Hydro-Solar Fields

Adaptive desert living through integrated infrastructural systems

by

Libby Dror

A thesis

presented to the University of Waterloo

in fulfilment of the

thesis requirement for the degree of

Master of Architecture

Waterloo, Ontario, Canada, 2010

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

ABSTRACT

In the current context of escalating climate catastrophes paralleled with depleting energy resources, degrading fresh water supplies and diminishing agricultural lands, there is an increasing preoccupation with the prospects of a fast approaching ecological global crisis. Arid regions, which under normal circumstances are places of acute extremes, are afflicted by these trends more profoundly. Dryland ecosystems are places where survival hangs on a most fragile equilibrium, therefore any anomaly or scarcity can be detrimental to their viability. Alternatively, due to their unique ecosystem properties, not available in other more moderate environments, deserts can represent places of immeasurable potential for a prosperous subsistence.

The Negev desert accounts for two thirds of the land area of Israel and is employed as a case study for this exploration. The thesis investigates the following four narratives:

FERTILE VISIONS dissects the ethos of blooming the desert and the inherent contradictions of realized utopias.

EPHEMERAL FLOWS constructs a broad framework of the Negev's ecosystem, while mapping the operating forces and their affect on the system's stability.

VITAL SIGNS curates a catalogue of strategies, systems and technologies in the fields of water management, solar energy and controlled environments. Their juxtaposition starts to suggest plausible hybrids.

Finally, EFFECTIVE TERRAINS defines design strategies for new models of desert living, based on integrated infrastructural systems. It envisions a prototype for a community planned through the synthetic interweaving of the existing desert ecosystem with water, energy and agricultural production.

Acknowledgments

I would like to thank the advising committee-

Supervisor: Val Rynnimeri- Thank you for your continuous encouragement and for believing in this vision with me.

Committee: Jeff Lederer- for your support and diligent commentary on the document throughout.

Lola Sheppard- for your insightful advice and well appreciated critical input.

External reader: Lisa Rapoport- for taking the time to contribute to this process.

I would also like to thank my parents, for their unwavering love and for always walking the extra mile for me, and then another.

My aunt Roni, for hosting me during my research trip and for helping in obtaining research materials early in the process.

To the 12 Walnut girls, thank you for your friendship, you were my home in these couple of years.

And to Tristan, thank you for your editing efforts, our inspiring discussions, and for being my escape when I needed it most.

Dedication

To my Grandparents -

Zipora and Adi Ephrat,

Masada Dror, and in memory of Ben-Zion Dror

CONTENTS

List of illustrations

Unless sources are otherwise specified, all illustrations are by author.

Preface

My grandfather was a corporate lawyer, a founding partner in a firm that made a name for itself in the prosperous business of oil exploration and development in Israel. Following the 1973 oil embargo, oil explorations expanded into the Sinai. Oil developers and their lawyers were in the habit of naming drilling sites after their children. It happened to be that one of the most significant discoveries of the time was in the Alma field, named after my mother. It was a large discovery, valued at over $100 billion. In 1979, the Sinai with its oil fields was returned to Egypt as part of the peace process. Alma field, which became one of Israel's most fruitful energy resources, was returned as well - a manoeuvre which in many opinions jeopardized Israel's prospects for energy self sufficiency.[1]

Thirty years later, during a visit to Israel, my grandfather was happy to share with me the news of a recent discovery of a significant natural gas field off the Israeli coast. Other than the obvious financial implications for the developers involved, my grandfather was impressed by the fact that this new resource could last for the next 50 years and potentially make energy an export industry for the Israeli economy once again, valued at over $300 billion. Since I was in the midst of thesis research and interested in the subject of energy imports and exports, the immediate thought that came to mind was: Fifty years? That would not even last to support my own grandchildren, what will we do next? Furthermore, the newly discovered fields, situated very close to the Lebanon and Gaza shores respectively, have already instigated political conflicts over questions of ownership.

When I suggested to my grandfather the proposition that with solar energy from the Negev desert, Israel could become energy self-sufficient permanently, with only an initial infrastructural investment and without the risks of not finding a deposit, running dry or suffering political unrest, he was genuinely intrigued. The idea

of a truly infinite resource, waiting to be tapped, with its implied development and financial benefits, was a compelling one. An idea that although familiar, was never seriously explored. It was during this conversation that for the first time we were able to find a common ground for this value based discourse.

My grandparents' generation was the avant-garde founder generation who built Israel and fostered its meteoric development. They were often the first generation to arrive or to be born in Israel, and they witnessed the holocaust as the ultimate crisis and its outcome as the rebirth of the new Jewish state in Israel. Their generational thinking was one of pioneering and entrepreneurship, where value was placed on progress and economic growth for the state and individual. This generational enterprise was optimistically and positively driven by the duty to establish prosperous life following a catastrophe.

