, influence material, form and space

Process and result:
Gaps or opening in rock create habitat. Context lead to micro-climatic in gaps/openings

Reaction:
Growth of plants in gaps occur

REACTION



LANDSCAPE CHARACTER

GEOLOGY: ROCK PALETTE

SAND

SANDSTONE

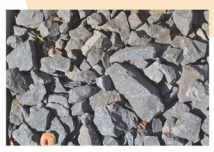
AMPHIBOLE SCHIST

AMPHIBOLE SCHIST

BIOTITE MICA SCHIST

BIOTITE MICA SCHIST

MICA SCHIST



CRUSHED GRANITE

CRUSHED QUARTZ

QUARTZITE

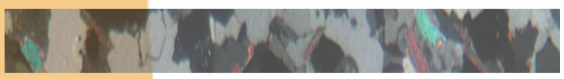
SLATE

SLATE

SAND/SANDSTONE

AMPHIBOLE SCHIST

BIOTITE MICA SCHIST



AMPHIBOLE SCHIST

MICA SCHIST

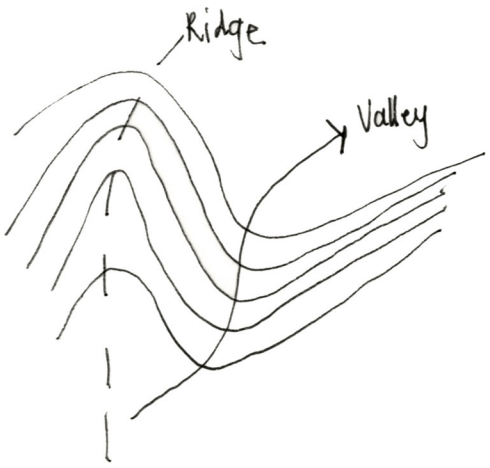
SLATE

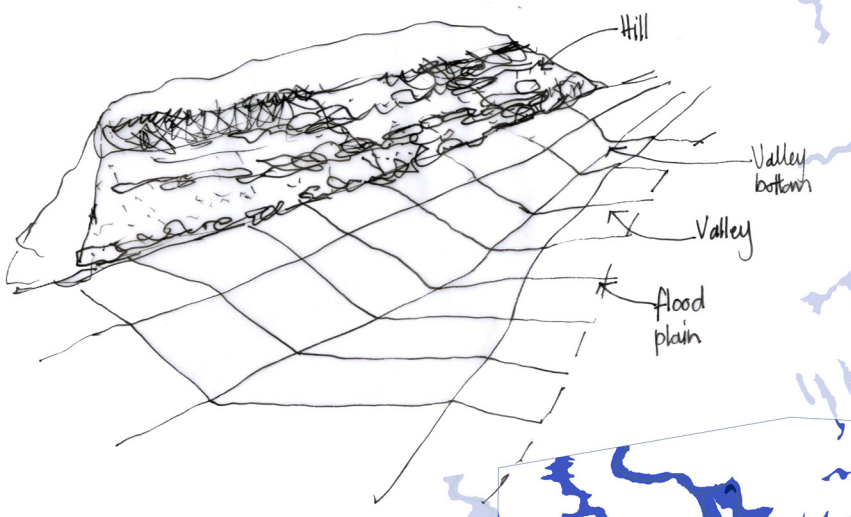
MICA SCHIST

QUARTZITE

N

HYDROLOGY

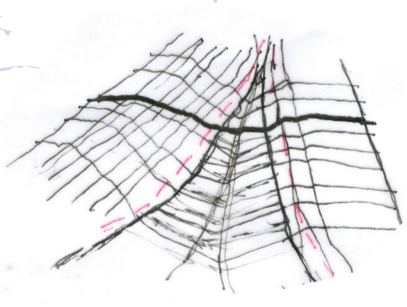


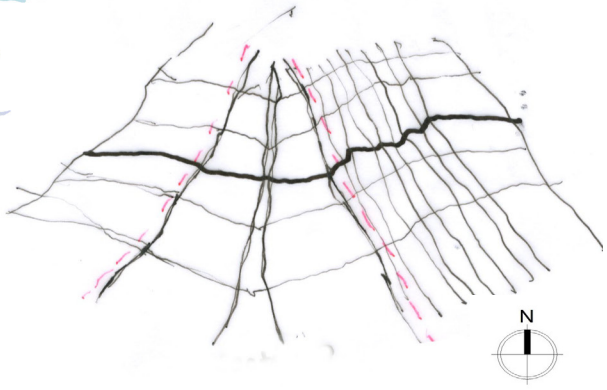


DAMS

VALLEY BOTTOM

RIVER





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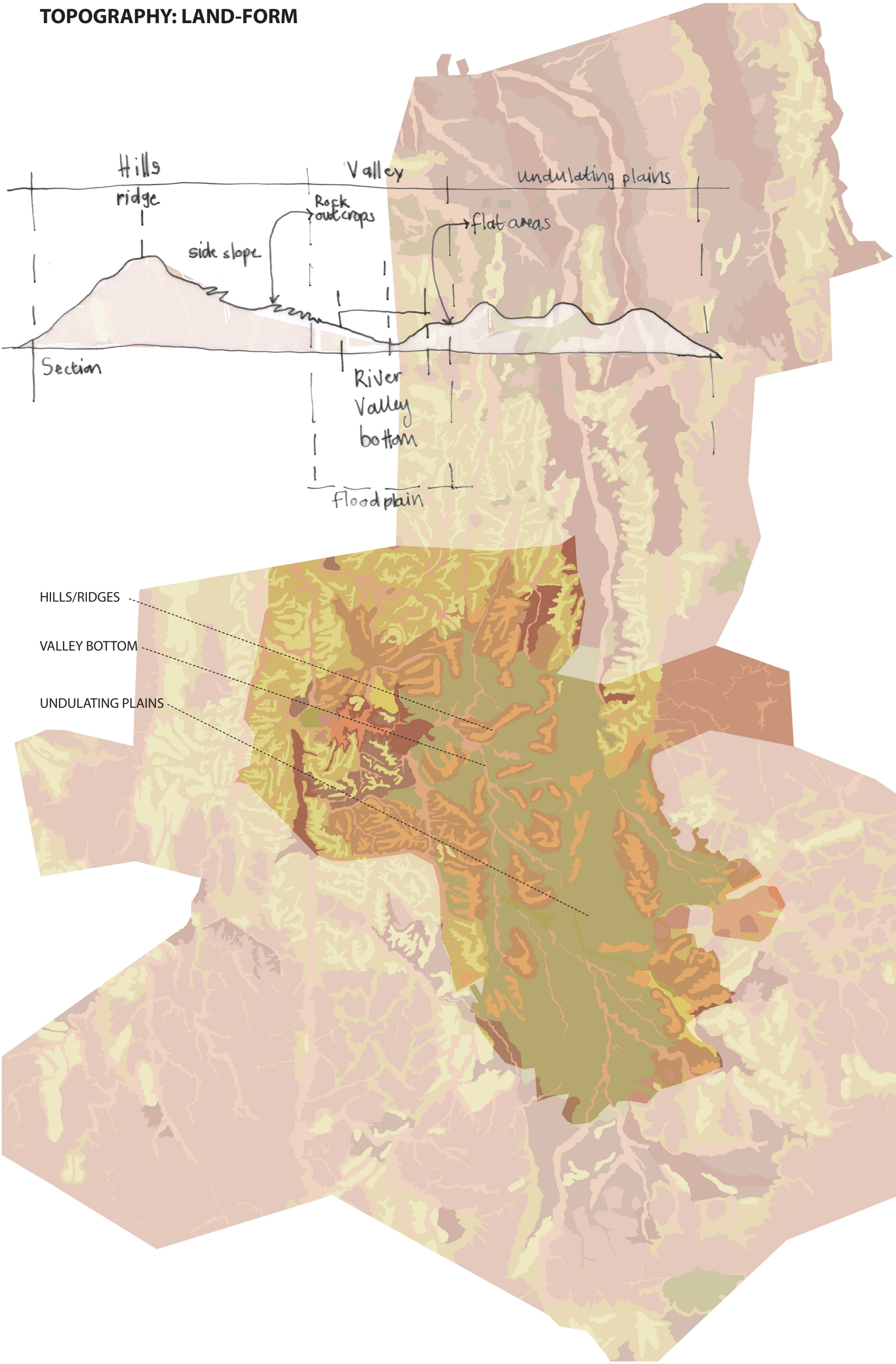
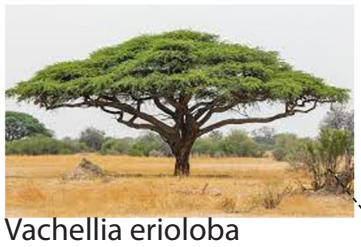
TOPOGRAPHY: LAND-FORM



