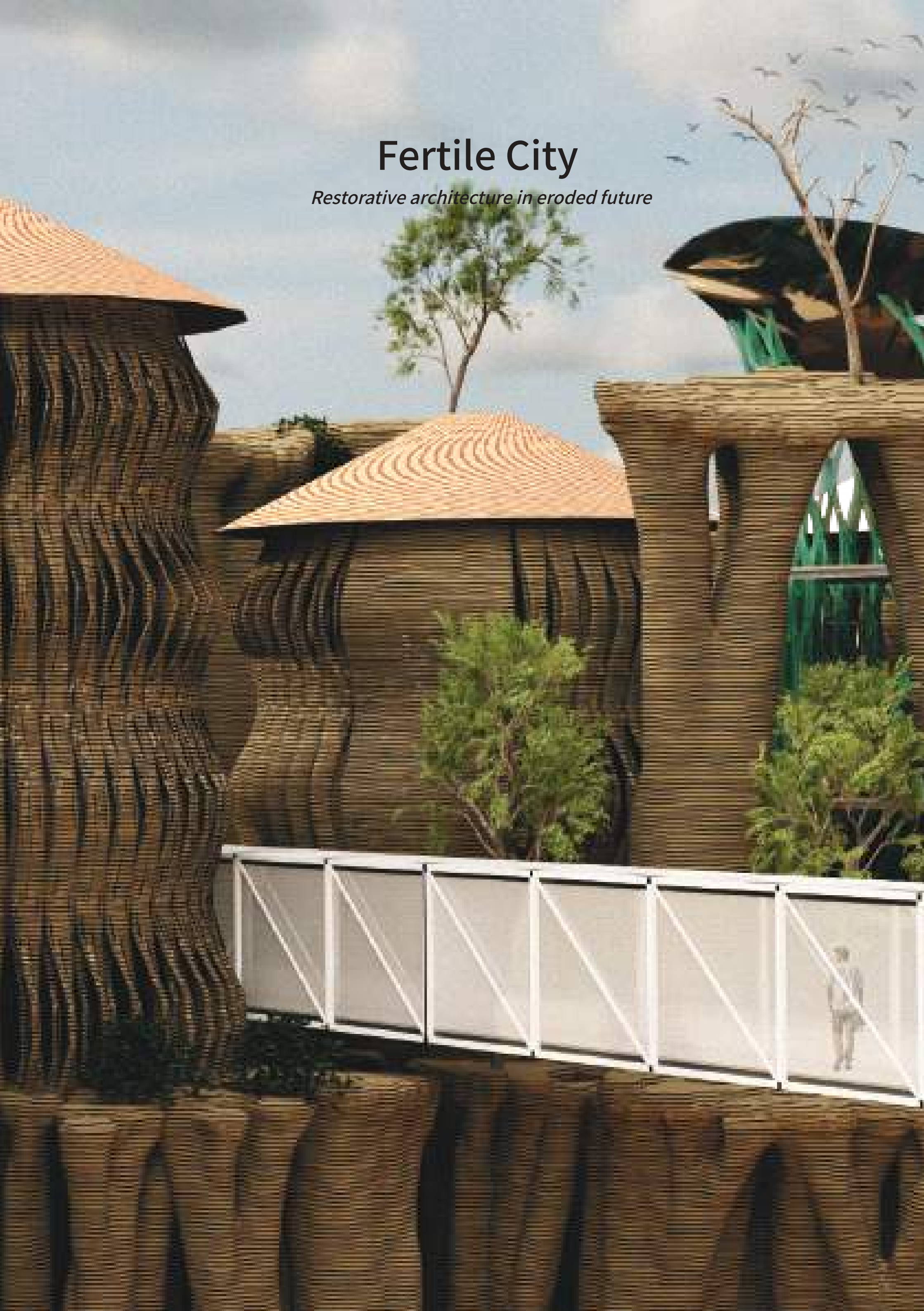
Fertile City

Restorative architecture in eroded future



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Final project

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Content

Abstract

Fertile City is an architectural project that demonstrates how architecture can act as a regenerative force in fragile dryland ecosystems, answering the research question: How can erosion derived design and 3D printing of structures using local soil and additives help mitigate the desertification process in the western Negev?

Set along the Besor stream, the project employed advanced digital tools and large-scale 3D printing with local soil enriched by natural additives to construct an integrated system of three layers : 3D-printed soil structures, vegetation and agriculture, and lightweight modular units. Together, these layers slowed runoff, diffused wind, stabilized terrain, and enriched the soil, while enabling human habitation with minimal ecological intrusion. Architectural applications such as the Water Retention Suburbs and the Wind Diffusing City show how embedding soil restoration into the spatial and material logic of architecture can regenerate landscapes, restore fertility, and establish long term resilience in desertification-prone enviroments

Introduction

Desertification is a process in which soil in drylands degrades, leading to loss of fertility, biological potential, and ecosystem functionality.[1]

In recent years, dryland expansion has increased significantly, now covering approximately 40.6% of the Earth's land surface and expected to reach 50% in the coming decades.[2] This shift means that more of the planet will become hotter, drier, and less capable of supporting biological activity.[3] At the same time, urban expansion continues to grow, especially around fertile and habitable land where water, arable soil, and favorable climate conditions historically enabled human settlement. This phenomenon, also known as urban sprawl, tends to be low-density, infrastructure-heavy, and spatially inefficient. It consumes vast areas of land for a relatively small number of people, further reducing the availability of fertile ground and increasing the ecological footprint of the cities.

These parallel trajectories, growing desertification and expanding cities, create a direct conflict between urbanization and the land's ability to regenerate and preform its biological function. Even as some planning models promote urban compactness, the scale of global population growth challenges the effectiveness of these strategies. Simply containing cities is no longer enough. New models are needed

1 United Nations Convention to Combat Desertification (UNCCD). "Desertification." In Encyclopedia of Sustainability Science and Technology, edited by Robert A. Meyers. Springer.

2 Katyal, J. C., and P. L. G. Vlek. "Desertification: Concept, Causes and Amelioration." Zentrum für Entwicklungsforschung (ZEF), 2000.

3 "Three-Quarters of Earth's Land Became Permanently Drier in the Last Three Decades." United Nations Convention to Combat Desertification. https://www.unccd.int/news-stories/press-releases/three-quarters-earths-land-became-permanently-drier-last-three-decades

that not only reduce expansion but actively contribute to the recovery of the environments in which they are situated.

At the center of this conflict is the soil itself, an often overlooked subject but essential infrastructure for all terrestrial life. When soil loses its fertility and structure, it loses its capacity to support both ecological and human systems. Therefore, the challenge, is not only to prevent further degradation but to think how cities can take part in reversing it.

This project proposes a model that tackles that challenge, led by the question: How can erosion derived design and 3D printing of structures using local soil and additives help mitigate the desertification process in the western Negev?

This question forms the foundation of Fertile City, a design proposal that recognizes desertification as a global driving force in the near future and treats soil degradation as a critical design parameter. The project offers both spatial and material responses to a world where fertile soil is increasingly scarce, erosion is intensifying, and the environmental cost of inaction continues to grow. It envisions cities and suburbs that are not only less harmful, but ecologically productive designed to intervene in the feedback loops of degradation by restoring soil, enhancing biodiversity, and capturing water and biomass.

By integrating site-responsive design, 3D-printed structures made from local soils, and lightweight modular structures, Fertile City proposes a framework in which architecture becomes a tool for land regeneration, embedding soil restoration at the core of urban design.

Desertification

Desertification prone lands refers to fertile lands that degrades and losses its productivity and vegetation cover. It is driven by combination of climatic stress, land use practices and human activity that destabilize soil systems and compromising its ability to support life. At the physical level, it means break down of soil structure, loss of organic matter and increasing vulnerability to erosion by water and wind.[4]

As plant cover diminishes, due to climatic stress or human activity, soil becomes more porous, less cohesive, and increasingly exposed to mechanical erosion. Erosion by wind tends to dominate in flat, sparsely vegetated areas where surface soils are dry, loose, and unprotected. Without root systems to anchor them or cover vegetation, fine particles are easily lifted and transported, stripping away topsoil and reducing the land's ability to retain moisture and nutrients.[5] Erosion by water, on the other hand, becomes significant during episodic rain events. On degraded terrain, rainwater runs off quickly instead of soaking in and infiltrating, carving rills and gullies, displacing sediment, and further exposing the surface to heat and evaporation.[6]

These processes are not isolated. They interact in a feedback loop that accelerates degradation. Drought and heat reduce vegetation. With fewer roots to stabilize the surface, erosion

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4 Katyal, J. C., and P. L. G. Vlek. "Desertification: Concept, Causes and Amelioration." Zentrum für Entwicklungsforschung (ZEF), 2000.
UNEP. *World Atlas of Desertification*. London: Edward Arnold, 1992.

5 Zhao, Yong, Yi Wang, Elgene O. Box, and Juergen Kessler. *Soil Erosion in the Loess Plateau Region of China.* Journal of Environmental Sciences 25, no. 1 (2013): 39–46.

6 Cherlet, Michael, et al. *World Atlas of Desertification: Rethinking Land Degradation and Sustainable Land Management.* Luxembourg: Publication Office of the European Union, 2018.

