Research Paper

Wadi Urbanism

From Threat to Resource

Yosra MALEK, Architecture and Urban Design Program, German University in Cairo, Egypt
Cornelia REDEKER, Architecture and Urban Design Program, German University in Cairo, Egypt

Abstract

This paper intends to throw light on the multiple landscape qualities of wadis as an untapped resource within the Egyptian arid urban context. Wadis are often perceived as obstacles when it comes to urban planning as they are prone to Wadi Flash Floods (WFFs) hazards. This results in prohibiting any building activities to take place within the wadi, making it a ''reduced economical value''. In this light 'Wadi Urbanism' (WU) proposes urban design guidelines and a methodological framework to attain a resilient planning and integrated design approach to the conventional sectoral and defensive flood-control solutions. The learnings from theory and practice are contextualized in a case study: Wadi Kharouba in Marsa-Matrouh located in the hinterlands of Egypt's Northwestern Mediterranean coast serves as an exemplary wadi cultivation project that is currently threatened by informal urban development. The research integrates international 'Water Sensitive Urban Design' (WSUD) guidelines along with other spatial planning tools at a regional and architectural scale. These studies inform the proposed 'Wadi Urbanism Guidelines' (WUGs) – a regenerative design strategy used to take advantage of naturally dynamic wadi landscapes to be integrated into an urban context.

Keywords

Wadi Urbanism, Water Sensitive Urban Design, water scarcity, productive landscapes, desert urbanization, rainwater harvesting, New Urban Communities, landscape urbanism

1. Introduction

Wadi Urbanism: an explorative urban design approach that integrates (cultivated) wadis as (green) open spaces by building on their diverse eco-systemic capacities such as water harvesting, local food production, floodwater management, habitat creation, and dynamic landscape qualities to create a public open space and aesthetic landscape. Wadi Urbanism as a research topic explores water resilient planning and design strategies to face climate challenges and sustainable urban development growth as an alternative urban design model for desert cities. Flash floods in wadis are considered both a threat and an essential source of water, particularly for groundwater recharge, but also to enable wadi bed cultivation. Both threat and intrinsic potentials need to be considered to transform these dynamic desert landscapes into a unique urban quality responsive to increasing water scarcity. This research proposes a set of guidelines consisting of a four-part methodology: 1) Site Analysis, 2) Water Management Plan, 3) Landscape & Environmental Aspects, and 4) Urban Planning & Design. These formulate the ***'Wadi Urbanism Guidelines' (WUGs)*** –a regenerative design strategy used to take advantage of naturally dynamic wadi landscapes and their intrinsic comprehensive ecological services. Beyond a case study based in Egypt, where we find wadis both along the coasts of the Red Sea and the Mediterranean as well as along the Nile River (Figure 1), the research further reflects on international wadi development. In response to highly dynamic population growth, the Egyptian government is currently developing a massive urban development program for 20 new cities planning to accommodate 30 million people by reclaiming about two million acres of the desert (Egypt Independent, 2018). Limited water resources have led to exploring alternatives such as the harvesting of flash floods in wadis. This research uses the case of Wadi Kharouba in Marsa-Matrouh Governorate, one of the urbanizing Mediterranean coastal regions, to serve as a national case study to explore previously proposed WUGs. This case has also been chosen for the *'Wadi Kharouba Rehabilitation Project'* which aimed to optimize wadi-bed cultivation by implementing several water harvesting techniques that also provide interesting landscaping features. This research argues for the potential of linking current urban development activities with the given topographical qualities of Egypt's diverse wadi landscapes through mapping and provides context to exemplarily show the environmental and socio-economical capacity within the given case study in Marsa-Matrouh. It intends to bridge the gap between the lower level wadi as a potentially productive and thus green landscape and its upper plain as an urban silhouette to define an integrative urban design approach supported by a methodological framework taking both constraints and potentials into account. Through research by design, the case study is further explored on an urban planning and design level. The research concludes with a reflection on the WU approach where wadis appear as site-specific, multi-functional open spaces that serve as productive landscapes, public urban parks, and last but not least as a major water resource as well as evolving questions as to how this integrated approach could be implemented in current practice.

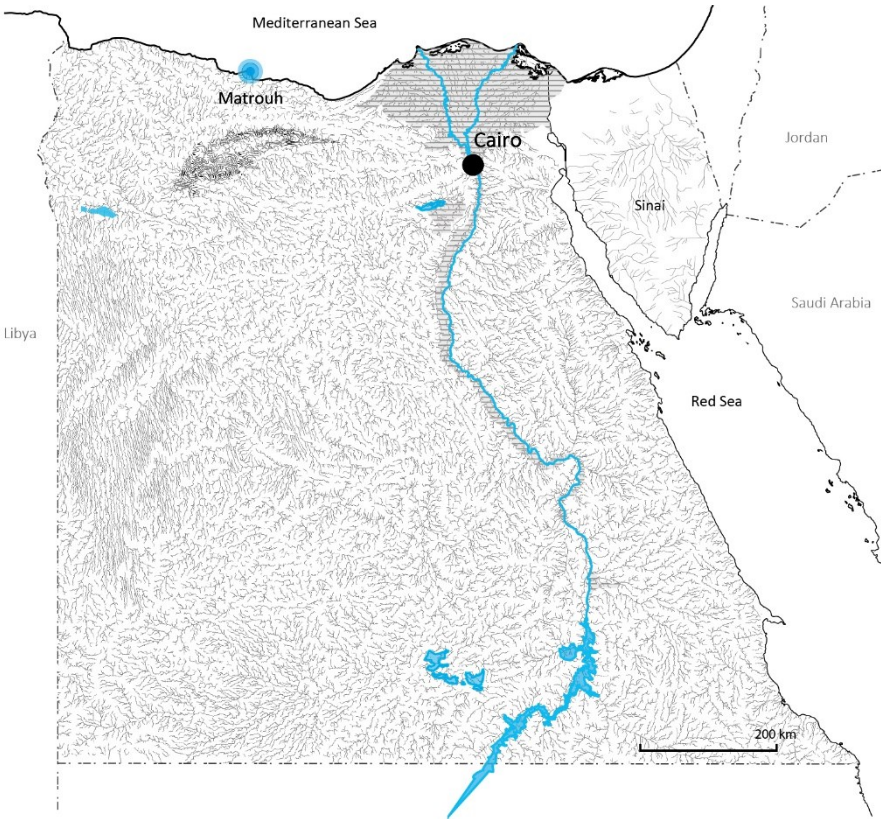

Figure 1. Map of Egypt Wadis & Marsa-Matrouh Location. Source: Yosra Malek generated by GIS (2019)

1.1 Understanding Wadis

WADI is an Arabic term for a valley or waterstream bed (a waterway). It is an impermanent waterstream that lasts for a short time, usually during and after a rainstorm, and varies from one season to another (Şen, 2008). A Wadi could also be defined as a deep winding channel engraved in the desert landscape formed by the action of water-flow and often leads to a continuous open water source such as e.g. rivers, seas, lakes, etc. (Figure 2) (Rima Mekdaschi, 2013). Wadis are situated in arid regions characterized by a severe lack of available water due to climatic conditions (Şen, 2008). According to this study, wadis are classified into four types depending on if water remains in wadis during the dry season and their scale: a wadi can be as small as a few square meters or as large as several square kilometers. The amount of water in the channel and the duration varies from one region and event to another. A wadi can vary in scale from a broad regional scale such as a river, e.g. the Nile River Valley or *Wadi El-Nile*, down to the scale of a creek. This research focuses on the local scale/seasonal flow wadis ranging from 1-10 km in length where the stream only carries water in the course of heavy rainfall.