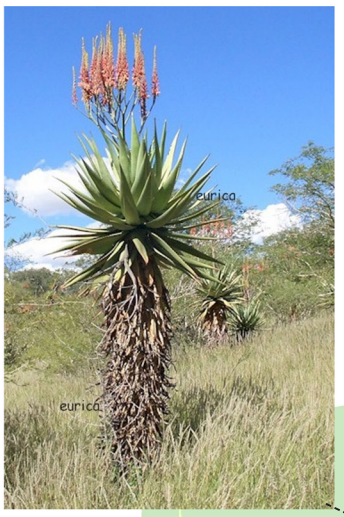
VEGETATION: PLANT PALETTE



Vachellia erioloba

Acacia mellifera

Microchloa caffra



Aloe littoralis

Brachiaria nigropedata

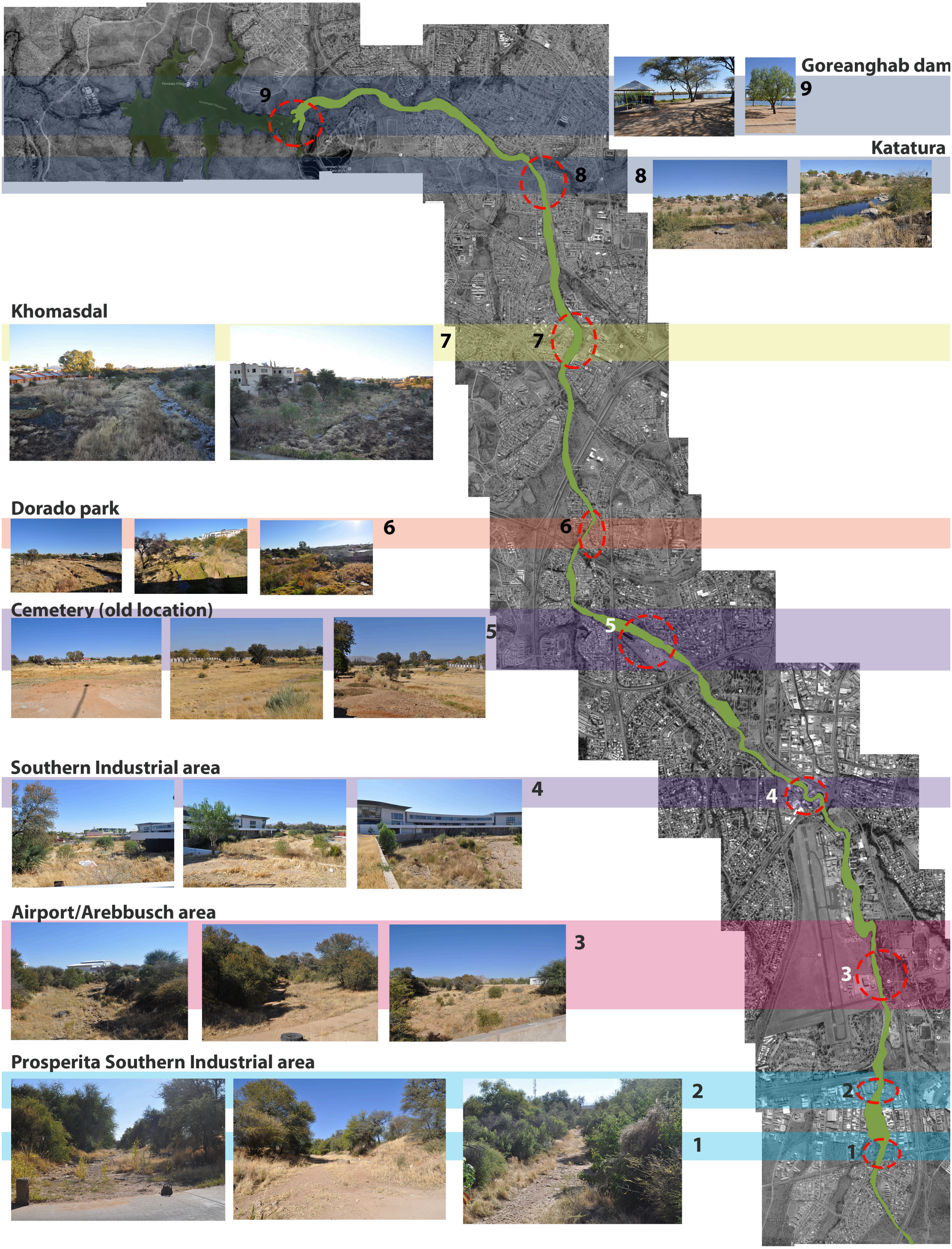
Anthephora pubescens

Aloe viridiflora

Acacia hereroensis

N

RIVER CONTEXT



Goreanghab dam

9

Katatura

8

Khomasdal

7

Dorado park

6

Cemetery (old location)