My own generational thinking, although very much rooted in previous generational narratives of growth and wealth, is also influenced by a shift of values. The previous generations had one sort of crisis to counteract; we today have another.

fig. 0.1 Desert Panorama

Introduction

POSITION In the face of contemporary global ecological concerns, the approach of doing "more with more" is becoming less and less viable as it becomes evident that "more" could not last forever. Doing "less with less" is not an acceptable option either since no system on a forward trajectory will allow itself to backtrack. The remaining viable option is doing "more with less" as suggested by Buckminster Fuller in 'Utopia or Oblivion'.[2] Fuller provides a wider definition for the economy of wealth:

"Wealth is our organized capability to cope effectively with the environment in sustaining our healthy regeneration and decreasing both the physical and metaphysical restrictions of the forward days of our lives," Or, "The number of forward days for a specific number of people we are physically prepared to sustain at a physically stated time and space liberating level of metabolic and metaphysical regeneration."[3]

William McDonough and Michael Braungart in 'Cradle to Cradle', define "doing more with less" with the term "eco-efficiency."[4] However, they argue that eco-efficiency is not enough. Minimizing human impact is a negative approach assuming there could be no positive interaction between humanity and the environment. Instead, they propose an "eco-effective" approach to building and product design. An "Eco-effective" process presupposes the flux of inputs and outputs of the system, to allow the designed object to maintain its value and health through a multi-cycled life span. They envision "buildings that, like trees, produce more energy than they consume and purify their own wastewater."[5]

Our current challenge is in achieving balanced equilibriums of inputs and outputs in the ecosystems we construct. On many instances, this means learning how manmade systems interact with the powerful and larger natural environments they are inevitably a part of. In other cases, it means adapting to system evolutionary dynamism and managing its inputs and outputs accordingly. A successful balance of inputs and outputs will enable stabilized longevities, otherwise defined as system sustainability.

The innovation that contemporary thinkers and designers contribute to this discourse is in the realm of the augmented, hybridized, networked and emergent environments which enable doing "more with less" in an "eco-effective" manner. Out of crisis and the need for highly effective solutions, emerges the opportunity to re-envision our infrastructures and landscapes as such that will induce richer environments.

In this context, the thesis investigates the unique conditions of the desert environment, and specifically the Negev desert in Israel. The desert represents a place of extremes: scorching heat during the day and freezing cold at night, extreme drought and flash floods, desolation and oasis, crisis and renewal. Christian Norberg-Schultz et al. give a phenomenological depiction of the desert's genius loci:

"As a whole the environment seems to make an absolute and eternal order manifest, a world which is distinguished by permanence and structure. Even the dimension of time does not involve any ambiguities. The course of the sun thus describes an almost exact meridian, and divides space into "orient", "occident", "midnight" and "midday", that is, qualitative domains which in the south are commonly used as denotations for the cardinal points. Sunset and sunrise connect day and night without transitional effects of light, and create a simple temporal rhythm."[6]

The desert therefore symbolizes an alternate place of primeval order, untainted, where nature's forces are strongly manifested and purification, renewal or rebirth are possible. These extraordinary qualities of the desert as well as its remoteness and isolation qualify it for social, cultural and technological experimentation.

PROCESS This thesis was born out of two incidental pieces of information I encountered during the summer of 2008. The first was a news piece I came across regarding plans to build another coal-fuelled power plant in the city of Ashkelon,[7] situated on the Israeli shore of the Mediterranean just north of Gaza and on the western edge of the Negev. The second was a small book about solar chimneys[8] that revealed an unfamiliar technology with the potential to double as a solar power plant and a greenhouse facility. This book also expanded on the great potential for solar technologies in deserts of the world and of the benefits that could arise to desert populations from such applications.

It seemed as though at once the problem and the solution presented themselves. In a place like Israel, where two thirds of the land is desert, the option to produce energy from the sun appears obvious. In 2010, to continue energy production from coal with its known adversity toward both local resident health and the environment as a whole, is atrociously short sighted.

With the problem and recourse in sight, the next step was to try to identify the unique qualities of existing desert communities. To this end, Michel Foucault's definition of Heterotopia well resonates:

“There are also, probably in every culture, in every civilization, real places – places that do exist and that are formed in the very founding of society – which are something like counter–sites, a kind of effectively enacted utopia in which the real sites, all the other real sites that can be found within the culture, are simultaneously represented, contested and inverted. Places of this kind are outside of all places, even though it may be possible to indicate their location in reality. Because these places are absolutely different from all sites that they reflect and speak about, I shall call them by ways of contrast to utopias, heterotopias.”[9]

It is deduced that heterotopias are ‘other places’ or ‘places of otherness’. They are imaginary and at the same time real. As a post-modern concept, the fascination with heterotopias relates to their ambiguity and multiplicity. This concept captures the characteristics of human and natural systems in the desert, which are otherwise extremely varied. The common denominator of these places is therefore their ‘otherness,’ and by their otherness, they define and comment on commonplace ‘real sites’.

From here, the thesis developed through preliminary design exercises that lead me to the idea of a living machine in contrast to Le Corbusier’s modernist notion of a machine for living. These initial explorations continued my thoughts of the infrastructural functions of buildings and cities, but directed them toward the way a living organism operates, a machine that is alive; an ecosystem.