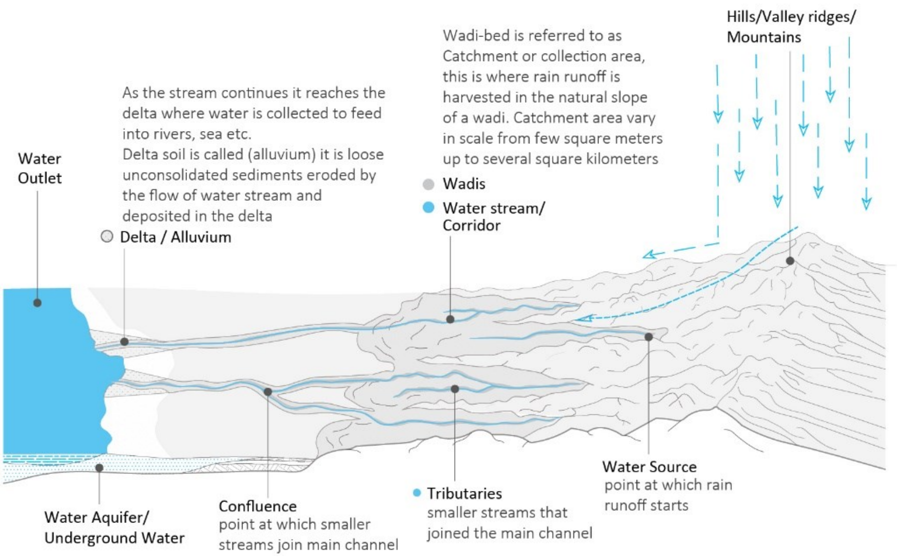

Figure 2. Hydrological Features of a Wadi. Source: Yosra Malek (2020)

1.1.1 Wadi Physical Features

To have a solid understanding, wadis need to be studied in the context of the respective watershed that they are a part of. A watershed is a topographically defined area where a group of streams that channel water into a main connecting stream, that drains off water-rainfall into a common outlet such as e.g. sea, rivers, etc. Watersheds can vary in size from a small drainage area to thousands of square kilometers (USGS, 2019). A top view and transversal section show the different wadi levels (Figure 3):

- First level: the wadi-bed where continuous or seasonal water-flow takes place
- Second level: wadi terraces/ embankments where seasonal run-off takes place
- Third level: wadi upper plain (flood-free zone)

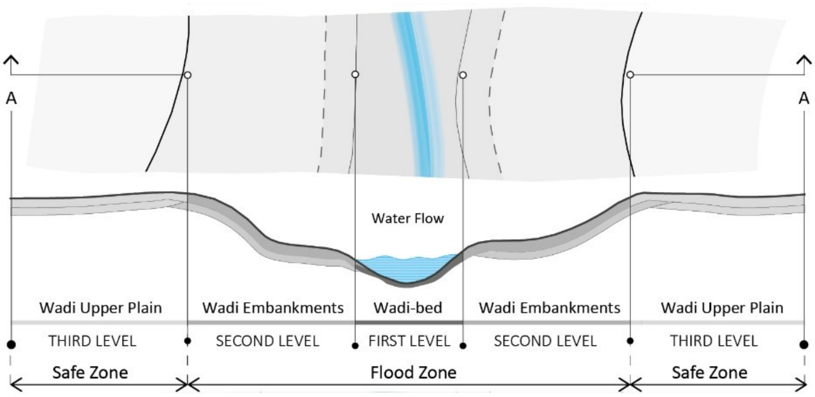

Figure 3. Schematic top view & transversal wadi section. Source: Yosra Malek (2020)

1.1.2 Wadi Potentials

This research aims to emphasize the vital role of wadis as a water harvesting resource and its potentials of advancing the quality of urban space through their capacity to be cultivated. The vital role of wadis and their intrinsic potentials are listed as follow:

Hydrological corridors: Wadis are hydrological corridors where seasonal and continuous surface runoff takes place. As natural drainage corridors, these can be integrated into urban drainage systems.
Water source: Dry wadis are considered as an essential resource to capture rainwater in arid and semi-arid regions by feeding groundwater tables and aquifers on site.
Ventilation corridors: Wadis are ventilation corridors and, if cultivated, green buffers with a potentially positive influence on macro- and microclimates.
Fertile bed: As dry, fertile beds, the cultivation of wadis as productive landscapes can simultaneously serve as recreational parks and aesthetically intriguing cultural landscapes.
Natural habitat: Wadis provide a natural habitat for numerous plants and animals thus playing a crucial role in biodiversity.
Wadi cliff walls: provide a natural landscape with vast views, a site-specific spatial quality that contributes to a collective identity, and may also provide prime real estate locations aligning the wadi borders.

1.1.3 Wadi Urbanism - Constraints

To attain the previously listed potentials, several constraints need to be considered and overcome. Physical changes in wadis are frequent due to climate change and irregular rainfall events which can result in a diversity of responses ranging from short-term events such as flash floods, landslides, and point-source contamination, to long-term events such as soil degradation, water exhaustion, and non-point-source pollution (M. Abdel-Fattah, 2017). Wadi Urbanism focusses on sustainable urban design solutions to overcome these limitations for better land and water management. In this context, the existing damage potential poses three main constraints (Figure 4).

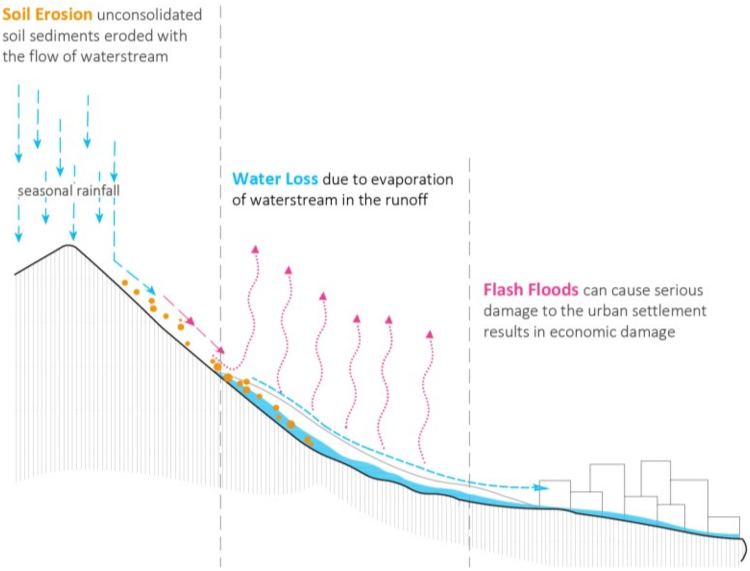

Figure 4. Wadi Urbanism Constraints. Source: Yosra Malek (2019)

2. Methodological Approach towards Formulating Wadi Urbanism Guidelines

2.1 Adapting Water Sensitive Urban Design to Wadi Urbanism Guidelines (WUGs)

Water Sensitive Urban Design (WSUD) provides a framework for planners and urban designers to integrate major and minor water-flow paths in the landscape in an urban context by setting certain guidelines for site analysis, water management plans, and landscape and urban design practices (Jacqueline Hoyer, 2011). WSUD incorporates water management in an urban context by integrating water source, landscape, and guiding urban design principles to preserve the natural water cycle (Dickhaut, 2011). WSUD sets a framework or guidelines for planners and urban designers to maximize the exploitation of the natural stormwater drainage network in an urban context responsive to working with the forces of nature

(Victorian Stormwater Committee, 1999). Wadis are considered a water sensitive topographical feature. Therefore, **Wadi Urbanism** (WU) is considered a form of WSUD. Accordingly, various **WSUD guidelines** (WSUDGs) were examined and adapted to **WUGs**.

2.2 Wadi Urbanism Proposed Guidelines

Through studying WSUDGs, four key steps in the following sequence were identified to specify WUGs: 1 Site Analysis → 2 Water Management Plan → 3 Landscape & Environmental Aspects → 4 Urban Design & Planning Practices (Figure 5).