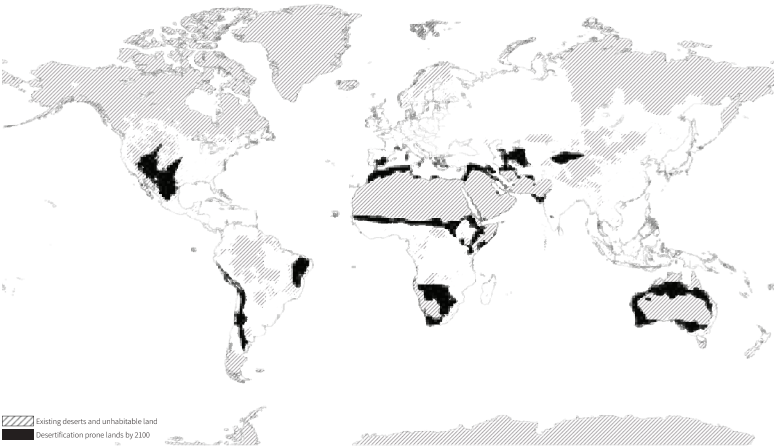


Figure 1 - Predectid desert by 2100

Köppen-Geiger climate classification prediction 2100 and UNCCD – Convention to combat desertification

Fig 2 - Water eroded stream at En Besor stream.

Photo by author

increases. Erosion removes fertile topsoil and weakens soil structure, making it harder for vegetation to reestablish. The more the soil is disturbed, the more vulnerable it becomes to the next shock, whether climatic or anthropogenic. Over time, this cycle undermines the land's capacity to regenerate; therefor restoration depends on deliberate and sustained action.

Understanding desertification as both a macro-scale environmental trend and a site-specific material process reframes its implications for architecture and planning. Due to the magnitude of the phenomena, it becomes a physical condition that is already reshaping the terrain on which future development will occur. The situation calls for a different design perspective, one that is more sensitive to erosion, soil processes, and biological activity, and that responds across both regional and material scales.

Fig 3 – The desertification process

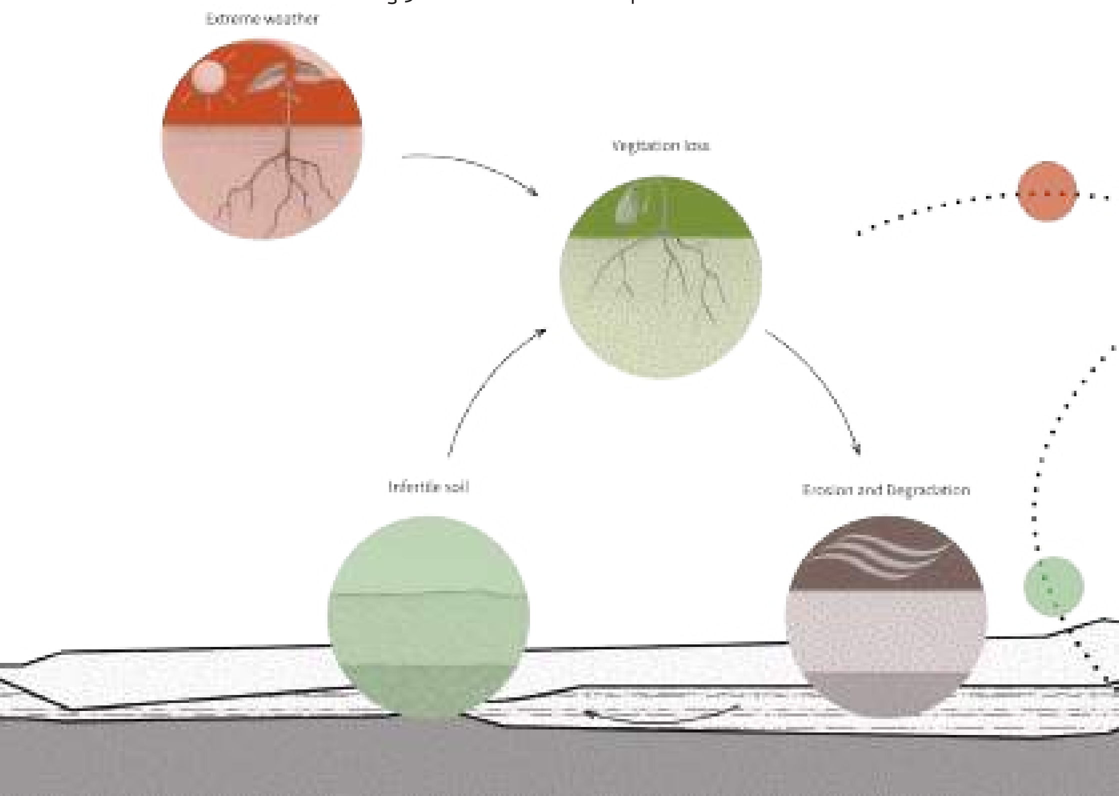


Figure 4 – Israel population density and predicted desertification area by 2100.

luminocity3d.org

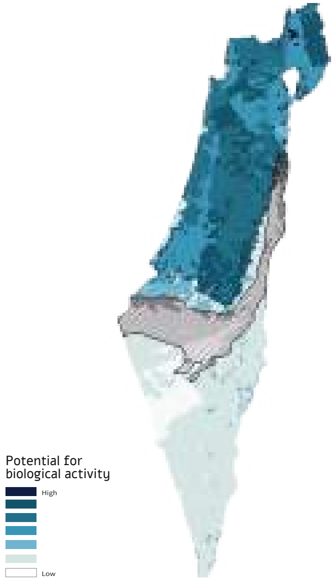
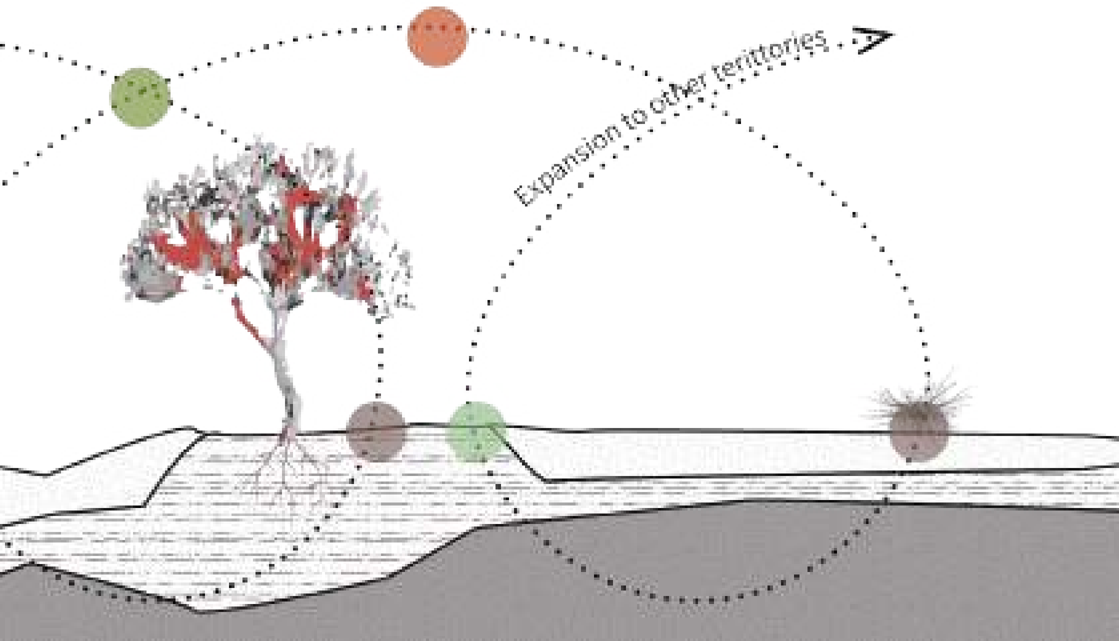


Figure 5 – Israel soil fertility map and predicted desertification area by 2100.

Israel Nature and Parks Authority



Desert settlements

Desertification is not only expanding the boundaries of drylands, it is reshaping the environmental conditions under which future cities will form and where many existing cities are currently located. As soils degrade and biological productivity declines, the spatial and material assumptions of modern settlement must be reexamined. Architecture is increasingly practiced in environments defined by aridity, heat, and climatic stress. The question is not how to sustain life in optimal conditions, but how to design for survival and performance in demanding climates. To approach this challenge, it is necessary to ask how people have adapted to living in dry, low-productivity regions. Across different contexts, communities have developed spatial, climatic, and material strategies that aligned with their conditions, offering lessons that remain relevant to the pressures of today.

In Yazd, Iran, compact urban morphology and narrow shaded alleys helped reduce heat exposure, while wind towers(badgirs) captured and redirected air to cool interior spaces. This passive ventilation system worked entirely with the local climate and materials like mud brick and adobe, showing how environmental design can shape urban form at multiple scales.[7]

In Shibam, Yemen, the city was organized into vertical mud-brick towers reaching up to seven stories. This strategy preserved agricultural land by limiting urban sprawl and created shaded, walkable public space in an extreme climate. The compact massing and thick earthen walls provided

7 Najafi Ashtiani, Azadeh. *Creating Shade in Arid Climates: A Welcoming Landscape Based on Zoroastrian Beliefs for the Towers of Silence*. Virginia Tech, 2019.

thermal insulation, dust protection, and spatial efficiency.[8]

These settlements demonstrate that environmental performance, thermal comfort, material efficiency, and spatial logic can be achieved through architectural decisions embedded in form, placement, and construction. Rather than treating climate as a constraint to be overcome, they use it as a design parameter.

This perspective is especially relevant as more regions shift into dryland classifications, and development increasingly occurs in ecologically stressed zones. The lessons drawn from desert settlements are not fixed formulas, but evidence of how architecture can respond to environmental conditions through spatial and material intelligence.

Figure 6 – Mud building in Shibam city, Yemen
hiddenarchitecture.net

Figure 7 – Passive cooling structures in Yazd city, Iran
visitworldheritage.com

Figure 8 – Syrian "Beehive" mud houses
eartharchitecture.org

8 Leiermann, Tom. "Rehabilitation of Historic Shibam and Zabid, Yemen as an Impulse for Community and Economy." *Built Heritage* 5, no. 1 (2021).