I then wished to gain a better understanding of the Negev desert. A valuable resource was the Jacob Blaustein Institutes for Desert Research and specifically, the institutes’ Albert Katz International School for Desert Studies, operating from Sde-Boker in the Negev. This institution is one of a kind in Israel and perhaps the world in its multi-disciplinary approach to desert study. Collaboratively, through its departments, a comprehensive volume of research is carried on topics varying from archaeology, sociology, policy, ecology, building science, planning and more. The publications put out by the institutes’ students and faculty provided continuous reference and insight into the specifics of real issues researched in the Negev today.

I visited Sde-Boker and the institutes in spring 2009, and was welcomed by Isaac Meir and David Pearlmutter who generously shared with me thoughts about their research interests and student work. I was especially impressed by the way the academic community of Sde-Boker exemplifies through its own desert architecture and everyday lifestyle, a vitally reciprocal relationship of design and research, impacting each other in a back and forth dialogue.

That same visit to Israel initiated the intentional process of collecting specific information to be later organized methodically. Following the visit to the institutes, I attempted to collect relevant mapping information. Finding this information proved to be challenging as I discovered many desert areas are not properly mapped, not updated regularly or access to them restricted due to security policy. Some of the maps obtained were through the Geography department of Tel-Aviv University, while others were eventually acquired electronically. The intricate politics of mapping and their availability is a topic which will not be elaborated on here, but it is important to note its far reaching implications on environmental design.

METHODOLOGY The thesis is structured in four parts:

PART I - FERTILE VISIONS constructs the mythology of the Negev desert as envisioned by David Ben-Gurion, Israel's first prime minister and a leader in the Zionist movement. The Negev was conceived as a fertile, uncontested ground for development, agriculture and settlement. Ben-Gurion emphasized the importance of a pioneering movement southwards which was to be supported by technological innovation:

"Without the settlement of the south and the Negev, this country cannot be secure, and we shall not succeed in attaining economic independence. They cannot be settled without the transformation of the facts of nature, which is not beyond the capacity of science in our day or the pioneering energy of our youth. Science and pioneering will enable us to perform this miracle."[10]

The utopian paradigms that impact settlement patterns of Israel and specifically, the Negev, are examined and their realization in the communal model of the Kibbutz is outlined. The model is investigated through the evolution of three generations, in an attempt to decipher the aftermath of realized Utopias and their viability as community models. This investigation is informed by the writings of Ita Heinz-Greenberg, Emanuel Tal[11] and Aryeh Sharon[12], linking utopian ideas to the development of early Israeli settlement models. Complementary to this topic is Bracha and Michael Chayutin's comprehensive research examining the connection between ideology, geometry, utopia and architecture in both international theoretical models and their realized Israeli counterparts.[13]

Finally, this section outlines the limitations of the utopian paradigm in accommodating the changing needs of the developing Israeli communities. The embedded subversive nature of Utopia is revealed through its territorial and colonial undertones, as criticized by Sharon Rotbard in his analysis of the 'Wall and Tower'[14] settlement system.

PART II - EPHEMERAL FLOWS applies James Kay's ecosystem approach[15] to analyze the Negev ecosystem through a multitude of scales and relevant trends. This approach identifies similar behaviours of self-organization between natural and human systems and therefore includes the latter in the broader definition of an ecosystem. Kay and Boyle emphasize the significance of such understanding:

"The most important scientific challenge facing humanity is to understand the co-evolution of the natural world and the human constructed world that together form the biosphere of our planet. Only with this understanding can we begin to manage our affairs such that the biosphere is healthy and vibrant, both now and in the future."[16]

The analysis carried in this part establishes a framework of holarchic scales in which the system operates. It identifies a series of ephemeral flows which ultimately indicate the system's instability. The flows and processes explored through this analysis include: desertification, solar radiation, water flows, energy flows and population flows. Finally, the links between these flows are identified and a synthetic approach is proposed.

PART III - VITAL SIGNS catalogues a collection of water management and solar energy generation precedents spanning from antiquity to current times to provide a resource of available technologies and strategies for future interventions. While energy generation is a primary motivation for desert settlement, water availability is the limiting factor of the system and its management will need to be addressed primarily and most thoroughly.

In the field of water management and agricultural systems in arid regions, significant work has been carried out by Michael Evenari, Leslie Shanan and Naftali Tadmor who laboured to unearth and revive these ancient systems.[17] Among their discoveries are Qanat networked wells, microcatchments and runoff farms. Daniel Hillel describes systems for catching and storing runoff and harnessing flash floods by means of underground cisterns and diversion channels.[18] More contemporary examples include using drop structures for erosion control and constructed wetlands for biological purification. Other recent projects exemplify a weaving of these infrastructural functions with recreational and cultural infrastructure within a vibrant urban fabric.

In the field of energy generation, an expanded scope of current solar technologies is provided. In *A Golden Thread: 2500 Years of Solar Architecture,* Ken Butti and John Perlin portray an evolutionary history of the development of solar architecture and technology, from passive solar gain, through burning mirrors in antiquity, to concentrating solar collectors and photovoltaics of the modern era[19]. Other interesting technologies considered include the convection towers experiment in Manzanares, Spain and Helio-Stat fields developed by the Israeli company Bright Source.