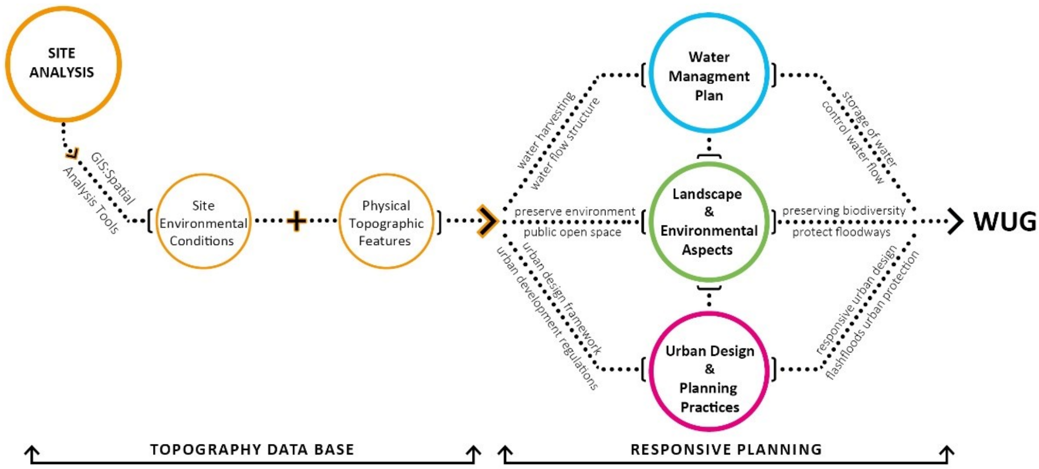

Figure 5. WUGs and topics that must be tackled during the design process. Source: Yosra Malek (2019)

2.2.1 Site Analysis

The site analysis is essential to the WU design approach. The site analysis includes two consequent parts: Environmental conditions and topographical features. It concludes with a database that many design decisions are built on focussing on characteristics such as (Figure 11): wadi scale, climatic conditions, water condition, soil type, slope, catchment, etc. (Guangyu Wang, 2016). Topographical features are generated via a Geographical Information System (GIS) programs to spatially represent captured data (Scott D. Bryant, 2012).

2.2.2 Water Management Plan

The water management plan includes the catchment as a whole with a focus on the first level of the wadi. It aims to maximize the use of rainfall-runoff while providing a safeguard environment for the public to enjoy. These objectives are met by defining a well-prepared plan to withstand all rainstorm ranges and to overcome flash-flood hazards that may cause slide slopes and water infiltration of the catchment (Jacqueline Hoyer, 2011). Water Harvesting Techniques (WHT) applied in dry areas play an essential role in accomplishing these aims (Theib Y. Oweis, 2012). WH takes advantage of a naturally occurring process – rainfall run-off collected through the existing topography e.g. the wadi-bed watercourse down a hill slope, mountains, etc. (L.S. Pereira, 1996). The water management plan is divided into two parts:

The Hydrological Buffer designates hydrological boundaries for a watercourse in a wadi-bed where flash floods occur. It is part of the legally defined floodplain which requires special planning and policies to protect water corridors from developments and provide public safeguard Figure 7 (BMT, WBM, Pty, Ltd, 2009). Further, the areas aligning the main channel to both sides, characterized by seasonally wet and damp lands, are not allowed to be built on due to the relatively high soil moisture content after the occurrence of rainfall that may result in landslides and building collapse (Victorian Stormwater Committee, 1999).

Water Harvesting (WH) Capturing rainwater that falls on one part of the land and transferring it to another while managing the water-flow ideally eliminates the risk of flash floods by redirecting the water-flow and slowing down the water velocity (Theib Y. Oweis, 2012). In that way, WH increases the amount of water available and stores surplus water for beneficial use such as the production of crops and livestock (L.S. Pereira, 1996). Consequently, the proposed WU water management plan synergizes WH and flow management to provide an alternative source of water for irrigation also of open spaces (Yosra A. Malek, 2020). Moreover, WH offers several environmental benefits, including reducing soil erosion, decreasing surface water and groundwater demand, and groundwater recharge (Rima Mekdaschi, 2013). To specify suitable WHTs for a particular site, selection criteria based on the wadi-catchment type are based on the environmental conditions and given the topography of a region. The most important selection parameters are the scale of the water-catchment and the amount of rainfall (Table 1) (Cox, 1979). Further criteria include rainfall intensity, application scale, run-off characteristics of the catchment, the water-storage capacity of the soil, water-storage (in cisterns), and water-harvested usage, as well as socio-economic conditions, etc. (Theib Y. Oweis, 2012). Water Harvesting may be classified as follows (Figure 6):

- Floodwater Harvesting (FloodWH),
- Macrocatchment Water Harvesting (MacroWH)
- Microcatchment Water Harvesting (MicroWH)

	Water Harvesting Groups	Floodwater harvesting (FloodWH)	Macrocatchment WH (MacroWH)	Microcatchment WH (MicroWH)
	Scale	regional city local	regional city local	regional city local
	Application Area	2km² ≤ 2km²- 50km² 1000m² -2km² 10m² - 1000m²	2km² ≤ 2km²- 50km² 1000m² -2km² 10m² - 1000m²	2km² ≤ 2km²- 50km² 1000m² -2km² 10m² - 1000m²
ENVIRONMENT	Annual Rainfall mm	500 - 750 250 - 500 100 - 250	500 - 750 250 - 500 100 - 250	500 - 750 250 - 500 100 - 250
ENVIRONMENT	Water Flow	continuous sesonal	continuous sesonal	continuous sesonal
ENVIRONMENT	Catchment Slope %	any slope 0 - 10 10 - 20 20 - 50	any slope 0 - 10 10 - 20 20 - 50	any slope 0 - 10 10 - 20 20 - 50
ENVIRONMENT	Catchment Legnth m	200 ≤ 200 - 2km 30 - 200 1- 30	200 ≤ 200 - 2km 30 - 200 1- 30	200 ≤ 200 - 2km 30 - 200 1- 30
ENVIRONMENT	Soil Texture	light moderate deep	light moderate deep	light moderate deep
	Water Storage	cisterns soil profile ponds reservoirs	cisterns soil profile ponds reservoirs	cisterns soil profile ponds reservoirs
	Water Use	domestic livestock irrigation GW recharge	domestic livestock irrigation GW recharge	domestic livestock irrigation GW recharge

	Water Harvesting Groups	Floodwater harvesting (FloodWH)	Macrocatchment WH (MacroWH)	Microcatchment WH (MicroWH)
STRUCTURE ESTABLISHMENT	Mechanis - ation	high medium low	high medium low	high medium low
STRUCTURE ESTABLISHMENT	Mainten- ance	high medium low	high medium low	high medium low
STRUCTURE ESTABLISHMENT	Labour	high medium low	high medium low	high medium low
COST US $	Establish- ment	0 -1400 0 - 450 0 -250	0 -1400 0 - 450 0 -250	0 -1400 0 - 450 0 -250
COST US $	Mechanis- ation	0 - 900 0 - 125 0 - 25	0 - 900 0 - 125 0 - 25	0 - 900 0 - 125 0 - 25
COST US $	Mainten- ance	0 - 150 0 - 100 0 - 50	0 - 150 0 - 100 0 - 50	0 - 150 0 - 100 0 - 50
COST US $	Labour	0 - 450 0 - 250 0 - 175	0 - 450 0 - 250 0 - 175	0 - 450 0 - 250 0 - 175
	Ownership	state community local individual	state community local individual	state community local individual
	Catchment Area Ratio CCR	10,000:1 ≤ 100:1- 10,000:1 10:1- 100:1 1:1- 25:1	10,000:1 ≤ 100:1- 10,000:1 10:1- 100:1 1:1- 25:1	10,000:1 ≤ 100:1- 10,000:1 10:1- 100:1 1:1- 25:1