Soil and Restoration

Soil is a thin and fragile layer that covers much of the Earth's surface. It forms slowly over time through the interaction of rock, organic matter, climate, and microbial activity. It plays a critical role in supporting vegetation, regulating water, and cycling nutrients. When disturbed, particularly in arid regions, its degradation can be fast and hard to reverse.[9] Soil's properties are usually described in three scopes: physical, chemical, and biological.

Figure 9 – Soil phisical, chemical and biological profile parameters

9 Brady, Nyle C., and Ray R. Weil. *The Nature and Properties of Soils*. 14th ed. Pearson Prentice Hall, 2008.

Physically, soil is defined by its texture, porosity, compaction, and structure. These determine its ability to retain water, resist erosion, and support root systems. In drylands, low moisture and sparse vegetation reduce cohesion, leaving the soil especially vulnerable to degradation. Once the surface is destabilized, both wind and water can remove fine particles, disrupting the balance of the ecosystem and making regeneration more difficult.[10]

Chemically, soil functions as a reservoir of nutrients. Its pH, salinity, cation exchange capacity, and organic carbon content all determine its fertility and its ability to support plant growth. In many arid and semi-arid environments, the overuse of land, irrigation mismanagement, and erosion contribute to nutrient depletion and salinization, making cultivation increasingly difficult.

Biologically, soil is home to fungi, bacteria, nematodes, protozoa, and a complex web of interactions that regulate decomposition, nutrient cycling, and aggregation. These organisms drive the processes that sustain long-term fertility and resilience. But biological health is also the most vulnerable to degradation and the slowest to recover once disrupted.

Restoration Practices

Soil restoration is the act of regenerating degraded soil, making it more biologically productive and fertile. Restoration practices include interventions that rebuild the three main domains of soil: stabilizing its structure, restoring chemical balance, and reviving biological life. Many of these practices originate from agricultural disciplines. The most successful strategies are site-specific, combining multiple layers of action over time.[11]

Physical restoration is often based on erosion control. Practices such as terracing, mulching, and constructing windbreaks or swales

10 Lal, Rattan. "Soil Erosion and the Global Carbon Budget." *Environment* International 29, no. 4 (2003): 437–450.

11 *Katyal, J. C., and P. L. G. Vlek.* Desertification: Concept, Causes and Amelioration*. Zentrum für Entwicklungsforschung (ZEF), 2000.*

are used to reduce surface runoff and diffuse wind. In northern China's Loess Plateau, once one of the most eroded regions in the world, a large-scale rehabilitation project combined check-dams, reforestation, and slope modification to reverse severe soil loss. These physical interventions improved water retention and enabled agriculture to resume on what used to be barren land.[12]

Chemical restoration involves enhancing the soil's nutrient profile and buffering it against further depletion. Organic amendments like compost, biochar, and green manure are often used to increase soil carbon and improve fertility. The Amazonian Terra Preta is an example for chemical restoration - an anthropogenic dark earth created by local communities through the combination of charcoal, bone, pottery and organic waste for agricultural purposes. Centuries later, until present days, it still holds exceptional fertility and microbial activity, illustrating the potential of designed soil chemistry.[13]

Biological restoration focuses on reintroducing microbial and plant life and increasing biomass. Mycorrhizal fungi, nitrogen-fixing bacteria, and pioneer plant species can be introduced or encouraged to regenerate a living soil system. Often, this is achieved by planting various climate-appropriate species, including agricultural crops and drought-resilient vegetation.

FIgure 10 –The great green wall in Africa
unccd.int/our-work/ggwi

FIgure 11 –Terra preta soil
earthlymission.com

12 Liu, Jiyuan, et al. *Ecological Rehabilitation in the Loess Plateau as a Regional Strategy for Sustainable Development*. Springer, 2012.

13 **Glaser, Bruno, Johannes Lehmann, and Wolfgang Zech**. "Ameliorating Physical and Chemical Properties of Highly Weathered Soils in the Tropics with Charcoal – A Review." *Biology and Fertility of Soils* 35, no. 4 (2002): 219–230.

A contemporary example is the Great Green Wall initiative in the Sahel region of Africa, which aims to restore vegetation along a 7,000 kilometer strip of land threatened by desertification. In countries like Senegal and Ethiopia, localized efforts have successfully reintroduced millions of trees and regenerated degraded hillsides, enhancing biodiversity, improving soil structure, and reducing wind erosion.[14]

These restoration strategies, even when properly applied and adapted to the local ecosystem, require maintenance and time before vegetation can naturally thrive and restoration can occur. Their success depends on long-term planning and spatial consideration, which makes architecture a potential restoration device.

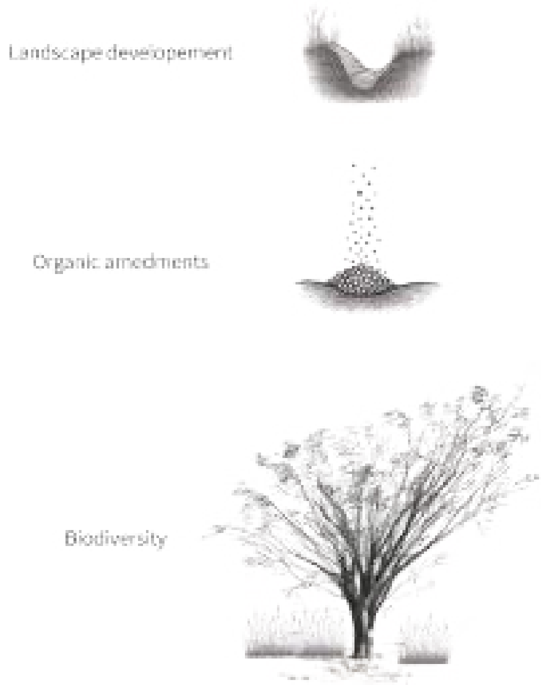


Figure 12 – Three main restoration strategies

14 **Gnacadja, Luc**. *Africa's Great Green Wall: Hope for the Sahara and the Sahel*. United Nations Convention to Combat Desertification (UNCCD), 2012.

Restorative Architecture

Architecture operates within space, shaped by environmental conditions, societal needs, and available technologies. In a world that going through increasingly desertification and soil degradation, architecture must evolve and respond to these realities. Fertile City proposes an architectural framework that treats soil restoration as a central design driver. Rather than building over degraded land, the project positions architecture as a device for ecological repair. This approach integrates physical, chemical, and biological restoration strategies directly into built form, material design, and spatial organization.

The system operates on three coordinated layers:

1. 3D-Printed Structures
   These structures are made from local soil mixed with natural additives, such as biochar and cellulose, creating a mixture similar to Terra Preta (Amazonian dark earth). They serve several purposes, both ecological and architectural: as erosion control elements that reduce water and wind erosion, as chemical restoration agents by mixing infertile soil with organic amendments, as structural foundations, as biological foundations for plants and organisms, and as functional spaces such as houses. These multifunctional structures are made possible through additive manufacturing methods, which enable the fabrication of complex geometries using natural materials.[15]

2. Biological layer - vegitataion and agriculture
   Biodiversity and increasing biomass are important for soil restoration. Trees and shrubs offer both ecological and spatial benefits: they improve the human experience

15 *Arrieta-Escobar, Javier A., Delphine Derrien, Stéphanie Ouvrard, Elnaz Asadollahi-Yazdi, Alaa Hassan, Vincent Boly, Anne-Julie Tinet, and Marie-France Dignac.* 3D Printing: An Emerging Opportunity for Soil Science. *Geoderma 387 (2021): 114986.*

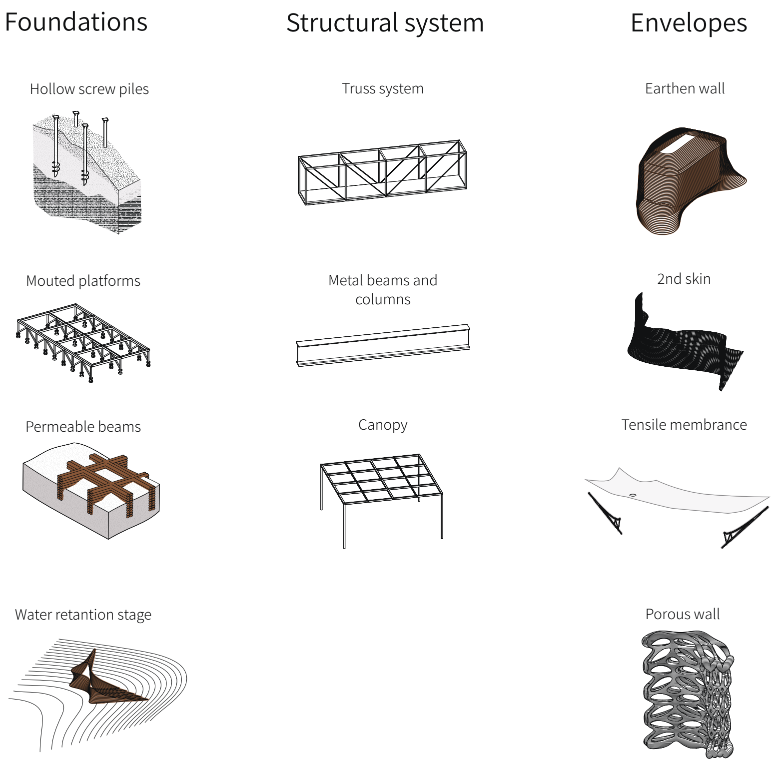


Figure 13 – Restoraive architecture tool kit

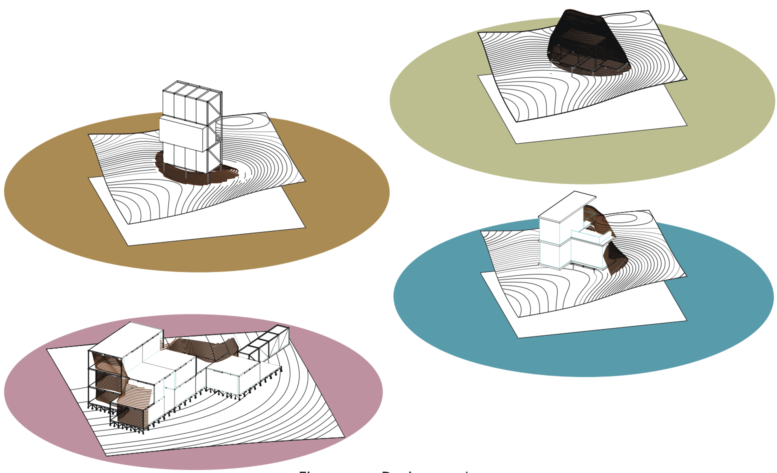


Figure 14 – Design catalog

in urban spaces, provide habitat for a wide range of organisms, and help mitigate soil erosion by stabilizing the ground with their root systems and diffusing wind with their branches.[16] Agriculture also contributes to biodiversity and biomass while serving human nutritional needs.[17] These functions make the vegetation and agriculture layer a vital component of the restorative architecture approach and should be integrated into the design process from the outset.