To conclude this part, notions of hybridized systems are explored through several projects operating as controlled environments: John and Nancy Todd's *Living Machines*, The *Biosphere 2* experiment in Arizona, Grimshaw Architects' *Eden project* and *The Sahara Forest Project*.

PART IV – EFFECTIVE TERRAINS, in a culmination of the three preceding sections, uses the case-studies investigated and the theories developed to derive design strategies, and propose a design for integrated desert community infrastructures. The proposal synthesizes operations of water flows, energy fluxes, agricultural cultivation and community life. These infrastructural operations are weaved into the landscape of Wadi Pharan, an eminent, yet ephemeral stream bed in the Central Negev, as they underpin prosperous desert life.

ENDNOTES

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01.

Fertile Visions

fig. 1.1 Moshav Nahlal- utopian settlement planning

PROPHECY

"The wilderness and the parched land shall be gladdened;
And the desert shall rejoice, and blossom as the rose.
It shall blossom abundantly, and exult,
Even with joy and singing;
And the glory of Lebanon shall be granted it;
The splendour of Carmel and Sharon...
Strengthen ye the weak hands,
And make firm the tottering knees.
Say to them that are of a fearful heart:
"Be strong, fear not..."
Then the eyes of the blind shall be opened,
And the ears of the deaf shall be unstopped.
Then shall the lame man leap as a hart,
And the tongue of the dumb shall sing;
For in the wilderness shall waters break forth,
And brooks in the desert.
And the parched land shall become a pool,
And the thirsty ground springs of water;
In the habitation of jackals herds shall lie down,
Amidst lush grass and reeds and rushes.
And a highway shall be there, and a way,
And it shall be called the way of holiness...
But the redeemed shall walk there.

-(Isaiah 35:1-9)"[1]

1.1 Ben-Gurion- The inception of Negev Visionary Mythology

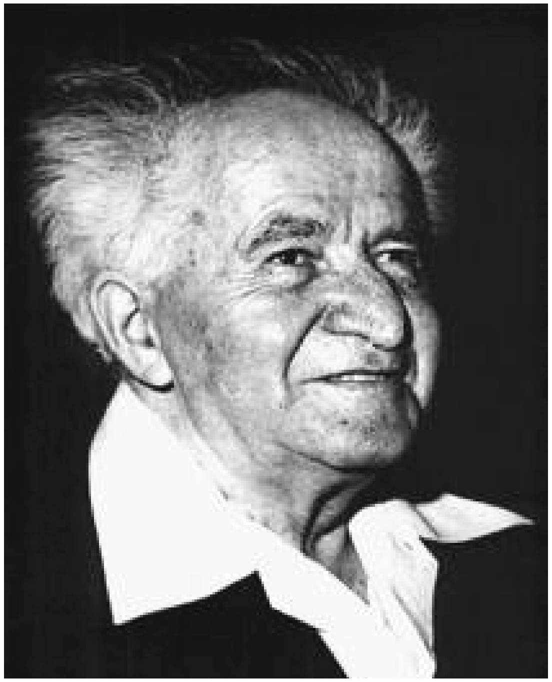

fig. 1.2 David- Ben Gurion portrait

David Ben-Gurion, a dominant figure in the Zionist movement, who was to become Israel's first prime minister mentioned the Negev as early as September 1935 in a letter to his children from Lucern, following the Zionist congress:

"For over a year I've been talking to the high commissioner about the Negev- a huge tract of land in the south, running from Gaza to Akaba, about eleven million dunams in all. Part of it is desert and useless. But there is also good land in the Negev, and if we can only find water in it a large and almost empty territory will be opened for mass settlement."[2]

Earlier in April that year Ben-Gurion visited the Negev with Berl Katzenelson and Eliahu Epstein, specialists of the political department on Arabs and the East. They were among the first Israelis of the new era to have visited this area and the first Zionist leaders to recognize the potential in the Negev for the Zionist movement. For the first time Ben-Gurion realized that in this place there would be no friction with the Arabs as there was in other parts of Palestine and that the 'Zionist vigour' and need for a land to settle could bring a renewed revival and blooming to the desert.[3]

Although the Negev was initially not incorporated into the UN's partition plan, Ben-Gurion believed that with time and increased Jewish immigration the Jewish people would make their way, peacefully if possible, towards inhabiting the Negev. As he mentioned in a letter to his son Amos:

"All our aspiration is built on this assumption, proven throughout our enterprise, that there is enough room for ourselves and the Arabs in Palestine."[4]

Ben-Gurion assumed that the Arabs could not and would not desire to inhabit the Negev themselves. He felt that a conflict could only arise if the Arab population chose to prevent the Zionist settlers from cultivating a land otherwise unused.

Ben-Gurion's faith in the Negev persisted and his early visions, inspired by the early biblical prophecies, evolved with the political concerns of the time. Ben-Gurion's exclamation that "The supreme test of Israel in our generation lies, not in its struggle with hostile forces without, but in its success in gaining domination, through science and pioneering, over the wastelands of its country in the south and the Negev"[5], still echoes strongly today.