Table 1. Water Harvesting Technique Selection Criteria. Source: Yosra Malek (2020)

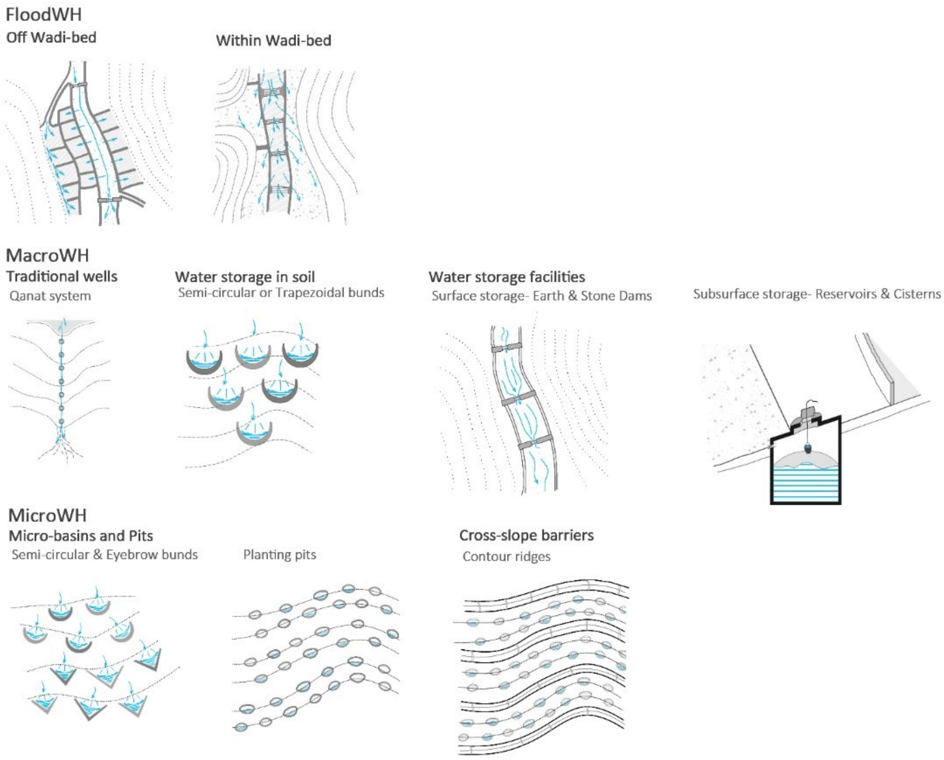

Figure 6. Water Harvesting Technologies classification. Source: Yosra Malek (2020)

2.2.3 Landscape and Environmental Aspects

Landscape and environmental aspects are one of the main design foci of WUGs to enable the incorporation of wadis within public open spaces (Jacqueline Hoyer, 2011). With a specific focus on the wadi-bed and embankments that together define the flood plain. Building activities in the flood plain are prohibited due to the relatively high soil moisture content, immediately after the occurrence of a rainstorm (Jacqueline Hoyer, 2011). These aspects provide open spaces for productive landscapes (reliant on soil fertility) and enhance urban environmental qualities through the establishment of wetlands improving wildlife habitat, for recreational purposes, public utilities, water distribution, and storage thus maximizing the beneficial use also increasing the land value (BMT, WBM, Pty, Ltd, 2009).

2.2.4 Urban Design and Planning Practices

Moving further from the flood zones to the third level (safe zone) where urban development can take place, urban design guidelines elaborate on how to incorporate wadis in an urban context and vice versa (Yosra A. Malek, 2020). By setting a framework for projects on the neighborhood or city scale to define areas where building activities are allowed to prevent building activities within a specific distance on both sides to avoid landslides and building collapse (Dickhaut, 2011). These distances may differ from one wadi to another based on the geographical and physical condition of a certain region (Lloyd, 2001). The urban plan includes the following information (Figure 7):

- Urban Practices and Land Use Plan
- Street Layout and Transportation Network
- Building Layout

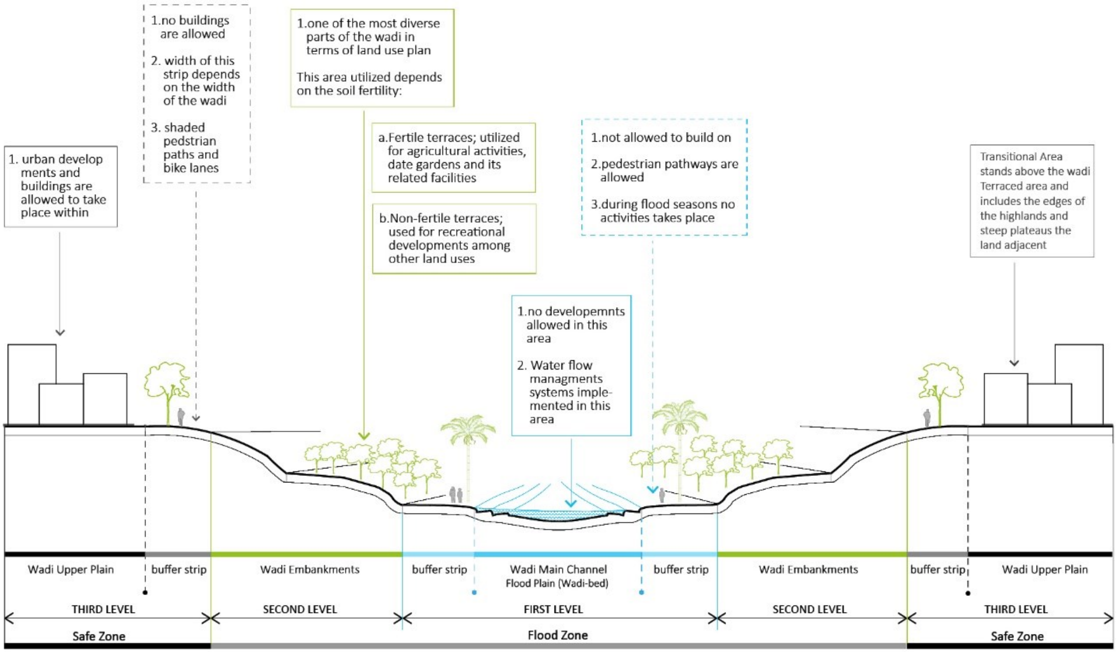

Figure 7. Wadi Transversal Section Showing WUGs Applied. Source: Yosra Malek (2020**)**

The Street Layout and Transportation Network coheres with the enhancement of views encouraging the public to interact with the landscape (Victorian Stormwater Committee, 1999). Also, it emphasizes the importance of implementing a pedestrian network alongside and through the wadi to facilitate access to the open public spaces through the incorporation of pathways between wadi activity nodes and by integrating recreational amenities. Also for safety reasons, the circulation layout is defined by the site topography (BMT, WBM, Pty, Ltd, 2009). Flood zones are served by rural roads that are different in the structure and design of regular roads. Culvert structures may be integrated subsurface to channel the waterstream under the road network. The WU street layout covers both longitudinal and transversal connections with the wadi to prioritize the pedestrian network and bike lanes whenever possible to ensure the urban quality of the wadi spine (Figure 8).

Building Layout Buildings are located on the higher embankment of the catchment possibly to both sides to create a vis-à-vis. According to the arid climate, residential layouts often comprise a more dense form of development. Along with the wadi embankment buildings should also comply with WSUD parameters to avoid barriers (Dickhaut, 2011).