5

Southern Industrial area

4

Airport/Arebbusch area

3

Prosperita Southern Industrial area

2

1

AREBBUSCH RIVER

N

Khomasdal 9

8
WHK West

WHK West Commerial 6

WHK West Commerial 7

Southern Industrial area 5

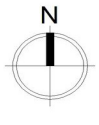
Suiderhof 4

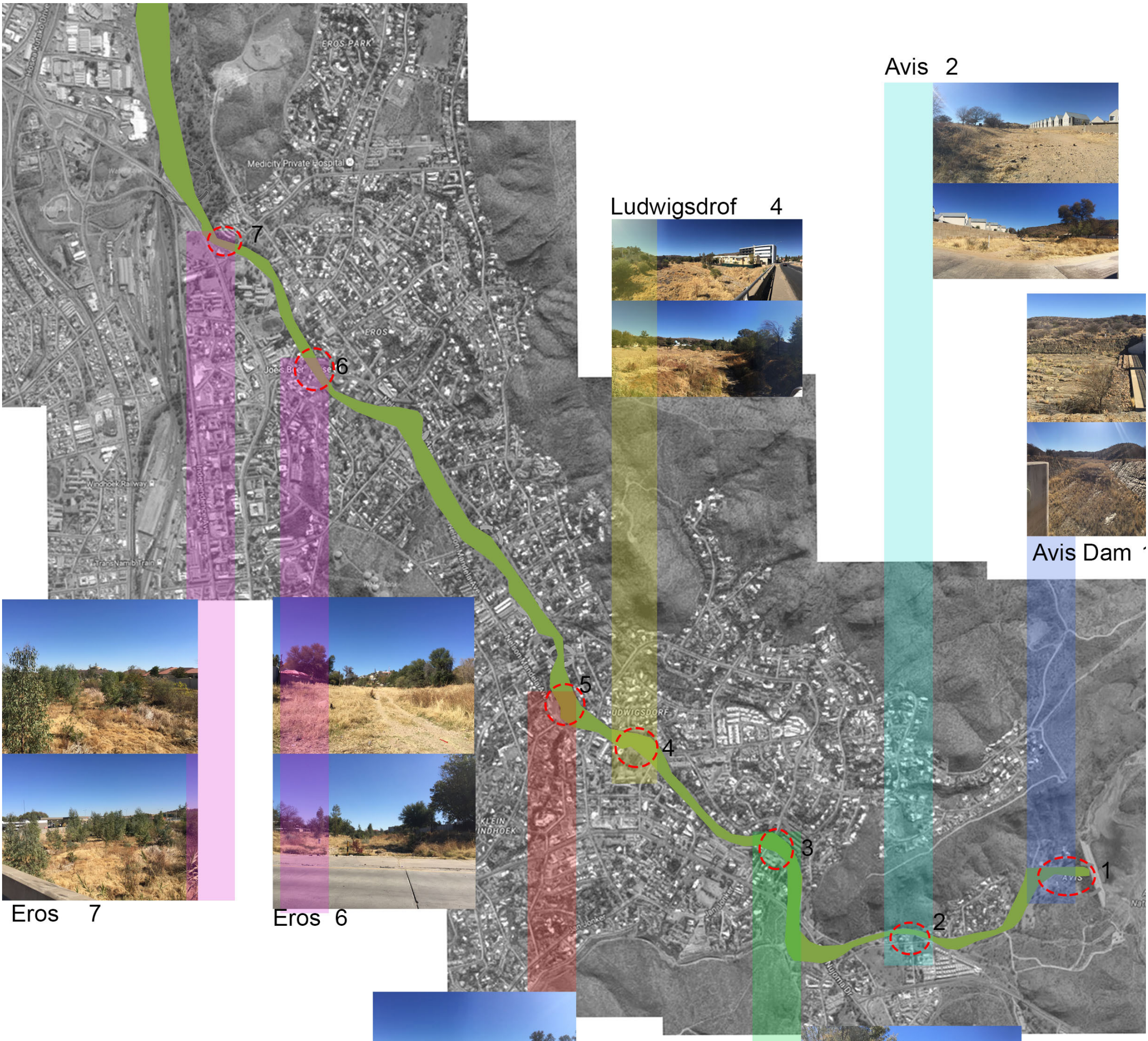
Auasblick 3

Auasblick ext1 2

Klein Kuppe 1

GAMMAMS RIVER





Avis 2

Ludwigsdrof 4

Avis Dam

Eros 7

Eros 6

Klein Windhoek 5

Ludwigdrof Ext. 3

KLEIN WINDHOEK RIVER

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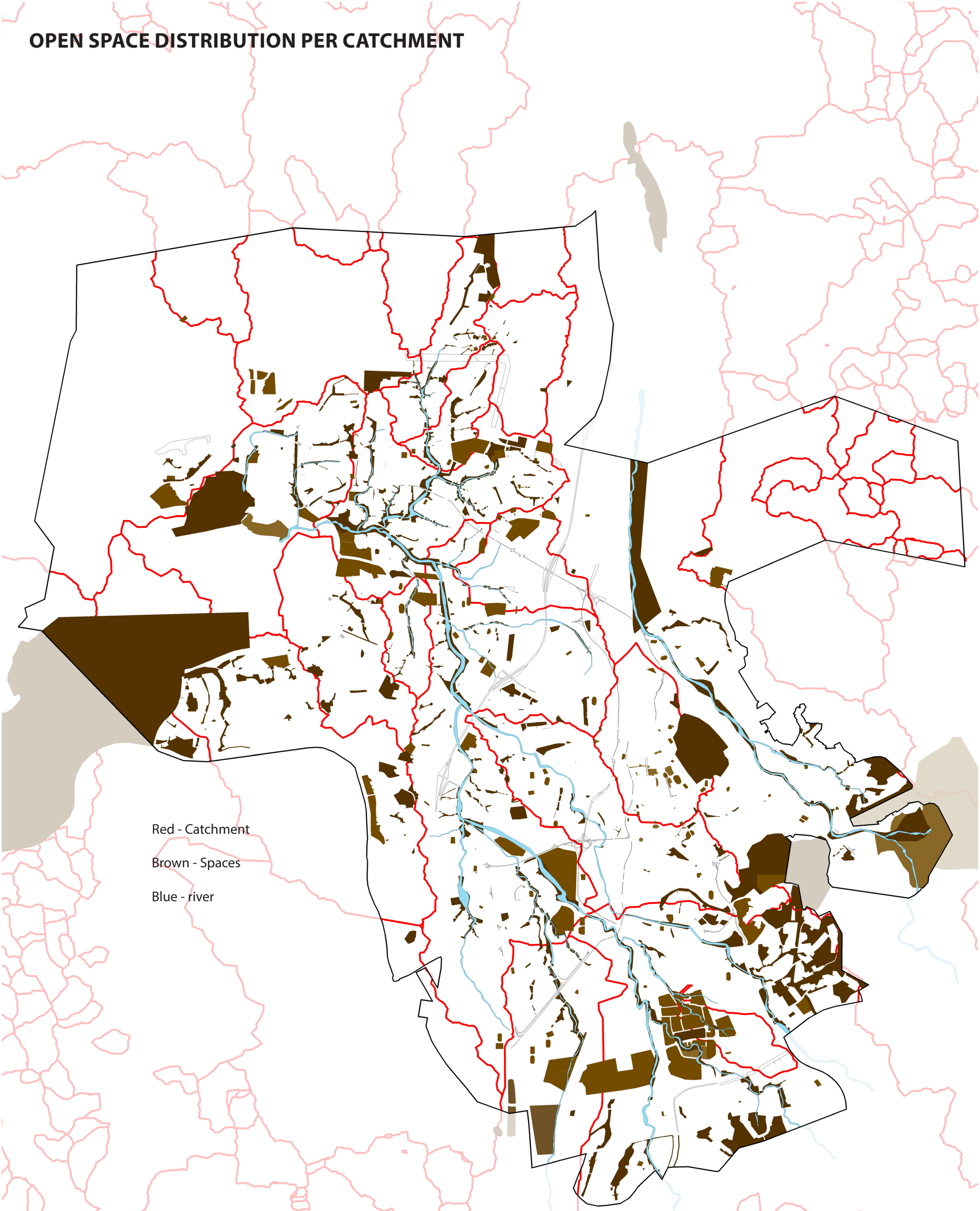
ANALYSIS - OPEN SPACE NET-WORK

OPEN SPACE DISTRIBUTION PER CATCHMENT



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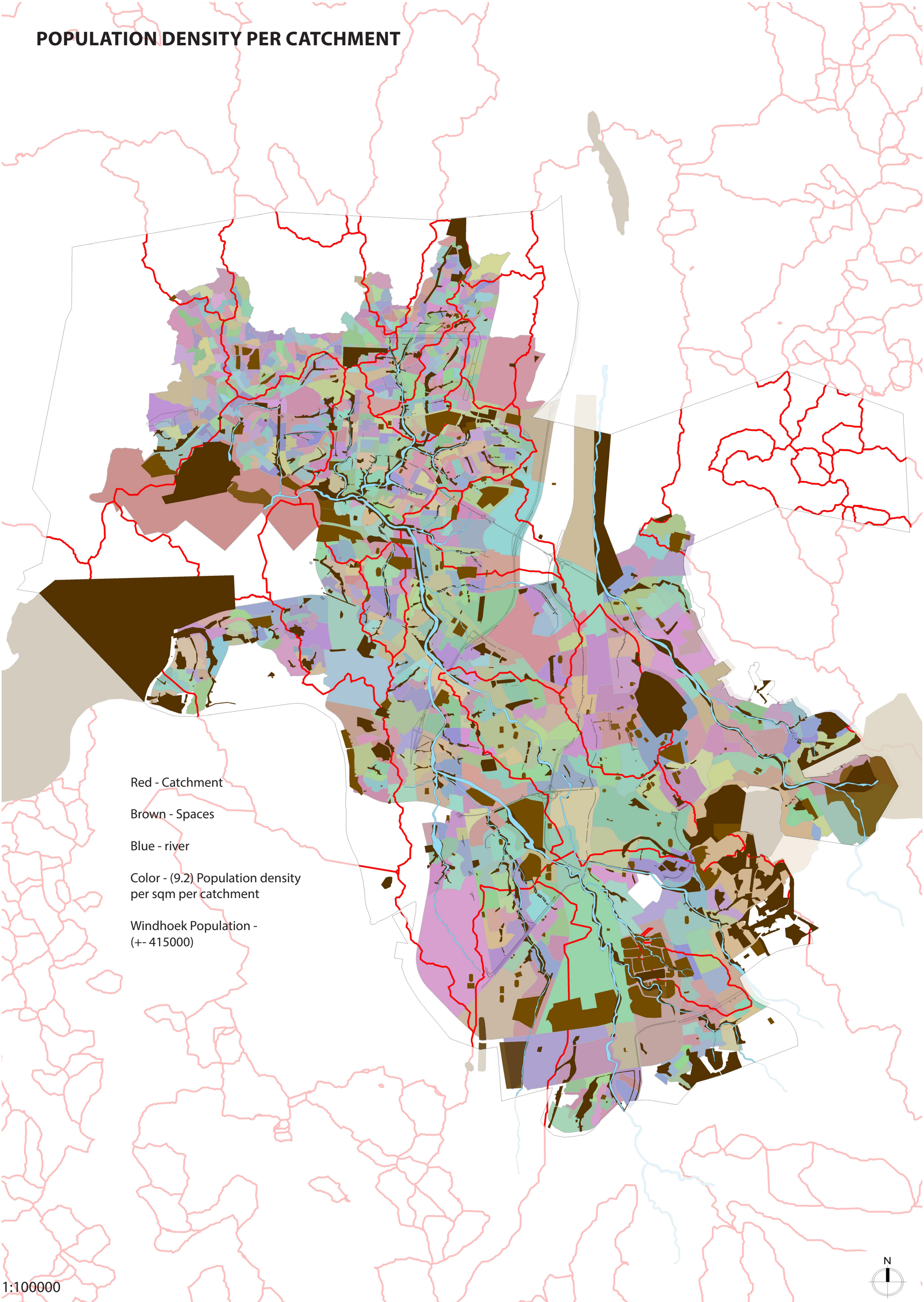
POPULATION DENSITY PER CATCHMENT



Red - Catchment

Brown - Spaces

Blue - river

Color - (9.2) Population density per sqm per catchment

Windhoek Population - (+- 415000)

1:100000

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MANAGE FLOOD RISK

1:100000

ACCESS TO OPEN SPACE AND OPEN SPACE DEFICIENCY

Brown - Open Spaces

Blue - River

+

Existing open spaces

Deficiency - Regional and Suburb Parks, mostly

-

1:100000

N

BROWN INFRASTRUCTURE

INFRASTRUCTURE: MULTI-FUNCTIONALITY

OBJECTIVE:

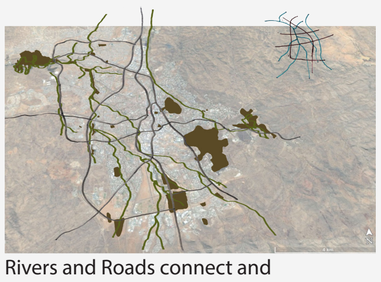
- PROVIDE AND PROMOTE CONNECTION, ACCESS AND MULTI-FUNCTIONAL SPACES

- FRAMES AND SHAPES THE GROWTH OF A SUSTAINABLE CITY

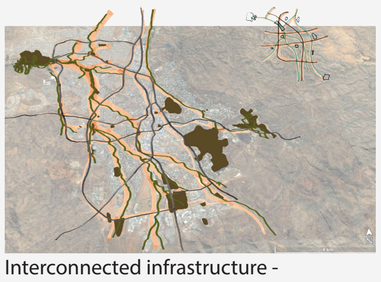
- STRENGTHEN THE IMAGE AND IDENTITY OF THE CITY