Yet the challenges of the desert were not to be easily overcome: "Everywhere they went they looked for water and did not find any. The place looks as if the creator had just finished it. The glory of nature is one thing and the settling of Jews is quite another. The difficult questions remain" (Katzenelson).[6] Despite the hardships, Ben-Gurion had an unwavering faith in the Negev's role for the settlement of Israel.

The war of 1948 brought about a major change in the political map. Israel gained independence and was founded as a state. The results of the war placed the land from Metulla in the North to Eilat in the South in the possession of the new state of Israel. To this outcome Ben-Gurion commented: "All legal and political hindrances to the settlement of the bulk of the country's lands have been removed – and the great part of the soil of the new Israel is in the south and the Negev."[7] And indeed, the Negev desert made up approximately 60% of this newly acquired land, most of which was uninhibited, save for the semi-nomadic Bedouin tribes, who roamed the desert since 5000 BC.[8]

In1963 Ben-Gurion, as a state visionary, whose unimaginable dream had materialized, extended a motivating call to new generations of pioneers: "It is absolutely vital for the state of Israel, for both economic and security reasons, to move southward: to direct the country's water and rain, the young pioneers and the new immigrants, and most of the resources of the development budget, to the south."[9]

Ben-Gurion identified the problems of water and power as of the highest priority. He encouraged further developments in the field of sea water desalination, aided by technological advances. On the matter of solar power, he reflected: "The mightiest source of energy in our world, the source from which all animal and vegetable life is nourished, and only an infinitesimal part of which is as yet utilized by the human race, is the sun... The Negev is most plentiful provided with this form of energy, for there are few cloudy or rainy days."[10] He continued to assess that long after all other natural resources disappeared, solar energy would still reach the earth in abundance. Ben-Gurion then urged scientists and 'technologists,' to devise effective means to put this resource to use.

fig. 1.3 Ben-Gurion's first planning survey to the Negev.

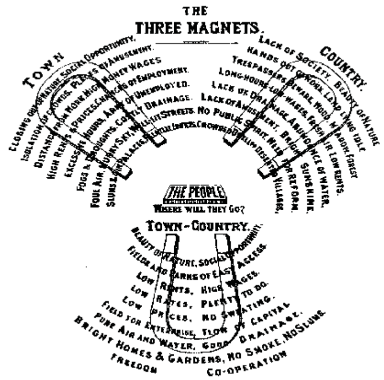

fig. 1.4 Howard's Three Magnets Diagram

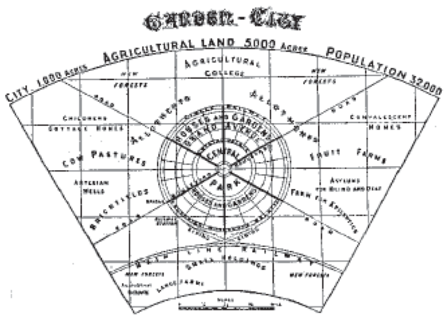

fig. 1.5 Howard's Garden-City Diagram

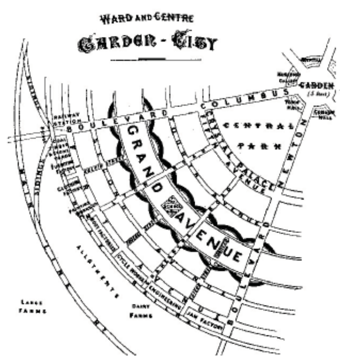

fig. 1.6 Howard's Garden-City Detail

1.2 Utopian Paradigms in the Settlement of Israel

Ebenezer Howard's Garden City developed from a desire to improve the living conditions of urban populations, through a newly devised concept for urban planning: the 'Town-country.' This new urban form was to provide all the benefits of both town and country living; the beauties of nature with the economic comfort of the city, while avoiding their respective disadvantages such as the sanitary degradation of cities and the lack of public spirit in the country. The people, as manifested in the three magnets diagram (see fig. 1.4), would naturally be attracted to the Town-Country magnet, choosing it over the two lesser options.

Two decades later, the Zionist movement, in search of an urban form for its new settlements in Palestine, as well as a new social order to reform the new Jewish society, adopted Howard's vision. In the early 1920's the Palestinian Garden City society, founded by David Trietsch worked to propagate the Garden City ideal throughout Palestine. Trietsch believed that Howard's model, combining agriculture and industry within a prototype society was more appropriate for the new colonies in Palestine than the European rural model. This model in particular, required resources not available in Palestine of the time. In his writing Trietsch refers to Howard's own description of the ideal city layout:

"A simple layout for the inner city is the grouping in circles, that presupposes flat grounds. In the center, public buildings and squares, one or more ring roads with houses and proper gardens (front gardens for flowers, back gardens for vegetables and trees), and a simple or double external ring-road, where the factories are located and which is crossed by a railway connection. The third exterior ring- road would have homes with bigger gardens and land for agriculture. The circle would be intersected by four, six, or eight straight roads."[11]

Many Kibbutzim, Moshavim and small communities followed these patterns, if not formally like Moshav Nahalal (see fig. 1.8), then certainly in spirit and in the established relationships between the environment, the community and the individual.