3. Modular Lightweight Structures
   The modular layer delivers the functional and programmatic volume required by contemporary cities, including housing, communal spaces, office, commercial, education and leisure areas and services. These components are prefabricated and designed for low-impact deployment. Raised or minimally anchored, they avoid compacting or sealing the soil surface and allow the land beneath to continue its restoration process. Their modularity permits flexible phasing and adaptation, allowing the built environment to grow in sync with ecological recovery. Rather than impose a static urban footprint, the v supports a responsive and evolving occupation of space.

Together, these three layers form an architectural strategy that aligns human inhabitation with the dynamics of soil regeneration. Architecture and the city are not passive backgrounds or dominating objects, but active agents in the restoration of land, capable of responding to erosion, nutrient loss, and biological collapse. The result is a living system embedded within the ecosystem.

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16 **Tzoulas, K., et al**. *Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review.*Landscape and Urban Planning 81, no. 3 (2007): 167–178.

17 **Gliessman, S. R.** *Agroecology: The Ecology of Sustainable Food Systems.* CRC Press, 2014.

Detailed design example - Water retantion suburb

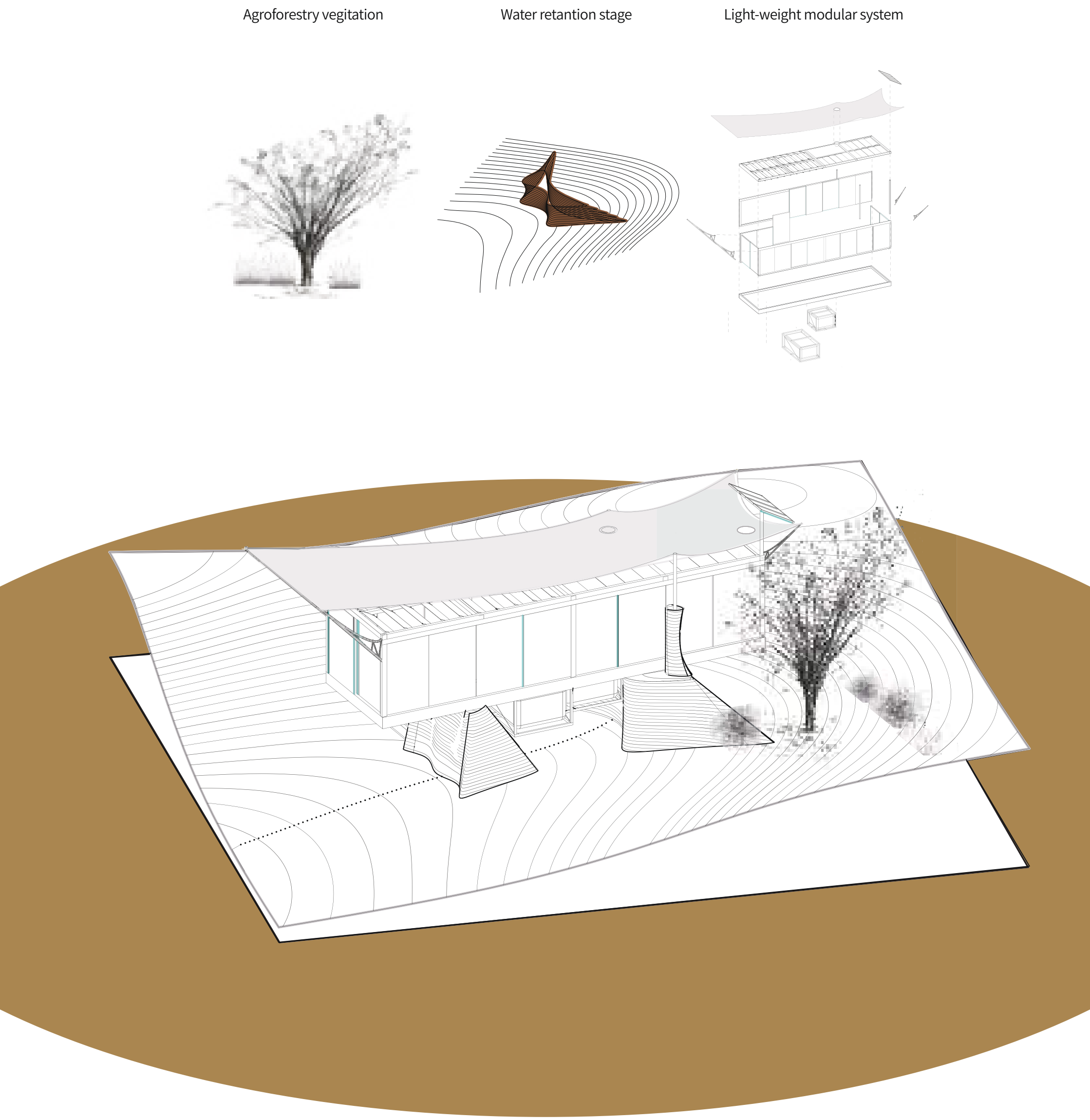


Figure 15 – Design example

Intervention Strategy

The intervention strategy proposed in Fertile City begins with a shift in the logic of site selection. Instead of avoiding degraded areas, the project targets regions already experiencing desertification and land erosion. This approach reframes urban expansion as an opportunity for ecological intervention, positioning the city as an active device for repair.

The strategy follows a sequence of actions, moving from landscape diagnosis to architectural implementation:

1. Using visual data and existing global models of land degradation, including climate projections and local soil studies, areas of already or soon-to-be degraded soil are identified as the basis for intervention.

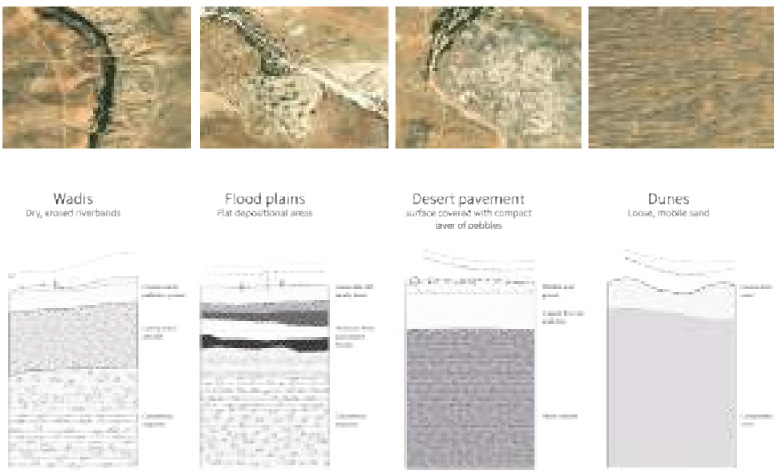


Fig 16 - Soil and erosion source analisys

2. Analyze the source and dynamics of erosion
   Once a site was selected, it was analyzed to identify the dominant erosion processes, whether by wind, water, or both. Wind erosion zones were studied based on prevailing wind directions, wind speeds, and soil

texture, while water erosion zones were examined for runoff patterns, slopes, catchment flow, and flood behavior. This analysis informed not only the placement and orientation and form of structures, but also the formulation of materials. It also helped define the intensity of intervention: the more severely degraded the area, the more intensive the architectural response. The distribution of these intervention sites will form a broader, urban-scale implantation.

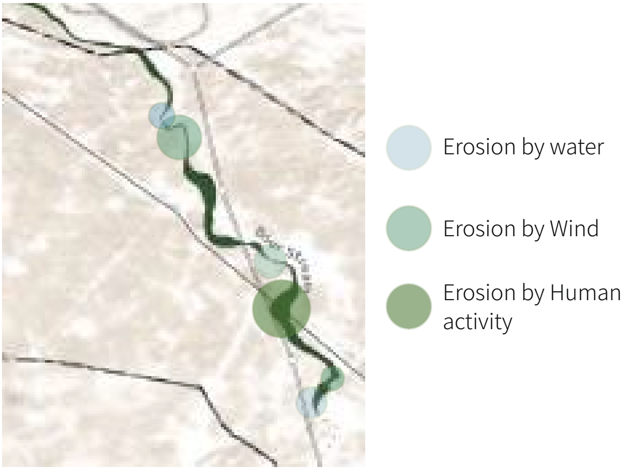


Fig 17- Eroded areas by type and intensity along part of the Besor stream

3. Define suitable soil restoration practices
   Each site’s erosion type determined the most effective restoration technique. In wind-dominated zones, printed geometries were used to reduce wind velocity and trap airborne dust. In water-eroded areas, earth forms slowed down runoff, caught sediment, and minimized gully formation. Additives like biochar were calibrated per site to enrich the soil chemically and promote biological regeneration.