- HELP CITIES TO ADAPT TO CLIMATE CHANGE, REDUCE FLOOD RISK AND/OR OVERHEATING

Rivers - Major Connectors
Roadscape - Secondary Connectors



Rivers and Roads connect and provide access to spaces



Interconnected infrastructure -
Movement
Access
Crossing

1:50000

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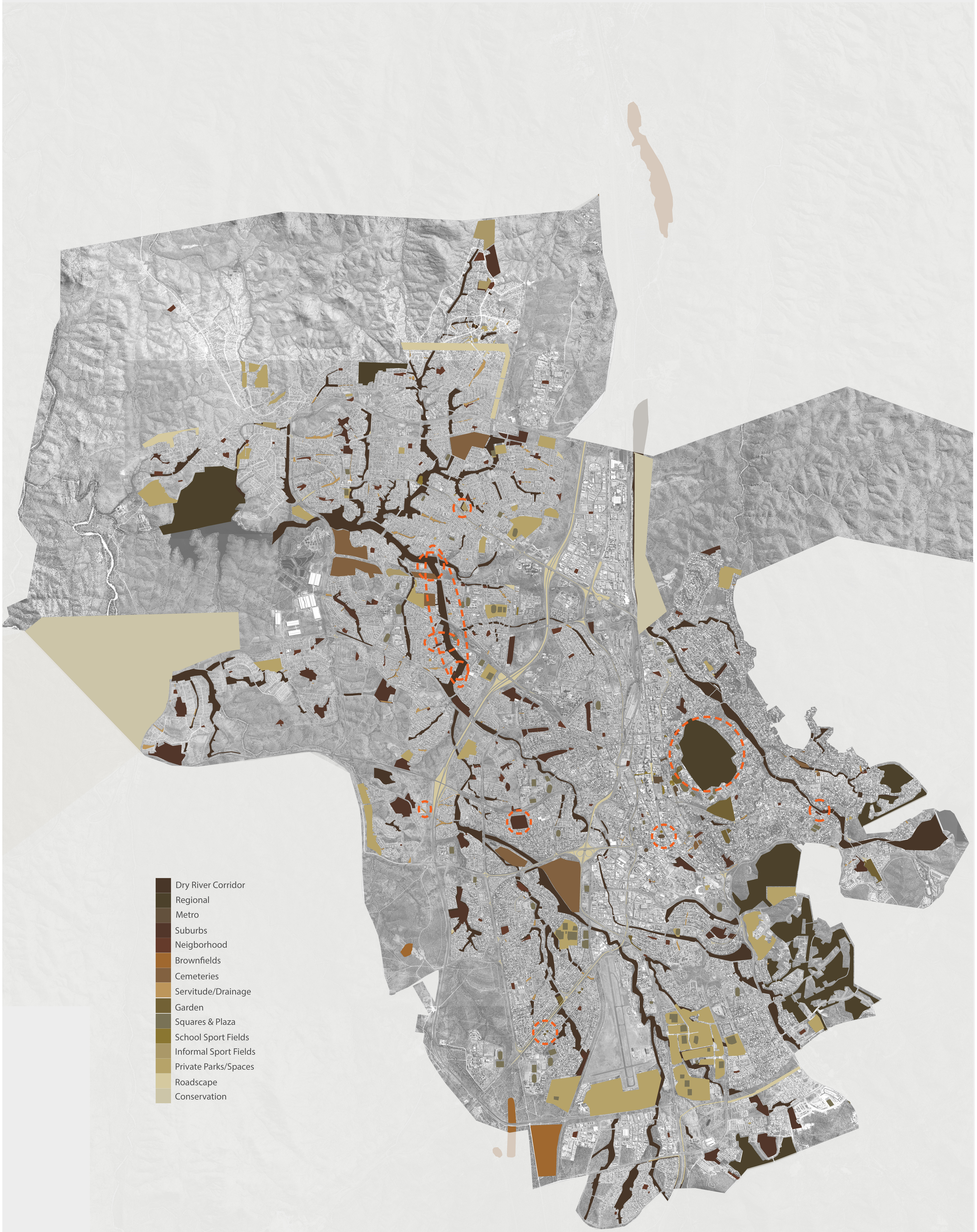
BROWN GREEN OPEN SPACE NETWORK



1:20000

CLASSIFICATION TYPES

Cemetries and Churchyards
- Public use
  - Muncipal Cemetery
- Private use
  - Special services
    - War Veterans cemetry
    - Memorial Parks

Squares and Plaza
- Meeting/Selling space
  - Fomal
    - Designed
      - Urban
        - Muncipal Urban Square
      - Suburban
        - Community Square
  - Informal
    - Road verges
      - Street market spaces

Amenity
- Institution space
  - Education
    - Universities
      - Public
      - Private
    - Schools
      - Public
      - Private
  - Commercial space
    - Informal garden space
- Residentail
  - Drianage
    - Informal PocketBioswale spaces
    - Informal Play space

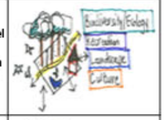
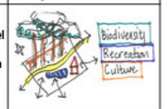
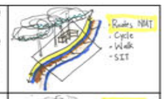
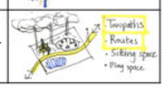
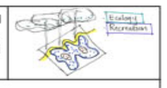
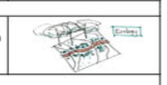
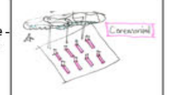
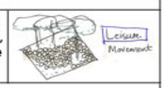
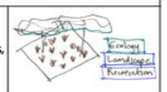
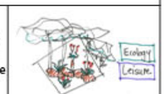
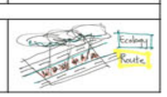
PARKS
- Designed for Public recreation use (facilities)
  - Formal passive, active and play recreation/ leisure and natural ecological spaces
    - Regional
      - Caters for the entire Windhoek
        - Windhoek Urban/ Municpal park(big)
    - District
      - Caters for several Suburbs
        - Public owned
          - Formal Active Recreation
            - Sport park
            - Sport park complex
          - Formal Passive Recreation
            - Community recreation park
        - Private owned
          - Formal Active Recreation
          - Formal Passive Recreation
    - Neighborhood
      - Specialised facilities
        - Designated for physical activities
          - Games/court park
        - Designated for non physical activities
          - Pocket parks
        - Designated space for play
          - Playground
- Natural space recreation_ few or no built facilities
  - Natural Public space
    - Not fenced off
      - Brown corridors
        - Rivers/canals
          - Linear dry Riverfront schist park
    - Fenced off
      - Natural open space of significance
        - Protect & preserve (nature)
          - Nature Reserves Parks /Conservation
      - Protection of biodiversity
        - Provide Passive space/Paths/ Trails
          - Private Animal parks
  - Natural Private space

Gardens
- Public
  - Passive Recreation
    - Ornamental city gardens
  - Food production
    - Caters for large population
      - Agriculture lands
    - Grown in Metro
      - Urban Garden pockets
    - Grown at neigborhood scale
      - Community gardens
    - Home grown produce
- Private

Waterbodies stored
- Recreation
  - Dams
    - Closed with facilities
      - Metro recreation Park
    - Open space with no facilities
      - Protect Natural habitat
        - Open Natural public space
- Not for Recreation
  - Ditches and road verges
  - Resevoirs

Brownfields
- Old industrial use
  - Brewery
  - Old power station
  - Landfills
- Urban regenerated parks