In his article "Gartenstadt" ("Garden City), on the application of Garden cities in Palestine, Franz Oppenheimer established the link between social structure and urban planning. In his view, the garden city was a realization of a co-operative social form.[12] Its design should be homogenous so as to minimize costs, but also to establish the city as a single work of art and prevent surfacing of disorder and personal differences.

This view echoes Thomas More's account of "Utopia" from 1516: towns of houses in a row, all of the same plan, proportion and build.[13] All Utopians dressed with the same simple garment, not wishing to distinguish themselves from one another by the thread of the fabric or jewellery that they wore. There was no private ownership of money, gold, silver or other precious materials. These were owned by all and reserved in the communal treasury for external commerce alone. Within the community, it would be considered a disgrace to adorn them. Furthermore, jewellery became a symbol that marked slaves and convicts, to single them out of society.

One of the most noteworthy models of collectivism to emerge at the time, lasting longer than many other models worldwide, and unique to the Israeli context is the Kibbutz. The Kibbutz is a collective agricultural community, whose members highly value equality and base their communal life on joint ownership of land, property and resources. They practice communal consumption, labour and education following the motto: 'From each, according to his ability; to each, according to his need."[14]

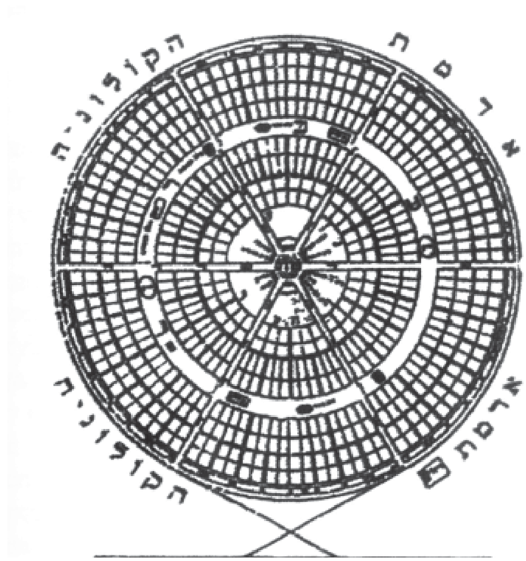

fig. 1.7 Circular colonial plan for a Garden-City in Israel

fig. 1.8 Moshav Nahalal- Aerial view

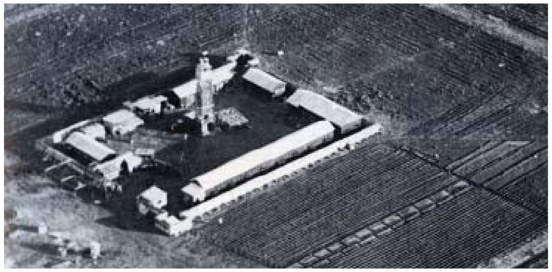

fig. 1.9 Twenties Kibbutz Planning

fig. 1.10 Kibbutz as an extended farm

fig. 1.11 Kibbutz young members as new farmers

In "Paths in Utopia," Ita Heinze Greenberg argues that social structures of egalitarianism and collectivism almost always are a consequence of an unmitigated necessity that arises in an acute crisis or state of an emergency.[15] In the case of the Kibbutz's earlier days, hardship and necessity were not foreign. The Eastern European settlers, who formed the first waves of immigration between 1905-1929, were faced with a hot and arid climate that they were not accustomed to. As well, the demanding agricultural labour of this land required experience they did not have.

From the social perspective, the often long separation from their families also proved to be a challenge. "The family was a thing of the past and now the '*Kvutza*' (the collective community) is our secure and true haven, joining people's souls in the hard struggle against chaos."[16]

These young immigrants, formed a new social structure through their search of companionship with similar people and need to collaborate in agricultural efforts. They formed units of 8-10 people who had strong spiritual ties. A group size could sit around a family table, discuss the daily events, and plan for the next day's work. Joint dining then became a central communal activity for which planning provisions had to be made.

The first Kibbutzim used to be much like an extended family in social structure, since they replaced the nucleus family. Hence, the planning of the very first Kibbutzim took the form of the extended family farm estate: "The early Kibbutz of the twenties was built in the form of a rectangular courtyard, with dwelling quarters on one side, farm buildings on the other side and the dining hall and children's houses in central position."[17] At the very center of this rectangular (or U shaped) plan, stood a water tower doubling as a watch tower (see fig. 1.9). In fact, a wall and a tower were the minimum requirements for a new town to break ground, and the new settlers, through a methodology of prefabrication, put these elements up over night, so as to evade British interjection:

"Temporary buildings constituted the first construction stage for a new Kibbutz in an isolated area. According to Turkish law, in force during the British mandate, a building once erected, even though illegally, could not be torn down. The structural elements for all new stockade buildings were prepared, therefore, in a nearby, existing Kibbutz, and were transported and erected during one night, ready for use the next morning."[18]

Between the 1920's and 1940's, the Kibbutz increased from an intimate family of tem to a community of more than a hundred. Couples united in the Kibbutz, had children of their own, thus compromising the role of the Kibbutz as "The family substitute." Needs of developing agriculture required a much larger number of working hands, and more spacious facilities. New waves of immigration followed the war, bringing with them stronger values of equality, collectivism and at times even anarchy. The Kibbutz design had to adhere to each of these added pressures and changes.