4. Adjust architectural form and material to the terrain
   Building forms were developed to follow the terrain,

preserving existing hydrological and airflow paths. Using Grasshopper-based environmental simulation and toolpath design, structures were adapted to reduce ecological disturbance while improving landscape performance. The printed geometry included cavities, textures, and variable densities to influence wind and water behavior at the surface level.

5. Integrate modular architectural components
   Once the printed and vegetated base was established, modular lightweight components were introduced for human needs and urban program. These were placed selectively in areas with minimal ecological sensitivity and arranged to establish the city’s dynamic. Elements included housing, 6 stories buildings, observation decks, and service units were designed for minimal footprint and reversibility.

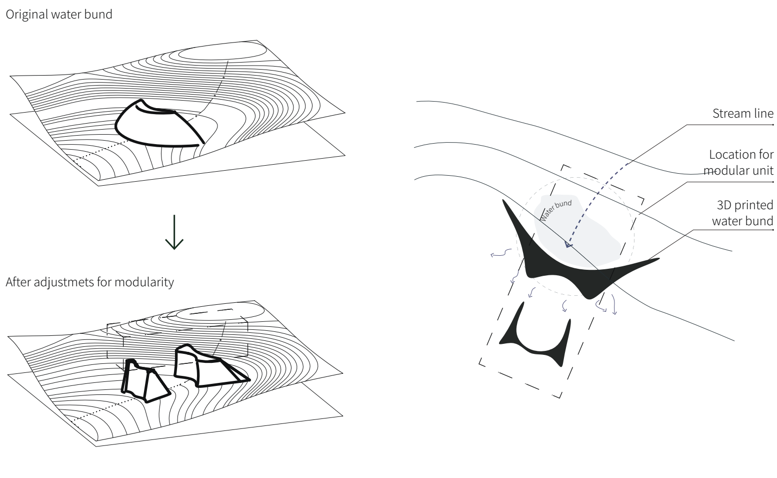


Fig 18 – Transformiing water bund into platform for modular parts

6. Dissolve or expand
   In its early stages, construction focuses on erosion control and soil enrichment, using 3D-printed structures made from local soil mixtures. As fertility returns and vegetation becomes established, additional modular units can be introduced to support habitation or agricultural use. Over time, if human presence is no longer needed or conditions demand withdrawal, the printed structures can degrade back into the landscape, enhancing the soil instead of leaving waste. Modular elements can be removed or relocated, making the city reversible by design - capable of dissolving or expanding depending on environmental and social needs.

This strategy combines site-specific erosion analysis, material design, and spatial programming into a single urban system. Rather than treating architecture as a fixed imposition, it becomes a tactical layer that responds to and reshapes the environmental processes of the land.

The interventions in this project were anchored along the southern reaches of the Besor stream, southwest of Beersheva. As the largest drainage basin in the western Negev, the stream serves as an ecological spine that concentrates runoff, vegetation, and biodiversity in a semi-arid area. Its role as a natural corridor for both water and life makes it a critical ecological pivot in the region.[18] *Given that this territory is projected to undergo intensified desertification, supporting the biological continuity and soil stability of the Besor stream is essential, not only for local ecosystems but for the resilience of the entire regional landscape.*

18 **בני גזית. חבל הבשור**: טבע, היסטוריה ופעילות במקור להתפתחות אזורית. משרד לפיתוח הנגב והגליל, **2017**.

Fig 19 – Sattlelite image of partly degraded area in Nahal Besor, southwest to Beer Sheva

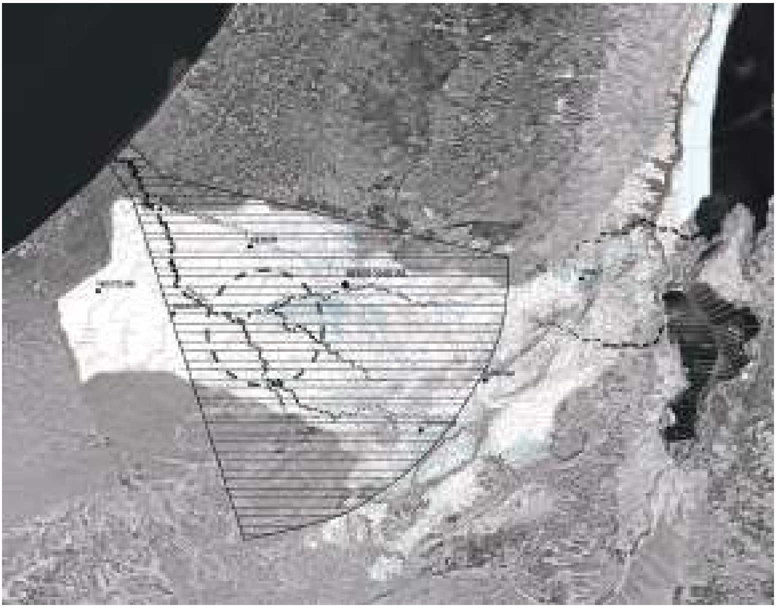


Fig. 20 – The Besor stream as the largest drainage basin in the Negen, and in Israel's "Desertification belt"

Fig. 21 – Spring at the preservation part of the Besor stream
Photo by author

Water Retention Suburbs

The next chapter presents a design application of the restorative architecture approach in a water-eroded landscape, where surface runoff and flash floods destabilizing the soil and causing degradation. The site, located at the margin of a dry stream system (wadi), along the Besor stream, experiences episodic but intense rainfall events, which have carved gullies and washed away fertile topsoil over time. The erosion type and its magnitude determined by the depth of the gullies and the spread of the wadis.

The Water Retention Suburbs function as both an urban extension and a hydrological infrastructure. The architectural strategy addresses the erosion process by shaping the built environment to slow down, spread, and retain water.

The intervention begins by mapping flow paths and sediment movement using hydrological simulations based on topographic models and Grasshopper code. By analyzing these hydrological patterns, the most effective locations for water catchment are identified and used to guide the layout of suburban units. Instead of a conventional grid, the housing follows the contours and natural drainage lines of the site. The suburb becomes a series of strategic catchments.

The primary structural elements are 3D-printed berms, constructed from local loess mixed with organic additives. Their form is made to catch water flows and retain effectively retain water. Over time, these forms capture runoff, slow erosion, and accumulate fertile material from upstream.

On top of these earthen structures, prefabricated lightweight dwelling units are placed. These modules are adapted to desert climates through the integration of solar panels, passive wind cooling, atmospheric water generation fabrics, and greywater recycling systems. This enables the units to remain relatively self-

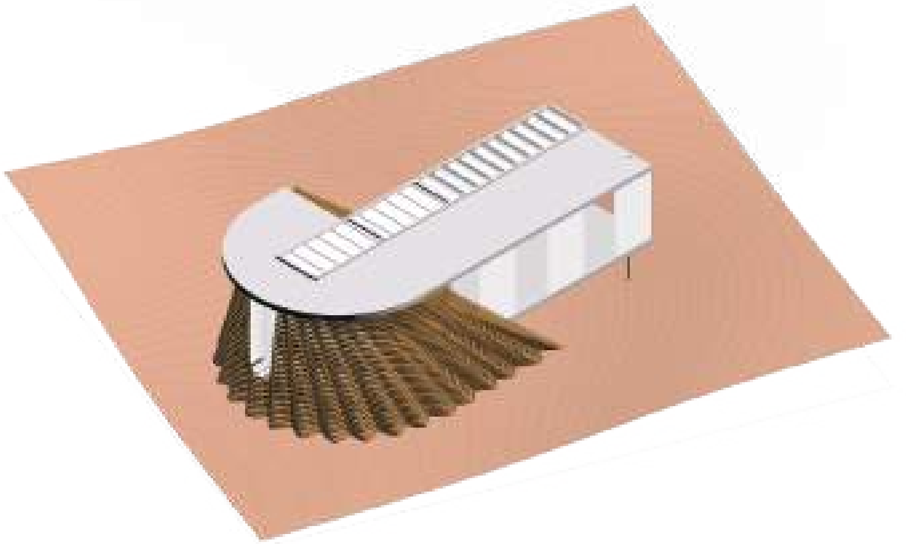


Fig. 22 – A suburban neighborhood layout following natural dendritic patterns

Fig. 23 – 1:5 scale model – 3D printed geometry test with local loess soil

sufficient and minimizes the need for heavy infrastructure. Their modularity allows for expansion and the development of larger communities.

The 3D printed system is seeded with pioneer plant species adapted to seasonal flooding and poor soil. Shaded retention areas offer improved conditions for root development and moisture retention, while accumulated sediment provides a nutrient-rich base for long-term fertility. Over successive cycles of rain and drought, these conditions lead to gradual re-vegetation, reduced gully formation, and a stabilized surface layer.