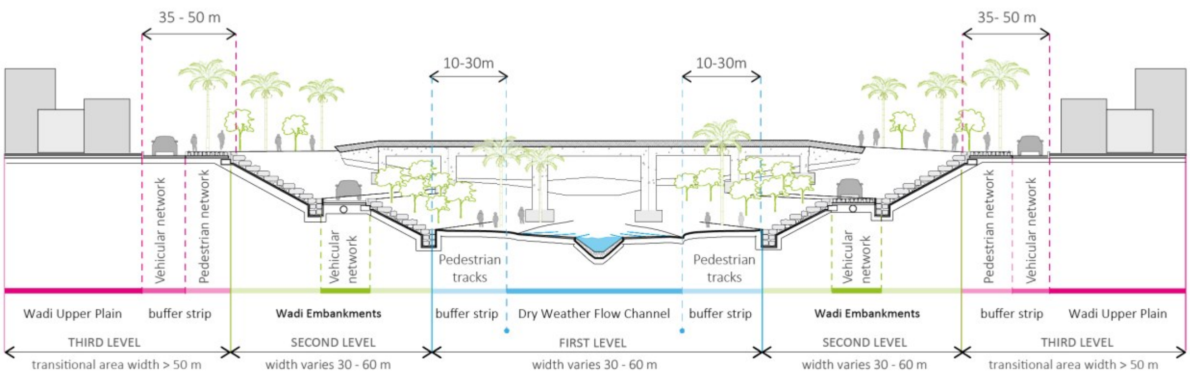

Figure 8. Schematic Transversal Section Summarizing WUGs. Source: Yosra Malek (2020)

3. Wadi Urbanism Guidelines Proposed Case Study Model: Wadi Kharouba

To test the proposed guidelines, Wadi Kharouba (Figure 9) as an Egyptian case study has been chosen as a WU model to be developed through research by design approach. In collaboration with the local Bedouin community, the wadis of Marsa-Matrouh as part of Egypt's North-Western Coastal Zone (NWCZ) (Figure 1) have been part of a development project of the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM) in cooperation with the National Desert Research Centre (DRC) to enhance water harvesting techniques and improving harvesting and distribution systems to create more sustainable models of the already existing wadi cultivation practice using rain-fed systems. The fig and olive production is one of the most important sources of income in the area (Shaaban, 2010), as Egypt is the second-largest contributor with 18.3% of global figs production right after Turkey (Francesco Nesci, 2000). However, until now these agricultural projects are not linked to any kind of urban development plan which consequently happens informally. Until today, Wadi Kharouba stands as an example of a productive landscape without sufficient urban development (Abd El-Rahman, 1986).

Figure 9. Wadi Kharouba Figs cultivation. Source: Menna Mohsen (2016), Adapted by Yosra Malek (2020)

3.1 Marsa-Matrouh Demographics and Wadi Kharouba Status Quo

The current confinement of tourism to a one-kilometer coastal strip has a negative impact on the population density of Marsa-Matrouh reaching up to 5,000 inhabitants/km^2 on the coast (Rady, 2011). 11% of Marsa-Matrouh population lives in areas further away from the coast with scarce development around the green fingers of the wadi (Figure 10) (Rady, 2011). These hinterlands include dispersed Bedouin settlements, most of whom plant figs. Moreover, agriculture, including figs, olives, and barley fields, accounted for 70% of the total employment of the coastal zone, earning its position as the dominating economical sector (Bonnet, et al., 2014). The main threat facing this economic sector is the scarcity of water supply (Ayyad, 1992). Due to the economical capacity of cultivation, the governorate has oriented its focus towards supporting agricultural development projects such as the 'Matrouh Rural Sustainable Development Project' (MARSADEV) from 2014-2017 (DRC, 2015). The rehabilitation of 3km of Wadi Kharouba enabled more than 60 families to have new plots of reclaimed land as an additional source of income thus reducing poverty in Bedouin society (DRC, 2015). Many actions of this project have deeply changed the social and natural environment of the region, mainly through RWH for rain-fed agricultural production. However, many of these wadis are still undeveloped with only 2-5% of rainfall being utilized (Salem, 2016).

3.2 Wadi Kharouba Site Analysis

Egypt's NWC is characterized by an arid Mediterranean climate with hot summers and mild winters. This area receives appreciable amounts of rainwater during rain periods varying from 102-140 mm/m^2/year. Heavy rainfall only occurs in winter with approximately 250 mm/m^2 (Figure 11). Wadi Kharouba is 5.5 km long with a total area of around 165.5km^2. The center of the catchment area lies at latitudes 31°20'14.7" N and longitudes 27°10'20.2" E (Mohamed E. A. Khalifa, 2015). The wadi-bed is characterized by thick alluvial deposits and constitutes a subsidiary aquifer of resourceful potential as fertile land for cultivation. It is distinguished by low relief and a mild topography (DRC, 2015).

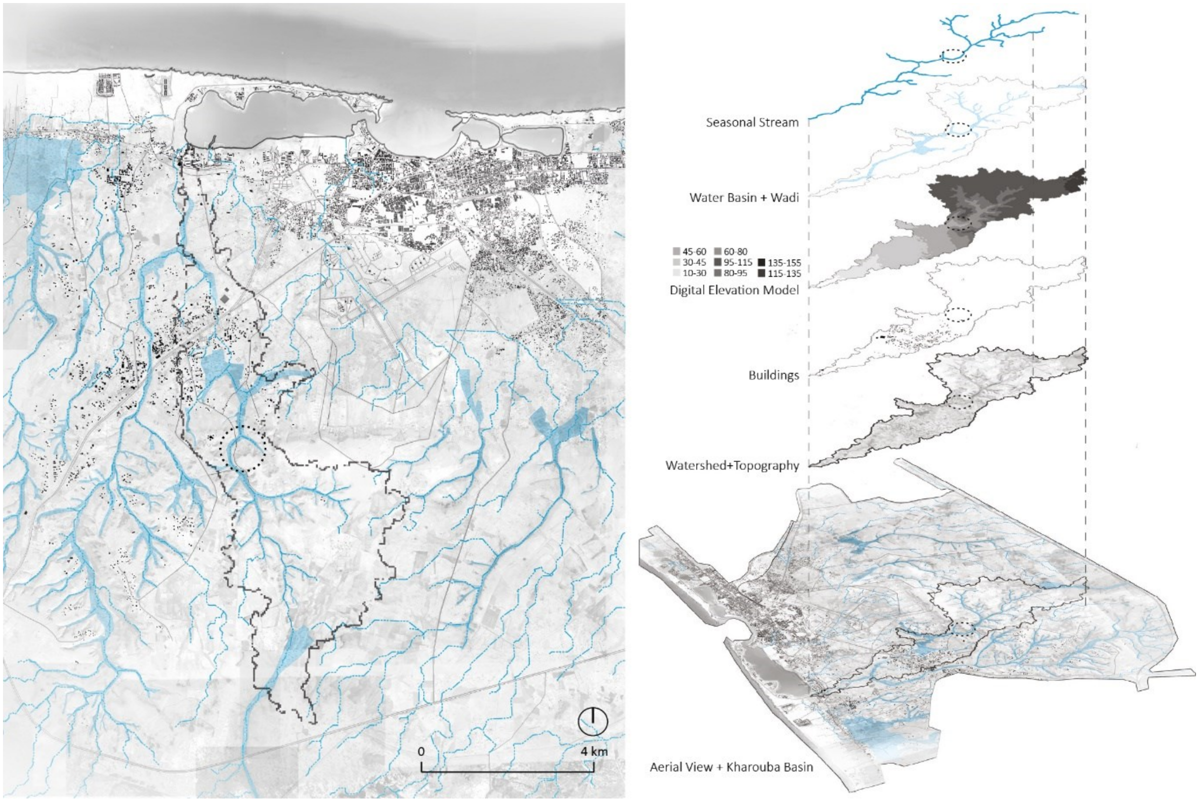

Figure 10. Wadi Kharouba Site Analysis and Site Boundary. Source: Yosra Malek (2020)