In essence, the Kibbutz remained a home but its infrastructure had to expand. The single communal farmhouse that accommodated all communal activities of dining, sleeping, congregating, farming and administration, spread out through the Kibbutz plan. This plan provided a building for each function that once required only a room. The general plan, however, was still organized around a central courtyard, much like the original farm layout. Corridors became external pathways and the dining table became a dining hall, functioning as the tribal fire and a locus of communal life.[19]

During the 1950s-1960s, the Kibbutz reached a point where agriculture could no longer sustain a sufficient source of income. As an alternative, many Kibbutzim started to incorporate industry into their urban fabric.

This shift in economy from self-sufficient, local and agricultural to a regional industry based structure, marked an ideological turning point. The Kibbutz started to rely on larger powers beyond its own boundaries to negotiate its livelihood and prosperity. Some members started working outside the Kibbutz as skilled professionals and service providers. During this time, many Kibbutzim switched from communal sleeping arrangements for children, to families sleeping together. The Kibbutz society experienced a fragmentation process, where its members disintegrated from a society sharing similar values and goals, to varied individuals with multiple characters and ambitions.

The changing times and necessities of finances brought about a major crisis of ideology, a crisis from which the Kibbutz movement as a collective was never quite able to recover.

fig. 1.12 Farming in the desert

fig. 1.13 Kibbutz Matzuva's textile factory- one of the first kibbutzim to incorporate an industrial branch..

fig. 1.14 Contemporary textile machinery in kibbutz Matzuva

Today, the Kibbutz movement continues to endure this crisis. As members of the third generation reached their prime, many of them chose to leave the Kibbutz. Having been born in the 1980's, this generation witnessed the global downfall of socialist structures. While at the same time, it has seen a change in Israeli society to one driven to capitalist achievement. "The kibbutz was never isolated from society," says Shlomo Getz, the director of the Institute for Research of the Kibbutz at Haifa University. "There was a change in values in Israel, and a change in the standard of living. Many kibbutzniks now wanted to have the same things as their friends outside the kibbutz."[20]

As the Kibbutz population continued to age, the younger generations continued to depart. The veterans who remained consisted mostly of a senior population (65 years of age and older). The remaining members could no longer meet the heavy workload required to sustain the community, and many Kibbutzim were faced with a financial struggle. As a result, and following a 1985 debt crisis and consequent government bail-out, many Kibbutzim elected to incorporate privatization measures[21] such as differential salaries, payments for services, allowances, hired work, and non-member neighbourhoods.[22]

With facilitating non-member developments, new residents now choose the Kibbutz for its perceived improved quality of life compared to that of the city. These residents often choose to keep their previous jobs and commute to the city daily. As Israel's metropolitan areas inflate and consume all rural areas within their vicinity, many Kibbutzim may evolve into 'North-American' style suburbs, a phenomenon out of place and out of the Israeli context. The Kibbutz movement has grown increasingly fragmented as each Kibbutz's balance between the individual and the community is delicate and differs from one Kibbutz to another. The Kibbutz no longer exists as the intimate, ideology driven, familial group of its idealistic heyday. Today it is a struggling society in search of a social equilibrium and a new urban form.

1.3 Points, Lines and Territories

As a timeless, mythical icon, the wall and tower of the early Kibbutzim remain an omnipresent symbol ingrained in the Israeli collective memory. 'Wall and tower' is the first model of both the community and the military base simultaneously. Home and camp were synonymous from inception, and therefore any later attempt to disengage them has been met with resistance.

Rotbard speaks of the importance of the 'Wall and Tower' symbolism to the making of a place: "As an almost dimensionless point in space, Wall and Tower is more an optical instrument than a place- an all seeing eye that cannot see itself. But nevertheless, with its Wall, its Tower, and its four shacks, Wall and Tower is a rough draft of a place."[23]

As an image, the Wall and Tower is always in motion. According to Rotbard it is a perpetual construction site.[24] It embodies a national ethos of *Rebuilding the Land of Israel,* perpetuated by Ben-Gurion's utopian visions of not only the Negev but of Israel as a whole. Building is perceived as the joint and binding destiny of the land as the words of a popular song demonstrate: "We came to this land to build and to be built."[25] The Perpetuum Mobile could not be stopped, as the pioneers and the state to come, are in an ever dynamic motion to transform the land.