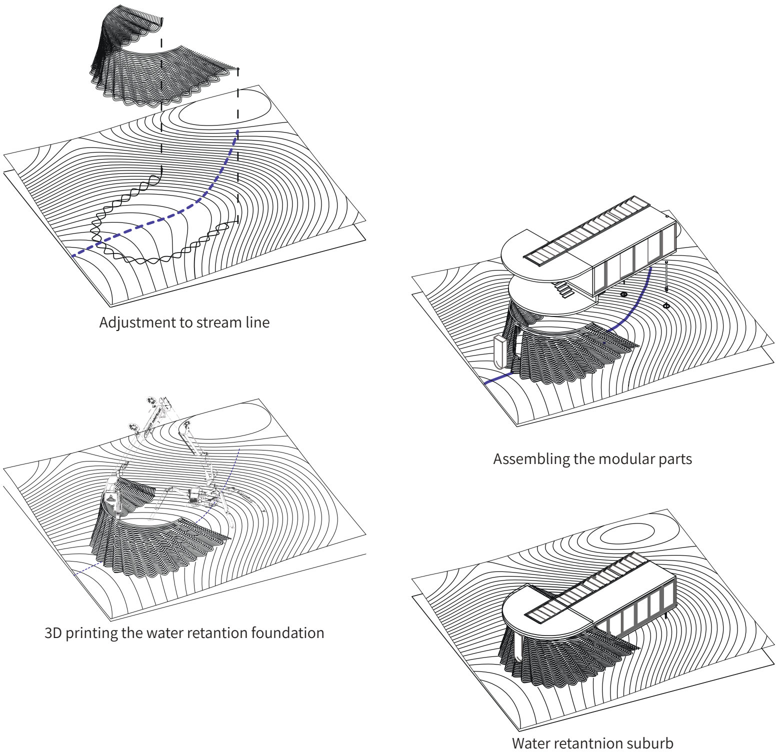
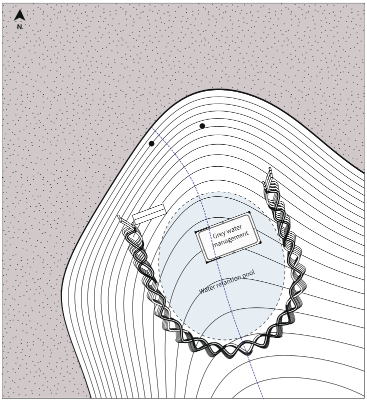
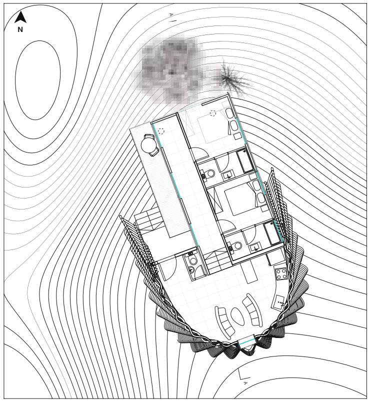


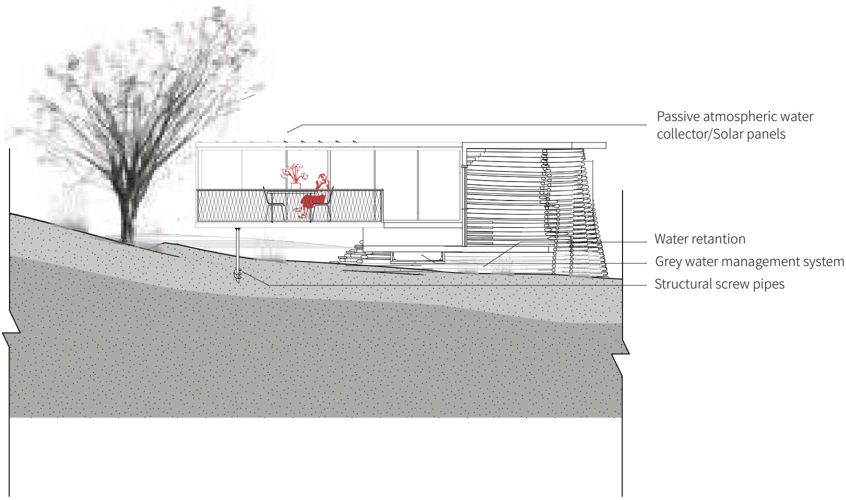
Fig. 24 – Suburban unit assembly drawings



Ground Floor | 1:100



1st Floor | 1:100



Section A-A

Fig. 25 – Suburban unit plans and section

Wind Diffusing City

The Wind Diffusing City is a linear, compact urban system developed as a protective and regenerative layer along the Nahal Besor stream in the western Negev. The city is located on highly degraded zone of the stream, eroded by wind and human activity.

The intervention takes the form of a continuous 3D-printed wall, running parallel to the stream and functioning as both urban infrastructure and ecological device. The wall is not straight line, but a curved line the created pockets from both of his sides for urban functions and for agricultural fields, both protected from the harsh weather by the wall.

The Printed Wall

The core structure of the city is a 3D-printed earth wall, fabricated on-site using loess soil mixed with natural additives. The wall's form is porous and articulated to diffuse wind, buffer runoff, and accumulate airborne dust. Over time, it serves as a windbreak, a dust trap, and a topographic barrier that protects the fragile terrain of the streambanks.

The wall includes three horizontal layers, each serving a specific ecological and social function:

- Layer 0 – Foundations: the printed base connects directly with the terrain, controlling runoff, stabilizing loose soils, and integrating into the geomorphology of the site. It also serves as habitat for low vegetation and organisms that prefer shade, moisture, and proximity to the ground.

- Layer 1 – The wildlife corridor: cavities, ledges, and shade pockets are embedded to support local fauna. These include nesting voids and shaded niches for microhabitats.

- Layer 2 – The agricultural roof: the top layer is designed as a productive terrace system, where crops are cultivated using retained dust, compost inputs, and greywater irrigation. The agricultural layer serves for biodiversity and for human nutrition.

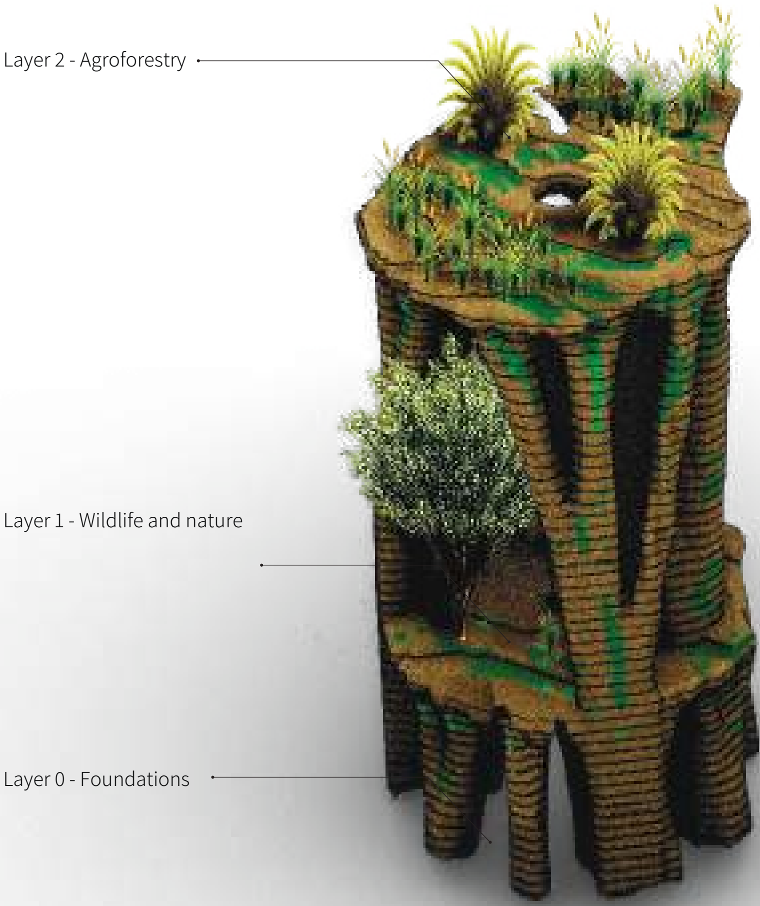


Fig 26– One wall coloumn

Urban Integration

At select intervals, the 3D-printed wall diverts, steps back, or thickens to create spatial pockets for human occupation. While its primary role is to diffuse wind and support vegetation and agriculture, in certain zones adjacent to the urban program, segments of the wall are specifically printed to accommodate dwellings. These printed housing units are physically and programmatically connected to the prefabricated city structures, forming a seamless interface between the natural functions of the wall and the urban life of the settlement. Dwelling modules, communal programs, and service elements are embedded within these zones, allowing residents to inhabit spaces that are shaded, climatically buffered, and closely integrated with both ecological and infrastructural systems. On the opposite side of the wall, agricultural fields benefit from improved microclimate conditions created by the wall's geometry.

Fig 27- Residential complex isometry

Together, this edge condition forms a productive and livable boundary that merges environmental restoration with human settlement.

Fig 28– The diffusing city's progromatic layout

Fig 29– Urban plan

The Wind Diffusing City is not simply a built barrier. It is a restorative infrastructure that reshapes the erosive dynamics of the site. Wind, dust, and runoff are not eliminated, but redirected, slowed, and used. The printed forms accumulate particles, support vegetation, and enable habitat succession. The modular urban system maintains a compact footprint, reinforcing the principle of minimal intrusion with maximum restoration.

While the local ecosystem is the catalyst of the project, the spatial intervention created an opportunity for a new kind of residential experience. one that **shares** the local ecosystem rather than **occupying** it. It is a way of living that coexists with nature while adding important value to the natural elements of its surroundings.