TYPE CRITERIA SHEET

TYPOLOGY								"BROWN "INFRASTRUCTURE								DESIGN COMPONENT	
TYPE								FUNCTION	NATURAL & SOCIO -ECONOMIC BENEFITS (Provide)							LANDSCAPE ELEMENTS	
No	Primary Type	Definition	Sub-types	Points/Spaces	Connectors	Definition	Size of type	Multifunction	Socio-Economic benefits	Climate change adaptation and mitigation	Flood mitigation and water management	Land and property value, economic growth/ investment	Tourism	Recreation and Leisure	Land and biodiversity	Space and material	Vision diagram
1	PARK	Areas normally designed, constructed, enclosed, managed and controlled for either recreation or non-recreation public use. Privately owned or managed by municipal or community	Regional, Metropolitan Suburb, Neighbourhood, Private spaces, Conservation	REGIONAL		Large or big parks at city scale designed to accommodate recreation and environmental features	Size variable depending on the function. 5ha+	Large spaces, corridors or network of spaces, the majority will be publicly accessible and provide a range of facilities, recreation, landscape features, ecological an cultural benefits. Readily accessible by public transport	Gathering space that attracts and invite the entire city for the enjoyment of the natural environment, Increase property value	Prevent overheating, provide shade	Retention-detention ponds	Attracts investors	Attracts tourist from other countries	Recreation and leisure	Landscape features, ecology, culture, access, movement	Natural type of landscape: Water collection storage areas. Demarcate hiking trails with gravel paths and stone edging. Savannah grassland spaces or tree species. Allocate picnic spots with stacked stone walls. Views and outlook points, facilities - restaurant	
				METROPOLITAN		Large or big parks at city scale designed to accommodate recreation and environmental features	Size variable depending on the function. 3-5ha+	Large areas or spaces that provide similar range of benefits as Regional and offer a combination of facilities and environmental features at sub-regional level	Gathering space that attracts and invite the entire city for the enjoyment of the natural environment, Increase property value	Prevent overheating, provide shade	Retention-detention ponds	Attracts investors	Attracts tourist from other countries	Recreation and leisure	Landscape features, ecology, culture, access, movement	Natural type of landscape: Water collection storage areas. Demarcate hiking trails with gravel paths and stone edging. Savannah grassland spaces or tree species. Allocate picnic spots with stacked stone walls. Views and outlook points, facilities - restaurant	
				SUBURBS		Medium parks at suburb scale serve several neighbourhoods. Designed for recreation, sport facilities and should consider biodiversity principles	2ha-5ha	Recreation, leisure and sport, Aesthetic, water storage, shading from sun, habitat for bird and small animals, Sud systems, oasis spaces, catalyst for wider regeneration	Gathering space that attracts suburb communities for the enjoyment of the a semi natural environment, and other various entertainment activity, Increase property value	Prevent overheating, provide shade	Storage sponges/ temporary water basins, Bioswales, SUDs	Increase property value	Attracts other suburb /community/inhabitants	Playfields and play space, outdoor sport facilities	Landscape setting with a variety of natural features	Semi-Natural type of landscape: Use topography to drain water to create oasis spaces, i.e. water collection ponds or ditches. Gravel paths, gabion retaining walls. Demarcate informal sport facilities. Demarcate braai facilities. Entertainment spaces and play spaces. Leisure walk or running path with dogs	
				NEIGHBORHOOD		Small/pocket parks designed for specific social use: playgrounds, kick bouts, picnic's and/or game courts.	0.5 - 1ha	Aesthetics, water filtration, learning, shading from sun, catalyst for wider regeneration	Attracts residents to a intimate playful space (playgrounds), opportunity to socialise, sense of place (distinctiveness) increase property value if well maintained	Prevent overheating, provide shade	Storage sponges/ temporary water basins, SUDs	Increase property value	Attracts other local inhabitants, residential communities	Playful spaces	Nature conservation on small scale - bird and plant species	Intimate spaces for active playgrounds. Stone/rock material stacked or boulders for play equipment. Manipulation of terrain to create pockets for play, active, passive space. Play and sit in shade	
				PRIVATE SPACES		Any park enclosed for public leisure, recreation or sport facilities	Variable	Recreation and sport, Aesthetic, water storage, shading from sun, habitat for bird and small animals, cultural assets, learning	Depend on the activity or function of space	Prevent overheating, provide shade	Storage sponges/ temporary water basins	Increase property value	Attracts foreign, community and neighborhood inhabitants	Recreation, leisure, outdoor sport facilities	Landscape setting with a variety of natural features	Enclosed spaces for either recreation, leisure or sport facilities.	
				CONSERVATION		Natural or semi natural areas with facilities to protect, conserve and rehabilitate, biodiversity	Variable	Leisure, Aesthetic, water storage, biodiversity for wildlife, corridor for wildlife	Attracts immediate and other regions for the enjoyment of the nature wildlife environment as well as leisure spaces- camping	Prevent overheating, provide shade	Retention-detention ponds	Increase land value	Attracts foreign, community and neighborhood inhabitants	Leisure	Landscape features, ecology, culture, access, movement	Leisure facilities -stone lodges and camping areas, rehabilitation and protection of wildlife, free roaming of animals	
2	BROWN CORRIDOR	Any continuous path that connects spaces like rivers, canals, waterways	Linear parks, Riverfront, promenades		RIVERFRONT PROMENADE/ PARK	A space designed along a stretched of river, canal, waterway that connect other brown-green spaces in the city and protects environmental principles	Depend on length of river	Corridors brown travel route - connection), ecosystem services, educational, catalyst for wider regeneration, soil bank stabilization,	Encourage people to be more active and reconnect and engage with the dry ecological features of the river. NMT system- walk, cycle. Sense of place, Encourage economic upliftment - pop up stalls, educational	Prevent overheating, provide shade,	Terraced retention spaces	Increase property value, promote investment along spaces	Attract all inhabitants	Leisure	Ecology, landscape features, accessibility, connection	Create gravel paths along river, stone wall edge to stabilize banks. Manipulate terrain to allow river to meander- contoured terraces. Dry stone wall to buffer space or walkways outside flood plain, provide resting spots, riverfront spaces, wooden decks, bridges	
					LINEAR PARK	A long narrow strip of land designed for recreation and consider environmental features	1-3ha	Recreation, Aesthetic, shading from sun, habitat for bird and small animals, learning, SUD system	Connects people to spaces and encourage walkable and cycable space. Encourage economic upliftment - pop up stalls	Prevent overheating, provide shade,	Retention and detention ponds	Increase property value and encourage small enterprises	Attract all inhabitants	Leisure	Ecology, landscape features, accessibility, connection	Use stone to create weirs and ponds, to drain water. Gravel paths, clumps of trees, pockets for picnic or resting space, cycle trail.	
3	WATER-BODIES	Areas natural or constructed to store water	Dams, reservoirs	DAMS		Space demarcated and designed for recreation and protection, rehabilitation of environmental features: water	Size determined by nature of water body	Recreation, water storage, habitat creation of fish and bird species, wetlands	Social gathering space, control flood water prevent huge infrastructural destruction, opportunity to clean water through natural system - wetlands	Captured water, provide cooling space	Wetlands	Increase property value and encourage investment	Attract all inhabitants	Recreation and leisure	Ecology, landscape features	Create mini wetlands to treat affluent water and entertainment/facilities like canoeing, fishing, swimming, demarcate spaces for picnic or braai facilities.	
4	SERVITUDE	Generally areas left open for stormwater drainage between events. Used as thoroughfare	Drainage Servitude		DRAINAGE	Narrow strip of land used to drain stomwater, but can be designed for leisure use	3-7m wide	Connection, SUD systems - bioswales(trap pollutants), water infiltration	Cleans water and provide a healthier spaces	Trees as cooling features	SUD systems to slow down water, clean and drain water	Increase property value	-	Leisure	Nature conservation	Stone packed gulley's to collect, clean and drain water, demarcate space for path	
5	SPORTS	Generally large flat natural grassland or artificial astro turf areas designed primarily for sport activities	Formal (school)Sport fields , Informal sport fields	FORMAL SPORT		Spaces designated for sport facilities. Should consider environmental features	Determined to standard size	Sport activity, water filtration	Physical activity: it promotes good health and well-being means of active social contact and ample opportunity for intensive experiences.	Trees as cooling features	SUD systems to slow down water, clean and drain water	-	-	Active facility	Small pockets of conservation	Active spaces, Flat surface, incorporate a water collection point to irrigate fields	
				INFORMAL SPORT		Space not designated for sport use but for leisure as well.	Undetermined	Sport activity, water filtration, recreation, learning	Social contact	Trees as cooling features	SUD systems to slow down water, clean and drain water	Increase property value	-	Recreation, leisure and active informal sport	Small pockets of conservation	Space flexible to change, demarcate space for informal sport activity, introduce garden patch, manipulate terrain, seating spaces under shade and water drainage.	
6	CEMETERIES & GRAVEYARD	Generally areas for burial or remembrance	Public and Private cemetery	PUBLIC CEMETERIES		Designed for burial of loved once but could be used as spaces for events	Designated according to population use	Habitat for birds, leisure, water interception, water filtration, shade from sun, noise absorption, wind protection	Ceremonial spaces for loved once	Trees as cooling elements	Sponges to trap water - infiltration	-	-	Leisure	Habitat - small animals and plants species	Intimate private reflection spaces, provide shade - trees, seating, Water collection and storage to irrigate plants.	
7	SQUARES & PLAZA	Squares, plaza, generally hard landscaped for pedestrian movement and gathering	Squares and Plazas	SQUARES		Squares are designed for social gathering or transformed into market spaces	Size differ according to urban fabric	Rain water run-off collection, leisure, aesthetic	Well designed and managed civic spaces should provide a forum for activities and gathering, major catalyst in revitalizing the surrounding neighbourhood and providing opportunities for small-scale entrepreneurship	Trees as cooling elements	SUD systems to slow down water, clean and drain water	Increase property and encourage investment	-	Leisure/recreation	Small pockets of conservation - plant species	Active spaces require hard surfaces for human traffic and soft spaces for resting, seating, shade, Impervious surfaces, manipulate terrain, provide pocket space for informal market space	
8	BROWNFIELD	Old derelict vacant land or industrial uses or landfill sites	Derelict land, old industrial spaces	DERELICT LAND		Any derelict land that have the potential to be transformed into a public space	Size determined by the previous use	Biodiversity, leisure, trap pollutants, biofuel production, soil stabilization	Potential for space to transform into a park	-	-	Increase property and encourages investment	Attracts all inhabitants	Leisure/recreation	Ecology, landscape features	Potential for space to transform into a park, temporary urban landscape regeneration spaces, reproduction of the land	
9	GARDENS	Areas of land normally enclosed, designed, constructed, managed and maintained as a public garden. These may be owned or managed by community groups.	Gardens: Botanical, home grown, community gardens	GARDENS		Any space designed either for ornamental or food production	Depends on the use of garden	Biodiversity, leisure, food production, water infiltration, learning, Indigenous use of plants	Horticulture, Community food production,	Trees as cooling elements	Water infiltration	Increase property and encourages investment	Attracts all inhabitants	Leisure/recreation	Plant species and small animals	Relaxation spaces, picnics, native trees, grass, flower spaces - provide a water collection point to irrigate meadow spaces/lawn, either gravel paths or hard surfaces. Manipulate terrain, terrace spaces, stone gabion walls	
10	ROADSCAPE	Road verges, islands, streetscapes, generally left over spaces, either soft or hard landscaped	Servitudes		ROAD VERGES ISLANDS	Spaces designed to connect one space with another. Design and function should consider environmental features/principles	All left over road verges, round about, islands, pavements	Corridors (connection), Heat absorption, water drainage, trap pollutants (runoff - bioswales)	Increased pedestrian and cyclist safety, street "brown-greening"	Trees as cooling elements	Water infiltration, bioswales	-	-	-	Plant species and small animals	Xeriscaping spaces, drought resistant plants, rockery, Sud systems	

EMBRACING DRYNESS

BROWN GREEN OPEN SPACE NETWORK AND TYPES

PLAN
1:10000

VIEW

PHOTO OF BEFORE INTERVENTION

River corridor are the major connectors in city.
Connects suburbs.
Towpaths for cyclist and pedestrians.
Ecological corridor, to allow for movement

VIEW

BROWN RIVER CORRIDOR

1:750

Rest spots

Danie Strydom street

AREBBUSCH
RIVER- Schist
outcrops

Kristante street

Small Pocket Park

Parks space

David Bezuidenhout street

J.James street

Footpath

PLAN
1:1000

N

VIEW

Biodiversity

Stacked/Mortar
Slate Stone

Footpath -
compacted earth

Tree growth
from mounds

Bioswale

PHOTO OF BEFORE INTERVENTION

Small dumpsites within river corridor provide a small pocket space for **play and sitting space**.
Treat stormwater - **Bioswale**