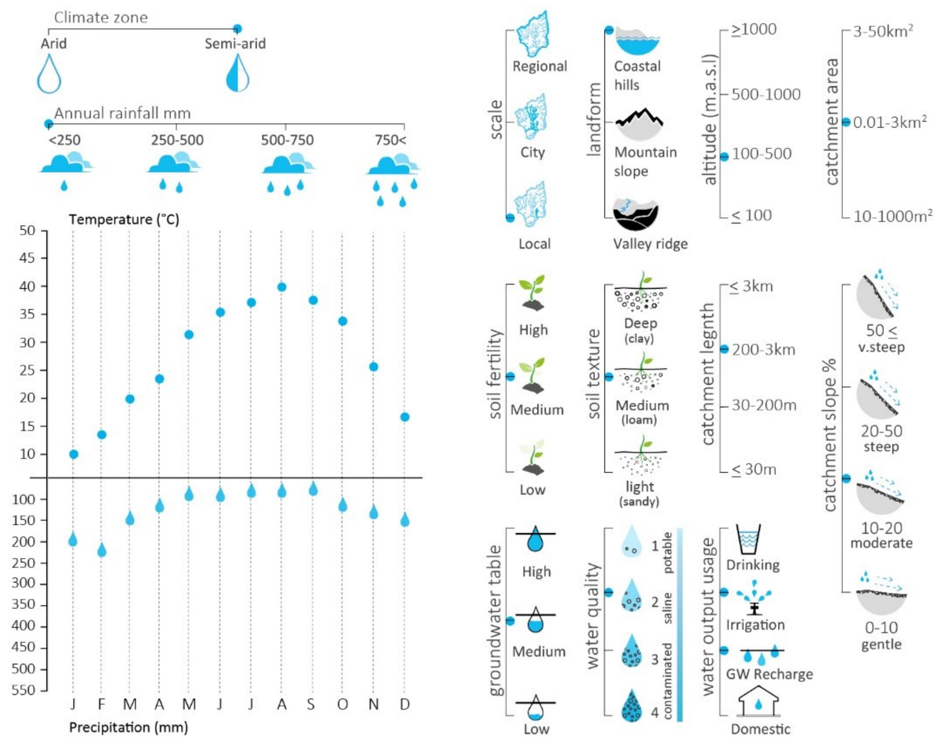

Figure 11. Wadi Kharouba Environmental Condition Matrix. Source: Yosra Malek (2020)

3.3 MARSADEV Project: Wadi Kharouba Water Management Plan

The MARSADEV project focussed on wadi cultivation, rainwater harvesting, and supplementary irrigation (Figure 12), disregarding the integration of any urban development in the context of this emergent agricultural community. Moreover, MARSADEV aimed to overcome constraints such as flash floods, soil erosion, and water loss as a frequently occurring event along the NWC. Steps of 3 km Wadi Kharouba reclamation Project (Figure 13).

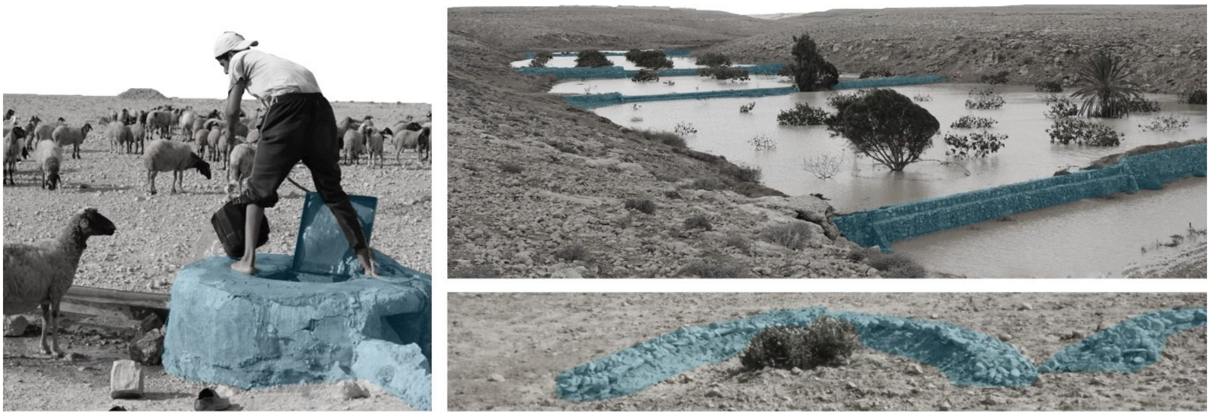

Figure 12. Existing RWH in Wadi Kharouba, Source: Naiim Moselhy (2016), adapted by Yosra Malek (2020)

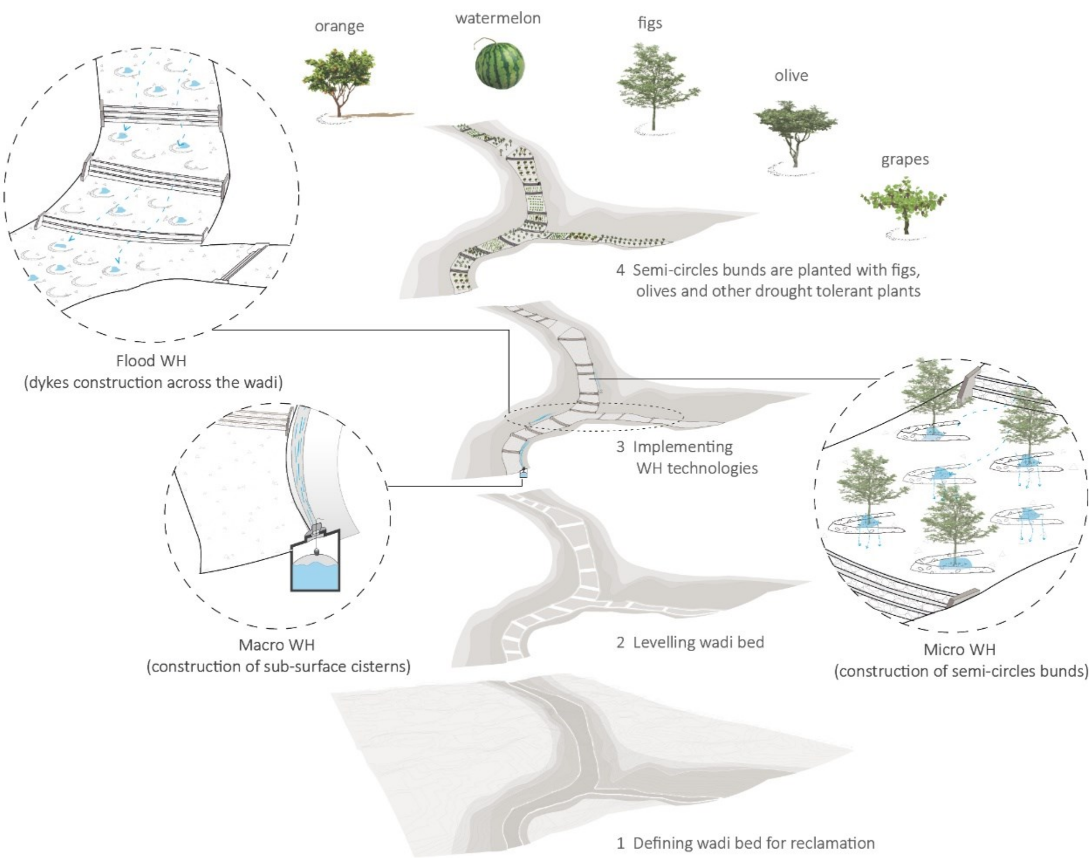

Figure 13. MARSADEV Water Management Plan in Wadi Kharouba, Graphics: Yosra Malek (2020)