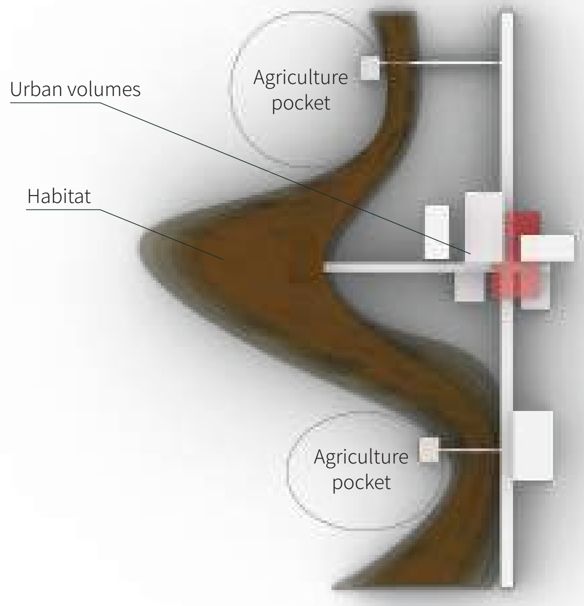


Fig 30- Segment of the wall and connection to the city

Fig 31- Residential complex plan | 1:100

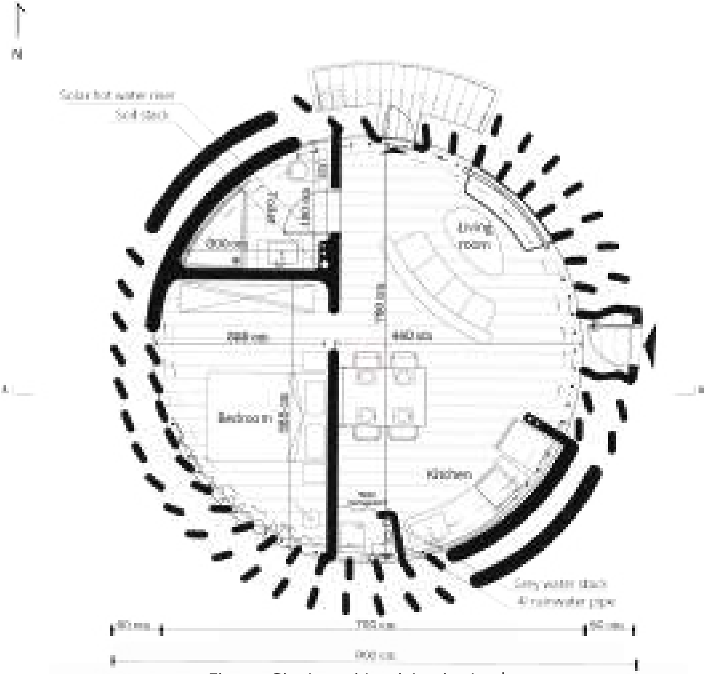


Fig 32- Single residential unit plan | 1:25

Fig 33- Single residential isometry

Fig 34– Residential building section | 1:25

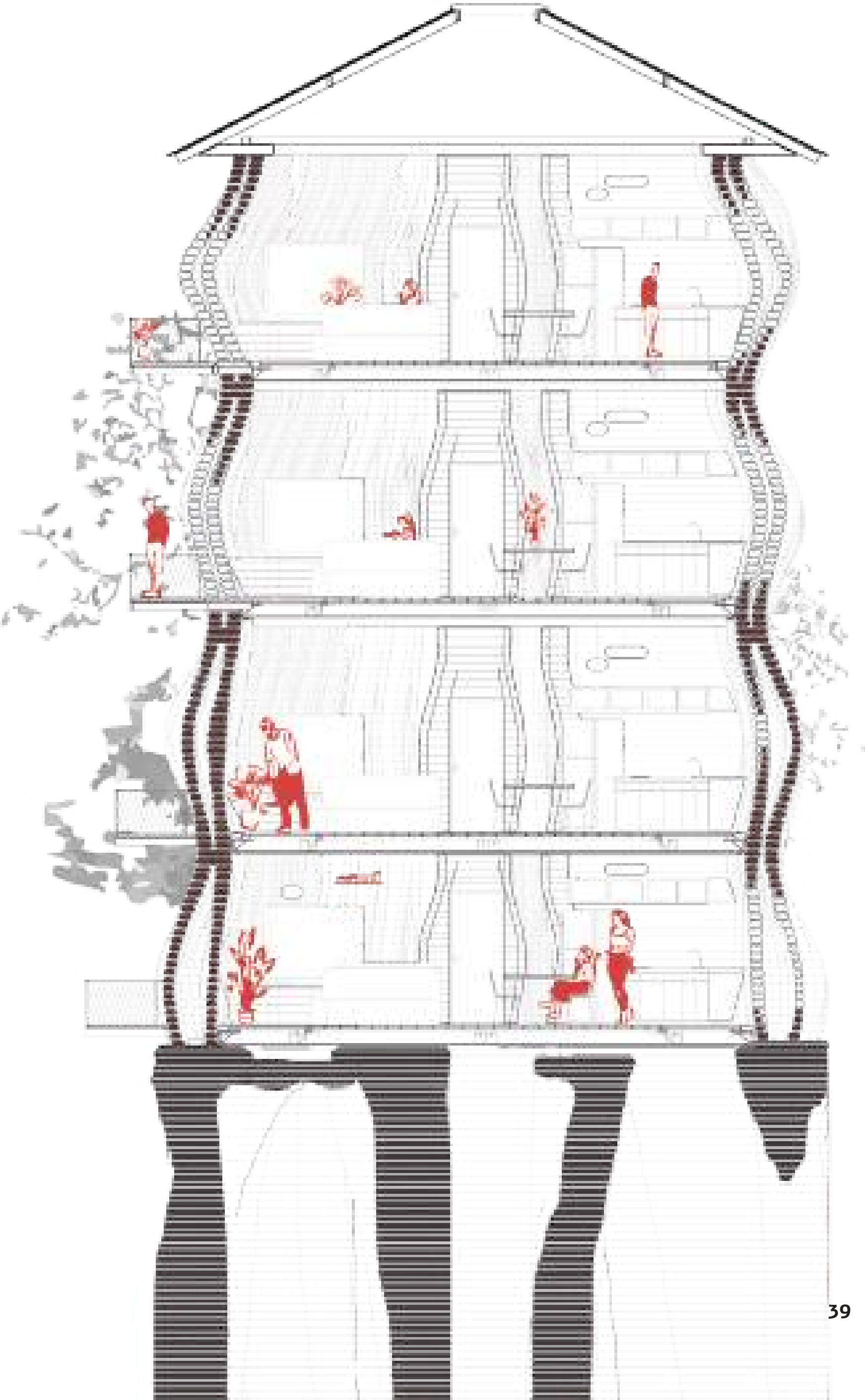


Fig 35- Wind diffusion city

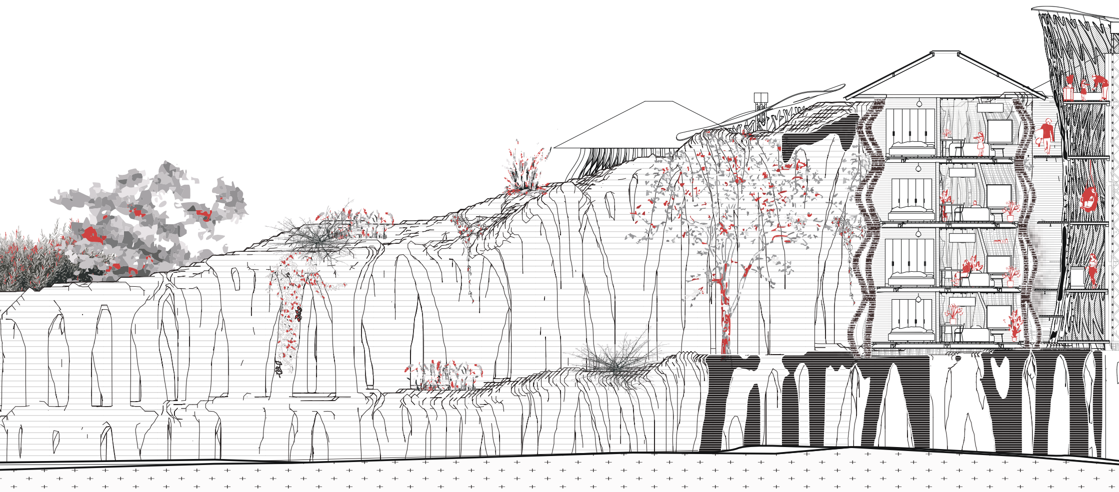
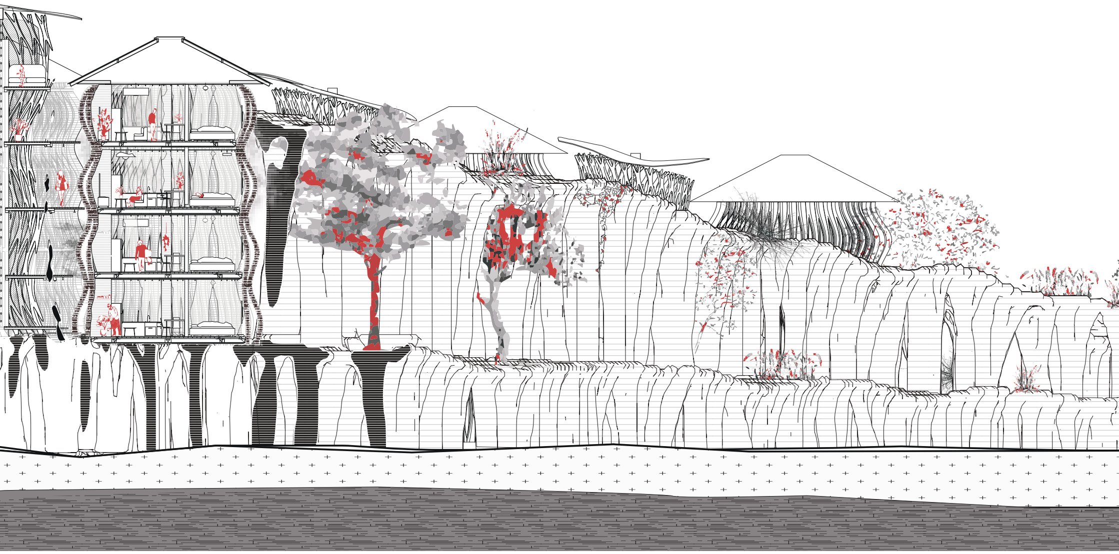


Fig 36- Whole wall section - biowall and residential complex | 1:100



Epilogue

Fertile City began with a question:
How can a restorative architecture design approach support soil restoration and mitigate desertification processes in desertification-prone areas?