VIEW

RIVER AMENITY BROWN SPACE

PLAN
1:200

VIEW

Terraced low sandstone walls

Butterfly and bird habitat

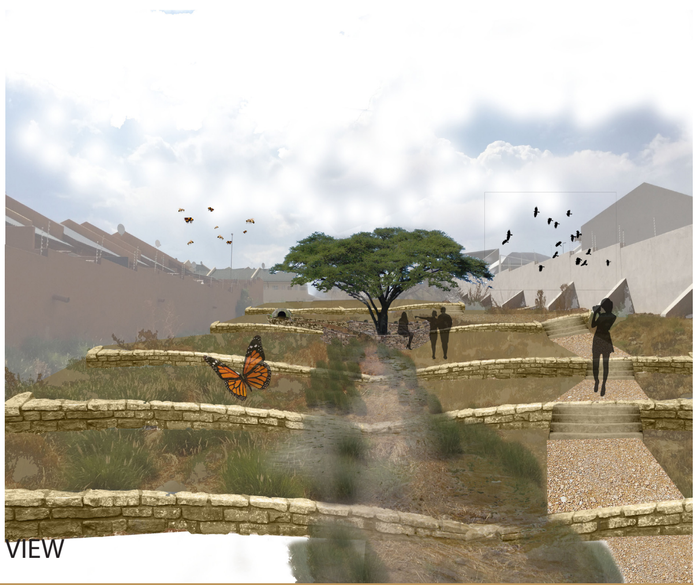
Bioswale

Compacted earth steps

Compacted gravel path

PHOTO OF BEFORE INTERVENTION

Drainage spaces are used as a thoroughfare and a spaces to drain stormwater. It can be a space to collect, hold and clean - **SUDs** as well as **Leisure space - sitting**



VIEW

SERVITUDE/DRAINAGE

VIEW

Trees provide shade - 25deg along footpath

Habitat - birds and butterflies (other smaller creatures)

Lizard in hot sun baking at 30deg

Rocky schist out-crop/look out point

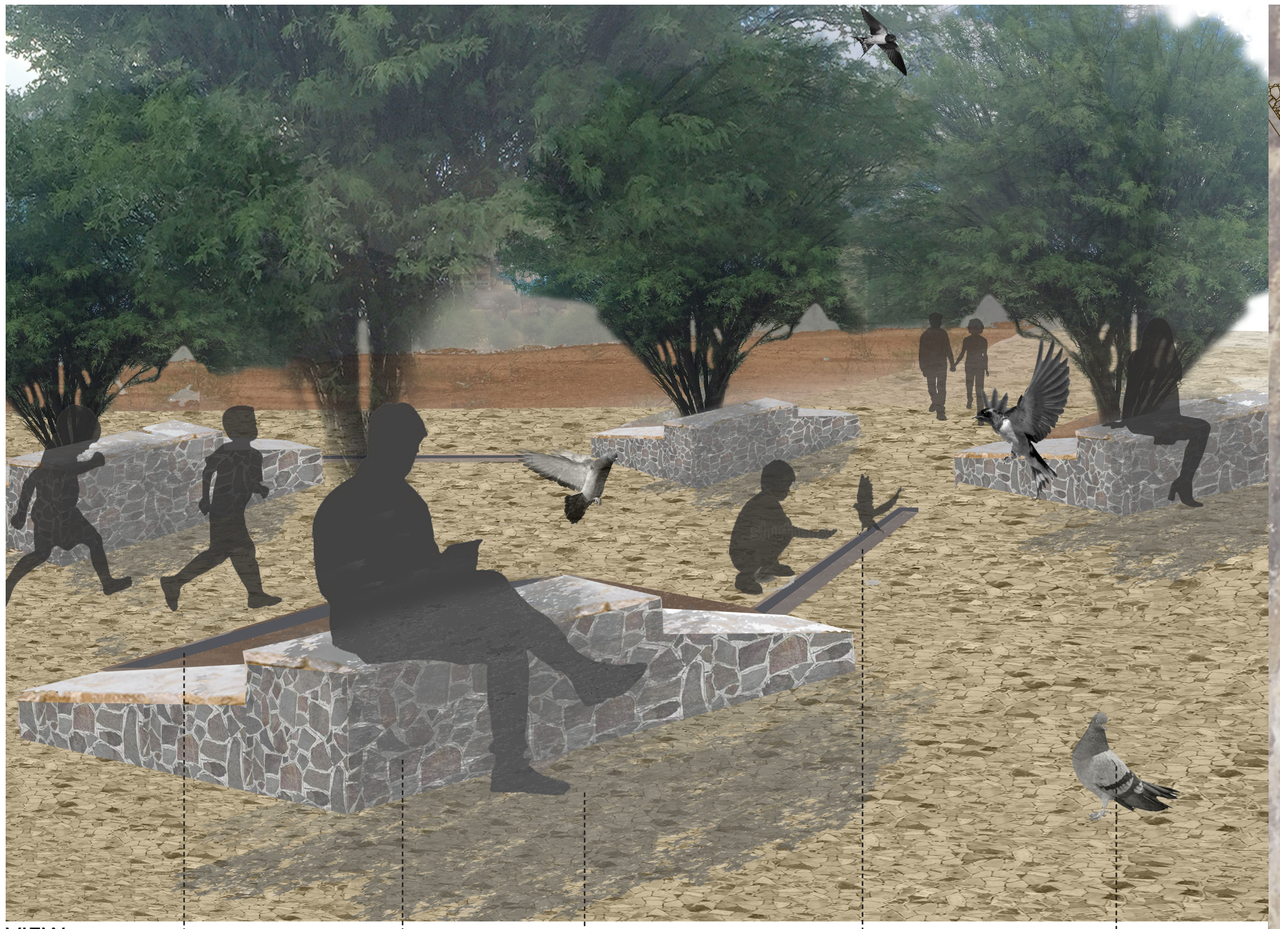
Green river-ine-vegetation - provide habitat

Riverfront park is a **focal point** along river corridor, provide **terraced spaces** to slow down flood water. **Trees provide shade** along footpath and terraces . **Natural riverine vegetation** encouraged for **habitat** to thrive.

PHOTO OF BEFORE INTERVENTION

RIVERFRONT SCHIST PARK

PLAN
1:2000



VIEW

Sloped drain ground to capture runoff

Flagstone low seat walls - trees provide shade 25deg

Flagstone paving - heavy movement through space

Drain to capture runoff - cooling mechanism

Birds and plant habitat

PHOTO OF BEFORE INTERVENTION

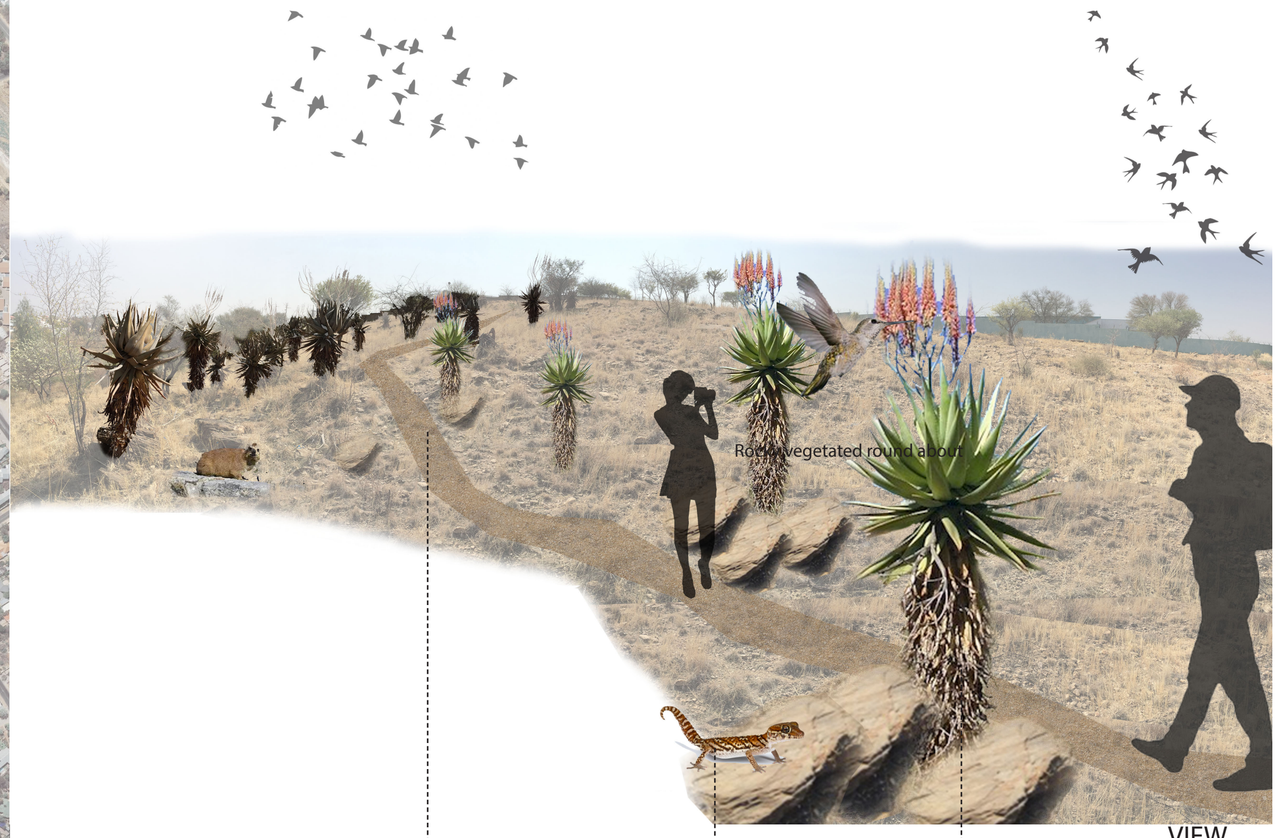
VIEW

Urban square spaces require **hard surfaces** for movement through space. **Flagstone - impervious** to allow runoff to drain. Space provide for **leisure and habitat**