3.4 Proposed Study Model for Wadi Kharouba

Until today, Wadi Kharouba stands as an example of a productive landscape without sufficient urban development around it (Abd El-Rahman, 1986), the proposed study model intends to bridge the gap between Wadi lower level as a productive landscape and its upper plain introducing an integrative urban design approach. The scale of the urban development and population numbers were defined based on water availability and varying densities to create an inclusive model taking different lifestyles of the Bedouin community and a new urban population as well as a potential ecotourism development into consideration. While the water harvested in the wadis was considered as a water source for crop irrigation only, the hypothetically available drinking water was reliant and quantified through the previously untapped resource of water harvesting from the roof and street escapes of Marsa-Matrouh City. Empirical research showed that the Bedouin community demanded a high degree of privacy and thus a much lower density. As a rough indicator, one Bedouin family on average cultivates 4-5 Feddans (4,200m^2) of wadi-bed (DRC, 2015). These givens were visualized through the extended Dutch layer model while the design proposals were illustrated through deep sections. The study model proposed the following (Figure 14):

- A transitional area on both sides of the wadi (upper plain) keeping development at least 20-25 meters from wadi edges depending on the width of the wadi
- Street layout according to the wadis naturally winding course
- Culvert structure channeling the waterstream subsurface to a transversal street network
- Longitudinal & latitudinal shaded pedestrian corridors & bike lanes in the transitional area
- Transversal connections through stepping stones as pathways built on the wadis sloped walls
- Buildings designed based on the different lifestyle communities with very low residential densities for the Bedouin community and a low-rise high-density urban fabric with an average of max. three floors

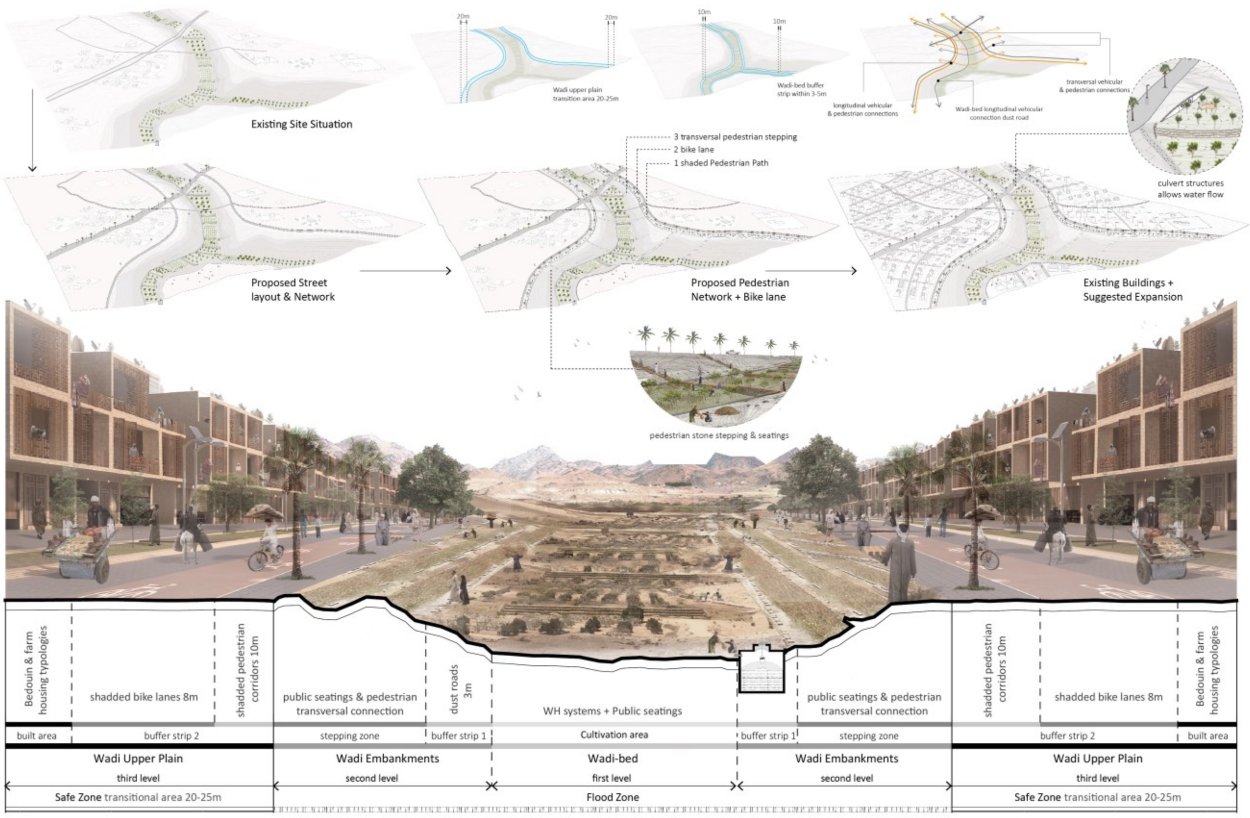

Figure 14. WU Design Proposal Visualised on Wadi Kharouba Deep Section. Source: Yosra Malek (2020)

4. Conclusion and Outcomes

Wadi Urbanism as a sustainable desert city model builds on the existing topography to create synergies between the dynamic wadi landscape, its productive capacity, and its open space qualities while creating a collective identity for cities through these cultural landscapes. Currently, we can say turning our open spaces which are until now only primarily static with a limited visual kind of pleasure and far away from local givens in terms of water demand, economical recurrent, cultural traditions, and local food production, etc. The Wadi as a topographical palimpsest already adds to the quality and distinctiveness of a city in terms of views, ventilation, wideness, the central access that can be cultivated, and with the agriculture it becomes even more of a special quality which adds more to the city. 'Wadi Urbanism' as an urban design approach provides the following research outcomes which serve the urban canvas for these main key points:

- **Site-specific vs. Generic:** By providing a canvas for urban development that is not generic but site-specific, wadis give a special identity and contextualized urban advancement for new desert cities. Especially, with the combination of agricultural production that can establish a new sustainable urban model.
- **Resilient vs. Restrictive:** There is a defensive approach to flooding which is restricting these zones as a – no go areas while building dams. Although an alternative approach such as developing flood-adaptive WHTScould be implemented which slows down the flow of the vastly running river on very few days a year. This opportunity creates a cultural landscape that is working with nature not against it. Cascading systems do not hinder the water but provide an interactive landscape that encourages inhabitants to enter the wadi landscape through the field's corridors and experience the agriculture landscape and make it accessible for people to learn from such resourceful landscapes and interact with them.
- **Cultural vs. Destructive:** With the agriculture it becomes even more of a special quality allying with the cascading land-scaped cultivated terraces alleviates the elevation difference between the wadi upper plain and the wadi-bed, safely reconnecting people to the water's edge. Also, the proposed WUGs does not allow any developments or permanent structures in the lower lands of a wadi to protect the city from any potential damage from seasonal occurring flash floods.
- **Identity vs. Replica:** Wadis can create an identity for cities through their respective landscape features resulting in different variations of urban forms and patterns for every wadi city. As a central vast public open space meandering through the city, wadis may create visual interest and refuge with opportunities for recreation and education.