In answering it, the project has proposed a new model of urbanism - one that engages directly with damaged ecologies, responds to the mechanics of erosion, and treats architecture as a device for soil regeneration.

Rather than resist the conditions of arid landscapes, Fertile City accepts them as the starting point. Wind, water, dust, and degradation are not obstacles to overcome, but systems to be integrated and redirected. Across its interventions, whether water retention suburbs along wadis streamlines or a wind-diffusing urban wall protecting the main stream of Nahal Besor, the project frames the built environment as part of the ecological logic of the land.

The project operates across several interconnected scales. At the territorial scale, it identifies desertification-prone regions as primary zones of intervention, treating degraded land as a site of restoration rather than abandonment. At the urban scale, the spatial layout is guided by erosion dynamics, with neighborhoods arranged along wind corridors or water catchments. At the architectural scale, buildings are designed to interact with these forces, some diffuse wind, others retain runoff or stabilize slopes, functioning as active erosion control devices. At the material scale, each printed component is formulated with local soil and natural additives to chemically and biologically support soil regeneration.

The result is not a masterplan, but a methodology, a way to build that also heals the soil. It is a system of spatial tactics and material protocols that can be adapted to other erosion-prone landscapes facing similar threats.

Over time, the interventions demonstrated their ability to reduce surface erosion, stabilize vegetation, and reintroduce microbial and plant life to previously sterile soils. Suburban edges evolved into productive, living terrains. The urban core, no longer insulated from its ecological context, became a buffer that enabled regeneration rather than displacement. The system itself was designed to change. Modular structures could be removed when no longer needed, leaving minimal trace, while the 3D-printed soil components gradually broke down and reintegrated into the ground, enriching it in the process. Just as easily, both systems could expand, new units printed or added in response to human and ecological needs. In this way, the city was not a fixed object but a responsive framework that grew, dissolved, and regenerated with the land.

By realigning the relationship between cities and soil, Fertile City offers a vision of future urbanism in a drying world not one of retreat, but of grounded re-engagement.

Fig 37– A biocolumn breaking down | 1:100

Fig 38– Future outlook a – The city expands

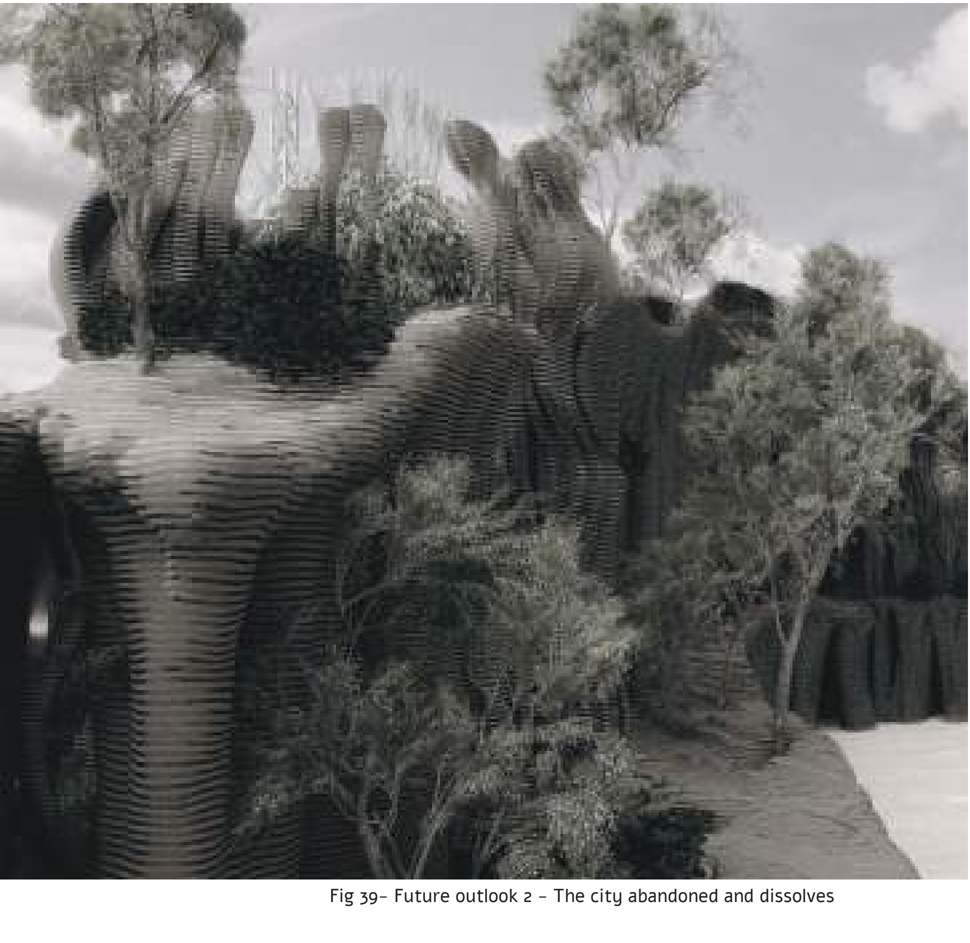


Fig 39- Future outlook 2 - The city abandoned and dissolves

Bibliography

Arrieta-Escobar, Javier A., Delphine Derrien, Stéphanie Ouvrard, Elnaz Asadollahi-Yazdi, Alaa Hassan, Vincent Boly, Anne-Julie Tinet, and Marie-France Dignac. “3D Printing: An Emerging Opportunity for Soil Science.” Geoderma 387 (2021): 114986.

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אזורית והגליל, 2017.

Brady, Nyle C., and Ray R. Weil. The Nature and Properties of Soils. 14th ed. Pearson Prentice Hall, 2008.

Cherlet, Michael, et al. World Atlas of Desertification: Rethinking Land Degradation and Sustainable Land Management. Luxembourg: Publication Office of the European Union, 2018.

Fearnside, Philip M. “Amazonian Dark Earth: An Ancient Technique for Sustainable Agriculture.” Environment: Science and Policy for Sustainable Development 47, no. 11 (2005): 19–24.

Glaser, Bruno, Johannes Lehmann, and Wolfgang Zech. “Ameliorating Physical and Chemical Properties of Highly Weathered Soils in the Tropics with Charcoal – A Review.” Biology and Fertility of Soils 35, no. 4 (2002): 219–230.

Gliessman, S. R. Agroecology: The Ecology of Sustainable Food Systems. CRC Press, 2014.

Gnacadja, Luc. Africa’s Great Green Wall: Hope for the Sahara and the Sahel. United Nations Convention to Combat Desertification (UNCCD), 2012.

Goudie, Andrew. “Understanding Desertification.” In Desertification, 1–28. Oxford: Oxford University Press, 2013.

Katyal, J. C., and P. L. G. Vlek. Desertification: Concept, Causes and

Amelioration. Zentrum für Entwicklungsforschung (ZEF), 2000.

Lal, Rattan. “Soil Erosion and the Global Carbon Budget.” Environment International 29, no. 4 (2003): 437–450.

“Soil Degradation as a Reason for Inadequate Human Nutrition.” Food Security 1, no. 1 (2009): 45–57.

Leiermann, Tom. “Rehabilitation of Historic Shibam and Zabid, Yemen as an Impulse for Community and Economy.” Built Heritage 5, no. 1 (2021).

Liu, Jiyuan, et al. Ecological Rehabilitation in the Loess Plateau as a Regional Strategy for Sustainable Development. Springer, 2012.

Liu, Shiyin, et al. “Restoration of the Loess Plateau.” Ecological Engineering 26, no. 1 (2006): 5–17.

Najafi Ashtiani, Azadeh. “Creating Shade in Arid Climates: A Welcoming Landscape Based on Zoroastrian Beliefs for the Towers of Silence.” Master’s thesis, Virginia Tech, 2019.

Tzoulas, K., et al. “Promoting Ecosystem and Human Health in Urban Areas Using Green Infrastructure: A Literature Review.” Landscape and Urban Planning 81, no. 3 (2007): 167–178.

UNCCD (United Nations Convention to Combat Desertification). “Desertification.” In Encyclopedia of Sustainability Science and Technology, edited by Robert A. Meyers. Springer.

“Three-Quarters of Earth’s Land Became Permanently Drier in the Last Three Decades.” United Nations Convention to Combat Desertification. https://www.unccd.int/news-stories/press-releases/three-quarters-earths-land-became-permanently-drier-last-three-decades

UNEP. World Atlas of Desertification. London: Edward Arnold, 1992.

United Nations Food and Agriculture Organization (FAO). "Global Soil Assessment." In Status of the World's Soil Resources. Rome: FAO, 2015.

Weng, Xiaoyan, et al. "Wind Erosion and Land Use in Semi-Arid Areas: A Review." Land Degradation & Development 30, no. 4 (2019): 399–411.

World Bank. "Implementation Status of the Great Green Wall." In The Great Green Wall: Implementation Status and Way Ahead. Washington, D.C.: World Bank, 2020.

Zhao, Yong, Yi Wang, Elgene O. Box, and Juergen Kessler. "Soil Erosion in the Loess Plateau Region of China." Journal of Environmental Sciences 25, no. 1 (2013): 39–46.