PLAN
1:500

URBAN SLATE SQUARE

PLAN
1:5000



VIEW

Lookout point: Viewports

Path - Aloe trail

Habitat - Plants and Animals - bathing in hot sun

Habitat - Aloe littoralis

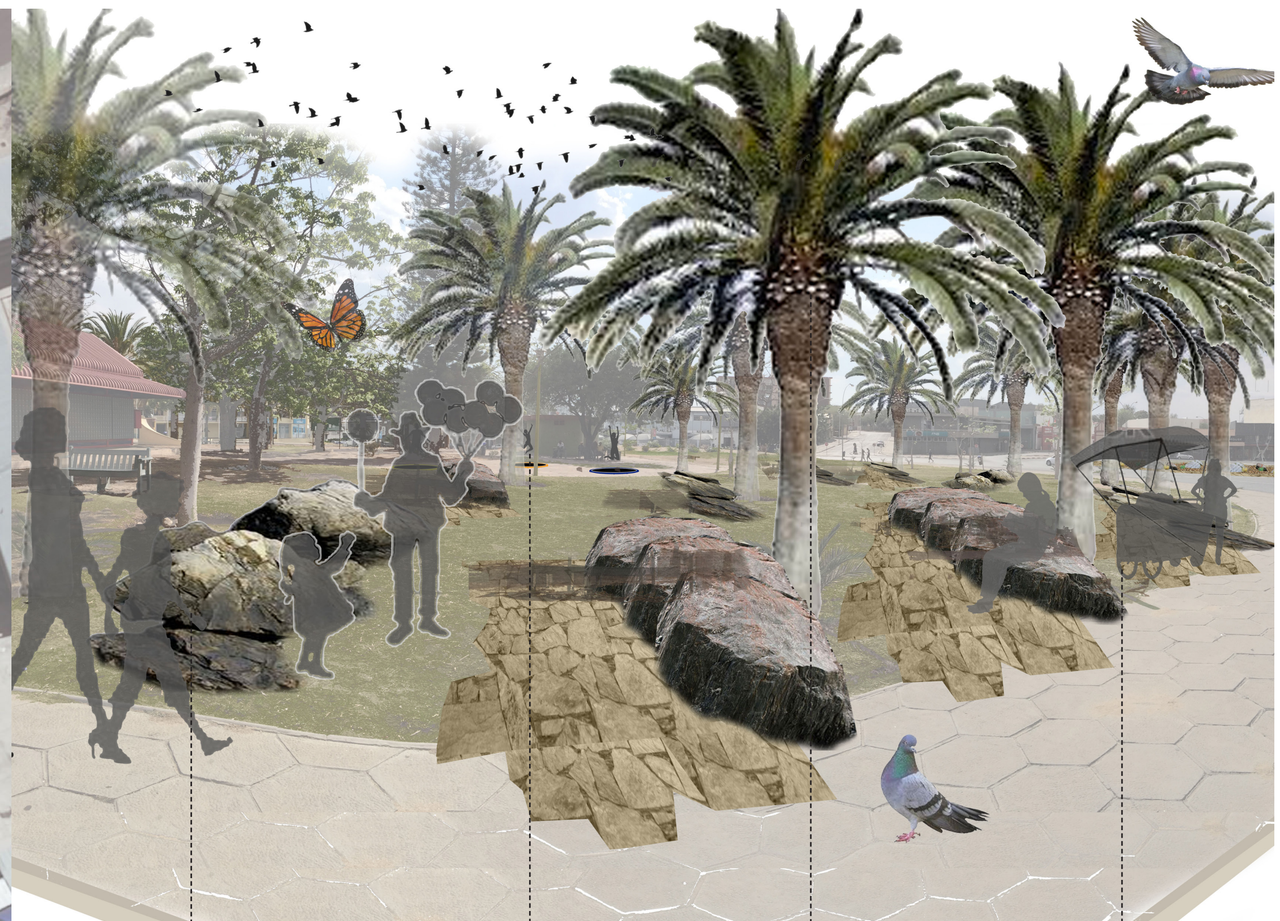
VIEW

PHOTO OF BEFORE INTERVENTION

Metro natural spaces provide and promote **habitat** for animals and plants especially **Aloe littoralis. Connects other types** (spaces) Provide **landscape features** and **facilities**, **Cultural identity**

METRO ALOE TRAIL

PLAN
1:750



VIEW

Schist Rocks - seating and habitat growth

Play spaces

Palms - create "Oasis" illusion

Flagstone pavers - provide spaces for stalls to set up

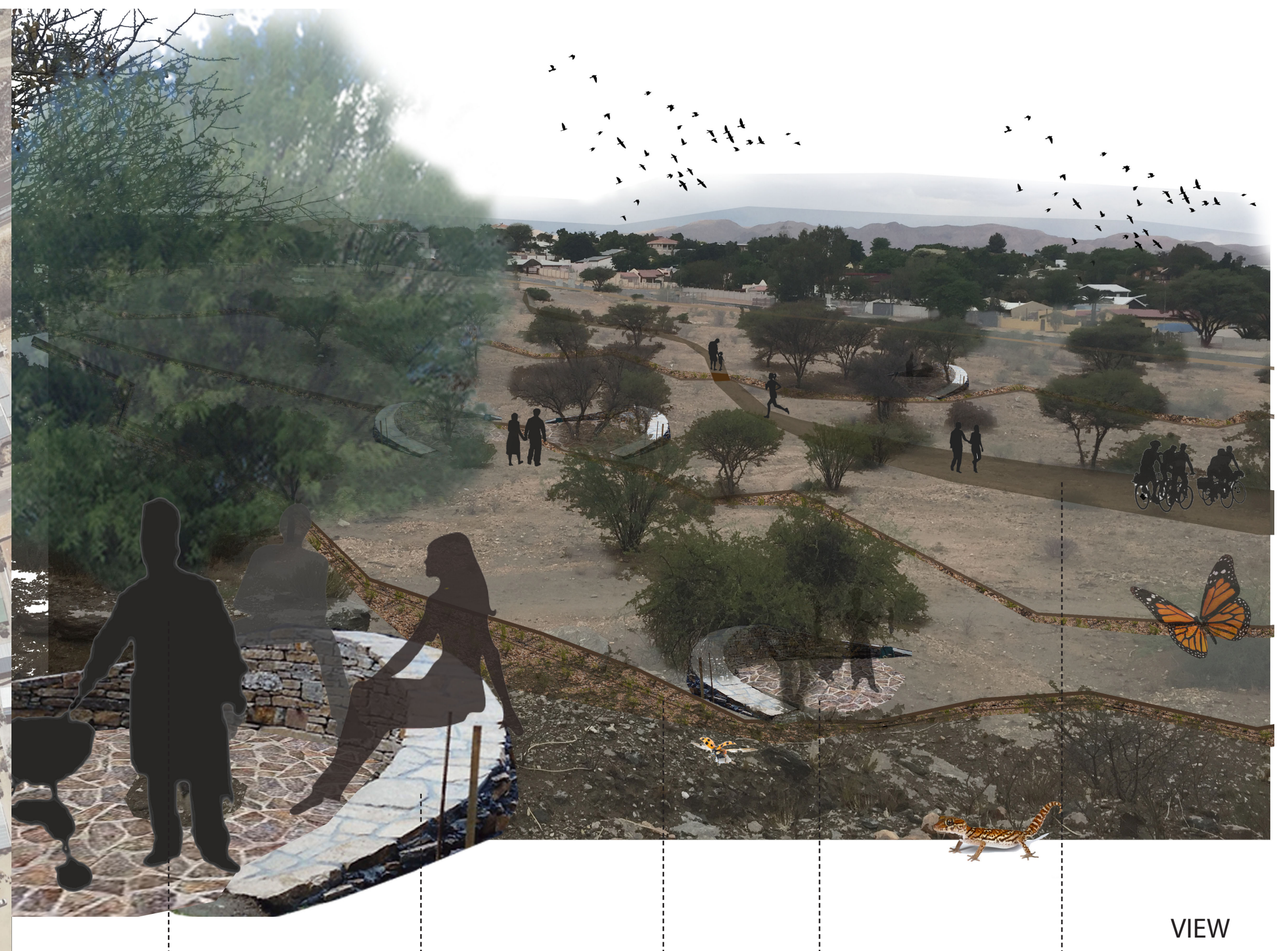
VIEW

PHOTO OF BEFORE INTERVENTION

Urban Parks provide **landscape features** - **rocks of the region,** promote **SUDs systems**, **Habitat**, **Play spaces, Facilities, Shade**

URBAN PARK (CBD)