4.1 Future Research Questions: Wadi Urbanism as a Valid Approach?

As a preliminary summary the following points demand further research and policy development:

- **Building regulations:** Although built in the wadi is categorically prohibited, a legal definition of according flood plains that define the area to be exempted from building remains vague. This leaves until now an unclear flood defense line which is for example along the Nile a setback of 35 meters from average water levels.
- **Also, the execution of building regulations**: is often weak, especially in the hinterland. While developments were previously scarce and vastly scattered Bedouin houses, they are currently evolving to laid-out grids to market plots accordingly leading to informal urban development, also in the alluvial flood plain with a high damage potential in the case of flash floods. Also, retroactively, the WUGs could be applied to areas that have previously been developed informally.
- **Feasibility study:** to show the economic potential in terms of water resource management through integrative approaches between aesthetic and productive landscapes, as well as through the harvest itself as a major pillar of the local community and a source of local food production.

- **Implementation:** To plan a wadi city it demands further research in terms of defining the implementation process in comparison to current practice.

The formulated WUGs and anticipated spatial qualities have been explored further through a research-by-design approach with a (10th Semester design studio VII spring'20 (DSVIIS'20) at the GUC Architecture and Urban Design Program) *'Wadi City: From Threat to Resource'*, under the joint-supervision of Prof.Dr. Cornelia Redeker, Asst.Lect. MSc. Yosra Malek and Asst.Lect. MSc. Manar Karam, based on a site survey guided by the National Desert Research Centre (DRC).

This research is a summary of Yosra Malek's master thesis Wadi Urbanism – An Alternative Urban Design Model for Desert Cities supervised by Assoc. Prof.Dr. Cornelia Redeker. It is also a part of the Landscaping Egypt – From the Aesthetic to the Productive Platform at the GUC Architecture and Urban Design Program that includes several design research studios, an international conference, workshops, master thesis, and the forthcoming publication Redeker, C. & Jüttner, M. (2020). Landscaping Egypt – From the Aesthetic to the Productive. Jovis Publishers, Berlin.

5. References

Abd El-Rahman, S. M. H. Y. S. K. a. H. A. E.-A., 1986. Soils of North-Western Coastal Region in Land Use Classification. *Egypt. J. Soil Sci., (Special Issue),* pp. 17-28.

Ayyad, M. A., 1992. *Present Conditions, Future Perspectives, and Research Priorities in Dry Rangelands: Case Study of the Western Mediterranean Region (Egypt),* s.l.: Cairo: International Center for Agricultural Research in the Dry Areas.

BMT, WBM, Pty, Ltd, 2009. *Evaluating Options for Water Sensitive Urban Design- A National Guide.* s.l.:© Joint Steering Committee for Water Sensitive Cities (JSCWSC).

Bonnet, P. et al., 2014. *Atlas of changes in Livestock Farming Systems: Livelihoods and Landscapes of the North West Coast of Egypt,* s.l.: Cirad LA RECHERCHE AGRONOMIQUE POUR LE DEVELOPPEMENT.

Brooks KN, F. P. M. J., 2013. *Hydrology and the management of watersheds 4th Edition.* Ames: Wiley-Blackwell.

Cornelia Redeker, M. J., 2020. *Landscaping Egypt: From the Aesthetic to the Productive.* s.l.: JOVIS.

Cox, G. a. A. M., 1979. *Agricultural Ecology: An Analysis of World Food Production.* San Fransisco: Freeman.

Dickhaut, W. H. J. K. L. &. W. B., 2011. *Water Sensitive Urban Design: Principles and Inspiration for Sustainable Stormwater Management in the City of the Future.* Hamburg: HafenCity Universität.

DRC, 2015. *Integrated Agriculture Development of Northwestern coastal wadies. Annual report,* Marsa-Matrouh: Desert Research Center publications.

Egypt Independent, 2018. [Online].

ElRashidy, R. H. E., 2019. *Territorial Development of the Egyptian Northwestern Coast Alamein New City as a growth pole,* Cairo: GUC Master thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Architecture Engineering (Architecture and Urban Design).

Ffolliott PF, B. M. E. C. D. M. K. K., 2002. *Land stewardship through watershed management, perspective for 21st Century.* New York, Kluwer Academic/Plenum Publishers.

Francesco Nesci, A. N. D. P., 2000. *Regional Marketing Of Dried Fig-Based Products: An Exploratory Consumer Study 1,* s.l.: s.n.

Guangyu Wang, S. M. H. C. S. L. Z. Z. L. W. J. L. I., 2016. *Integrated watershed management: evolution, development and emerging trends,* Berlin: CrossMark, Springer.

Ismail, H. A. S. M. H. A. E.-R. a. F. H. A. E.-K., 1986. Pedological study of Omayed topo-sequence northwestern Mediterranean desert of Egypt. *Cash ORSTOM,* pp. vol. XXII, no. 1, 63-76.

Jacqueline Hoyer, W. D. L. K. B. W., 2011. *Water Sensitive Urban Design- Principles and Inspiration for Sustainable Stormwater Management in the City of the Future Manual.* Hamburg: HafenCity Universität Hamburg (HCU).

L.S. Pereira, R. F. J. G. B. L., 1996. *Sustainability of Irrigated Agriculture.* s.l.: Springer.

Lamaddalena, N., 2017. *Italy: Food and Agriculture Organization.* [Online] Available at: http://www.fao.org/fileadmin/user_upload/agwa/docs/bari2017/Session3/Harvesting_country_experience_Egypt.pdf

Lloyd, S., 2001. *Water Sensitive Urban Design in the Australian Context.* s.l., s.n., pp. Technical Report 01/7, Cooperative Research Centre for Catchment Hydrology, 20p.

M. Abdel-Fattah, M. S. S. A. K. M. F. K. T. S. A. M. S., 2017. A Hydrological and Geomorphometric Approach to Understanding the Generation of Wadi Flash Floods. *MDPI's journals.*

Mahesh R. Gautam, K. A. M. S., 2010. Best Management Practices for Stormwater Management in the Desert Southwest. *Journal of Contemporary Water Research & Education.*

Mohamed E. A. Khalifa, N. F. B., 2015. Soil Classification and Potentiality Assessment for Some Rainfed Areas at West of Matrouh, Northwestern Coast of Egypt. *ALEXANDRIA SCIENCE EXCHANGE JOURNAL,* pp. VOL.36, No.4.

Rady, A., 2011. *Profile of Sustainability in some Mediterranean tourism destinations,* Plan Bleu: UNEP/MAP Regional Activity Centre.

Rima Mekdaschi, H. L., 2013. *Water Harvesting: Guidelines to Good Practice.* s.l. Centre for Development and Environment (CDE) and Institute of Geography, University of Bern; Rainwater Harvesting Implementation Network (RAIN), Amsterdam; MetaMeta, Wageningen; The International Fund for Agricultural Development (IFAD), Rome.

Salem, D. H. a.-A., 2016. *Egypt: Ministry of Agriculture and Land Reclamation.* [Online].

Scott D. Bryant, K. A. C. J. N., 2012. *Management, GIS Tools for Proactive Urban Watershed.* Florida, American Society of Civil.

Şen, Z., 2008. *Wadi Hydrology.* Istanbul: CRC Press.

Shaaban, 2010. Vertical electrical sounding for groundwater investigation in northwestern Egypt: a case study in a coastal area. *African Earth Sciences,* pp. 673-686.

Theib Y. Oweis, D. P. A. Y. H., 2012. *Water Harvesting for Agriculture in the Dry Areas.* Leiden, Netherlands: CRC Press/Balkema.

USGS, 2019. *United States Geological Survey.* [Online] Available at: https://water.usgs.gov/maps.html

Victorian Stormwater Committee, 1999. *Urban Stormwater: Best Practice Environmental Management Guidelines.* Australia: First published in 1999 by CSIRO PUBLISHING, Electronic edition published in 2006 by CSIRO PUBLISHING.

Yosra Malek, 2020. *Wadi Urbanism: An Alternative Urban Design Model for Desert Cities,* Cairo: German University in Cairo (GUC).

Zheng, L., 2004. *History of watershed resource management.* Beijing: China Water Resources Management Publishing House.