PLAN
1:1000



VIEW

Impervious flagstone paving spaces

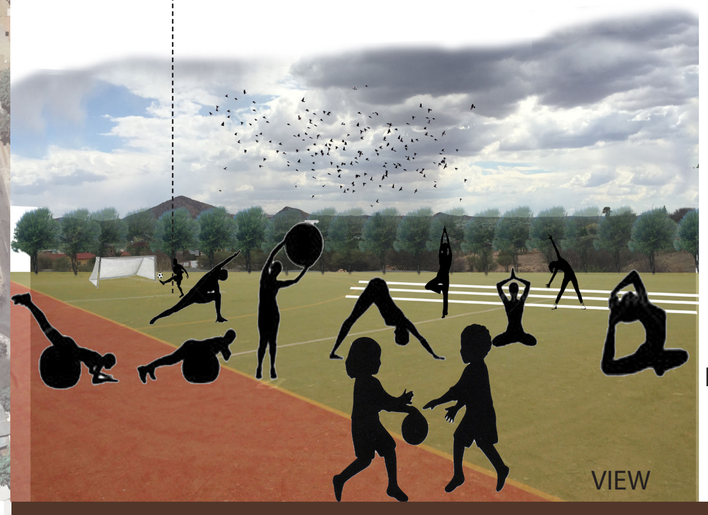
Flagstone Low wall seating (mortar)

SUDs- Bioswale

Shade and Habitat

Gravel/ Compacted earth foot and bike paths

Multiple sport facilities

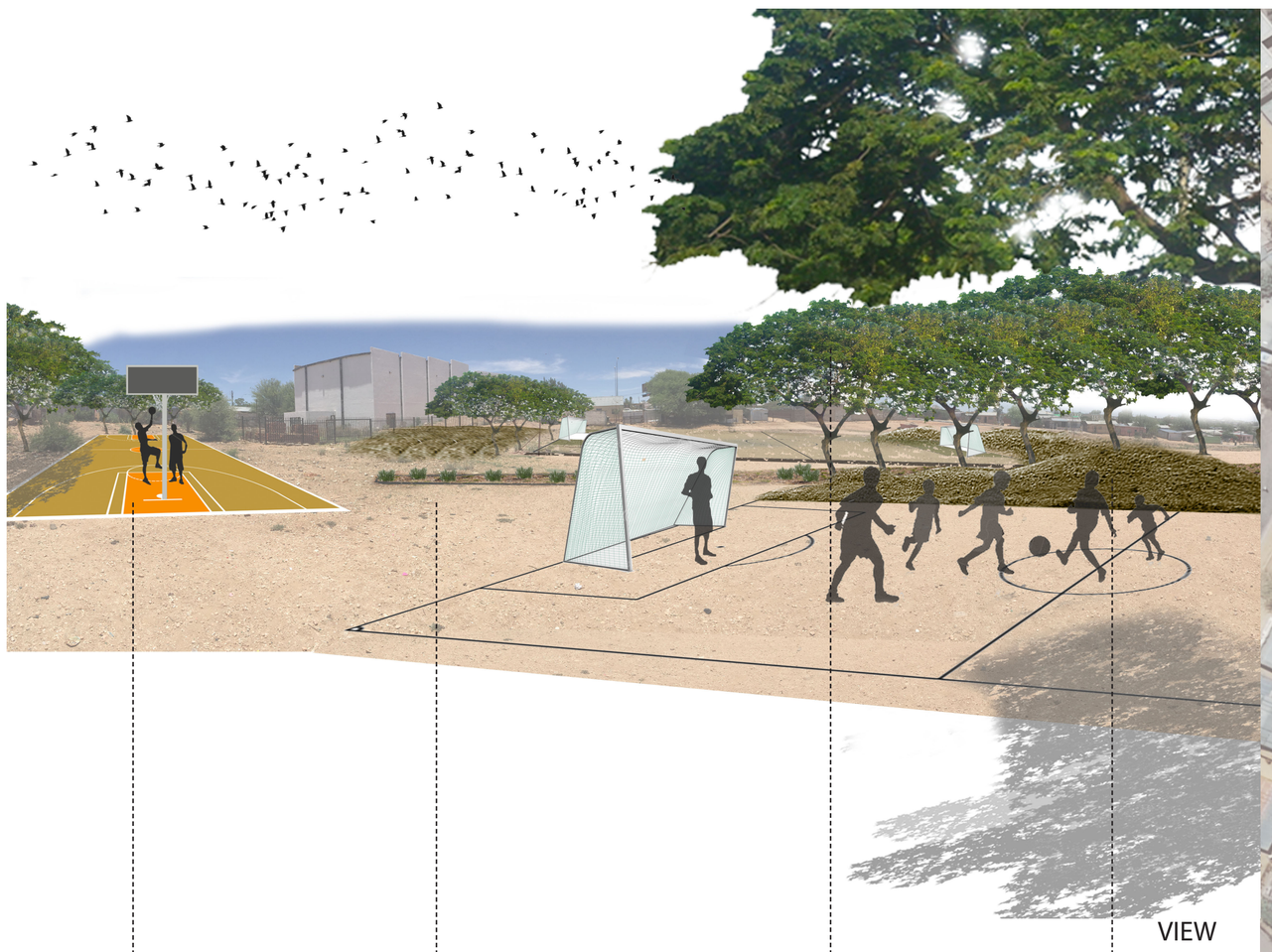


VIEW

PHOTO OF BEFORE INTERVENTION

Suburb Parks **provide outdoor facilities - informal/ multi purpose sport fields, Entertainment braai** natural spots, **play spaces, SUD systems**

SUBURB PARK



VIEW

Informal - formal demarcated sport fields

SUDs

Trees provide shade

Compacted earth mounds - Play and provide for habitat

VIEW

PHOTO OF BEFORE INTERVENTION

Informal **sports** are popular spaces it provide **active outdoor spaces.** Formalizing the space would also provide **Suds and Micro climate spaces (trees-shade)**

PLAN
1:1000

INFORMAL SPORT FACILITIES

VIEW

Stone retaining walls - Climbing spaces - Flood management

Gravel footpath

Play space - hard and soft surfaces - impervious

Play space - mounds

SUDS - habitat

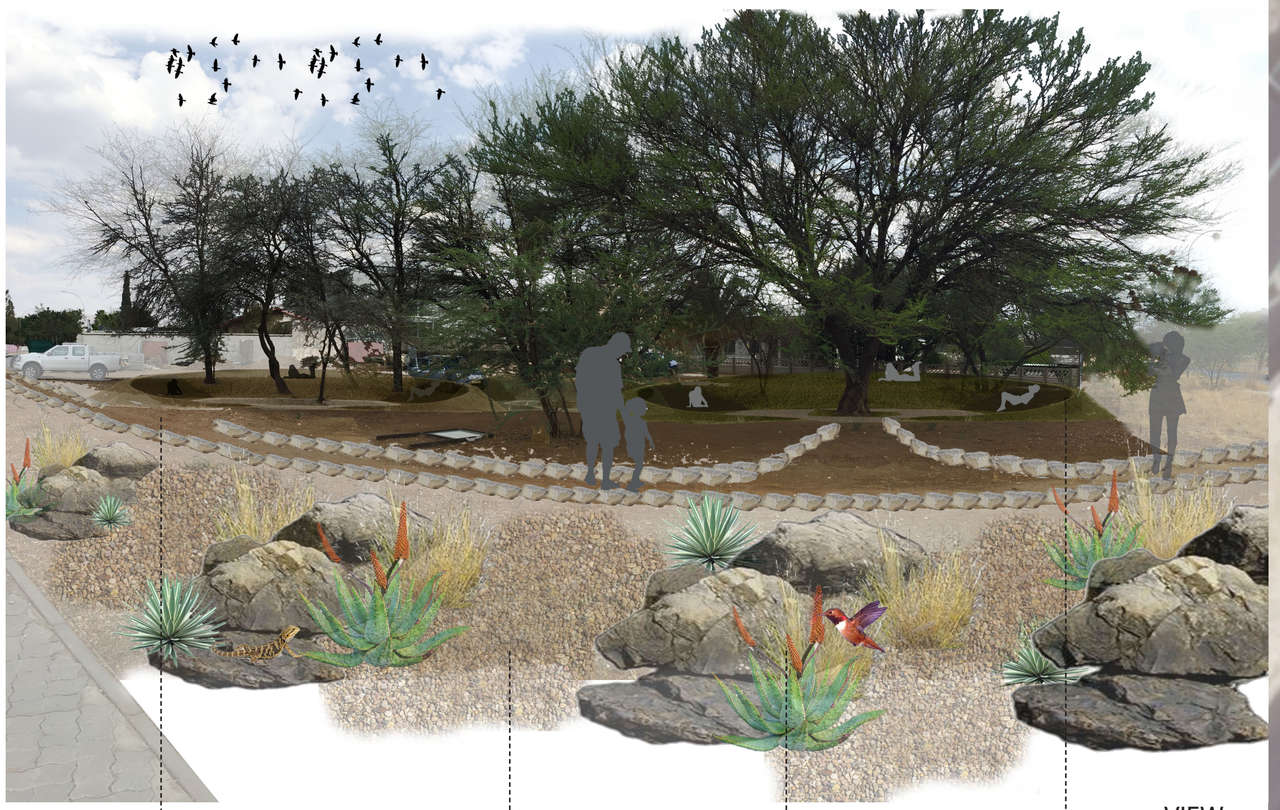
VIEW

PHOTO OF BEFORE INTERVENTION

Neighborhoods provide spaces for **Play space** for children, Leisure spaces and promote **bird and butterfly habitat**

NEIGHBORHOOD PARK

PLAN
1:500



VIEW

Compacted path and stone edge

Gravel patches - succulent vegetation

Rockery (Schist) Vegetation growth animal diversity - 30deg

Mounds frame tree Vachellia erioloba - provide shade - 25deg

Road verges, islands, corner spaces provide spaces for **informal garden** spaces to promote **indigenous vegetation** and **beautify** Neighborhoods

PHOTO OF BEFORE INTERVENTION

PLAN
1:200

GARDEN