In "Public-space heterotopias", Yael Allweil and Rachel Kallus discuss this subversive relationship between the newly forming Israeli identity and the construction of the land of Israel. The prevailing approach was that 'people without land are weak, effeminate, impotent.' The Jewish people of the Diaspora's existence had no land of their own, were transient and lived a life of impermanence, always dependant on the goodwill of a hosting nation. However, the Israeli born 'Sabra, - a self-prescribed title in Hebrew that alludes to a thorny desert plant with a soft, sweet interior - was to become independent, fit and strong through the hard work and construction of his own land. This was both a calling and a moral necessity. According to Allweill and Kallus, The Zionist ideology placed great importance on the link between territory, body and identity. The nature of that connection was not 'one of containment but of mutual construction."[26]

However, when the Wall and Tower form a network of lines and points, meticulously arranged along the borders, architecture is dominated by militarist strategy. The Wall is reduced to a line, a boundary, and a threshold. Rotbard also points out the search of a borderline in this context as a means of self definition.

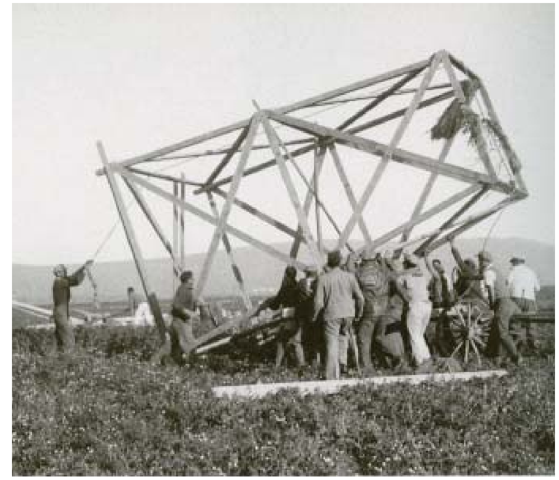

fig. 1.15 Erecting the tower, marking down the 'point'

fig. 1.16 Constructing the wall, defining the bounding 'line'

fig. 1.17 A complete 'Wall and Tower' town

fig. 1.18 Idealistic military planning, Palma-Nova, 1597

The act of drawing the line is a political act of control and possession over the land, differentiating between 'inside' and 'outside,' 'us' and 'them,' 'civilization' and 'wilderness.' The Tower is a surveillance apparatus, as well as the point on the map, whereby strategic emplacement enables the stretching of the line, from one point to the other. "The 'point' on the map becomes more important than the 'settlement" itself', argues Rotbard,[27] and the architecture of Wall and Tower, as a process of rapid placement of strongholds, replaces a genuine affiliation between the people and the land.

A network of points and lines establishes a territory. A territory in itself is a deceiving term, referring to "a geographical area, belonging to or under the jurisdiction of a governmental authority."[28] Yet it is questionable whether a geographical area can truly be owned by a private or a political entity, and what the ramifications on its ecological integrity become. Wall and Tower architecture is offense in the guise of defence, in as much as it is rewriting the memory of the land.

As Ignasi de Sola-Morales observes: "When architecture and urban design project their desire onto a vacant space, a terrain vague, they seem incapable of doing anything other than introducing violent transformations, changing estrangements into citizenship, and striving at all costs to dissolve the uncontaminated magic of the obsolete in the efficacy."[29]

The term 'Terrain Vague', commonly interpreted as 'Wasteland', is most often used when referring to reclamation of abandoned or non-developed sites within a dense urban fabric. The desert embodies this dual quality of the 'Terrain Vague'; it is an ambiguous territory, conceived as void of all life while at the same time impregnated with sublime qualities and the imminent potential for a genuine, even cosmic existence.

When interacting with the desert, much like its urban counterpart, the 'Terrain Vague,' it is assumed to be devoid of past and present. The utopian plan wishes to bring it into life by giving it a future. We aim to conquer the wilderness, establish boundaries, order mechanisms and control devices enabling the annihilation of the void. In fact, this act is in the very essence of architectural utopianism.

1.4 Emergency

The story of the Kibbutz is brought here, because it is the community 'type' most prevalent in the process of the Negev settlement. Moreover, the evolution of the Kibbutz from hopeful Utopia to a painful awakening to reality embodies the loss of innocence of the Israeli society as a whole. Through 'points, lines and territories,' the mechanism of place making, in Israel and in the Negev particularly, is exposed. It is revealed as strategically aggressive, destructive to the land and its inhabitants and far from innocent. A continuous state of emergency has always been the reason and justification for this state of affairs. In a place where life under fear of attack is a daily routine, city becomes camp.

In "Heterotopia- an ecology" James D. Faubion describes the condition of the camp: "Like *Heterotopia*, the camp is a space that is 'neither economical or political,' however in a very different manner. It is a space in which the very distinction between the economical and political, between the public and the private, has been suspended. Heterotopian space as space of mediation entertains very precise relations to the other spheres. The camp, in contrast is the object of total rejection, a space devoid of mediation, unrelated in a sense of residing outside of all relations. If the heterotpia is the place for otherness, for 'alterity', then the camp is the space where the other, all otherness, is abolished, annihilated."[30]

Israel is a place where military camps are in the midst of bustling cities like Tel-Aviv. Young soldiers, girls and boys in uniform, can be mistaken for scouts, due to their carefree, casual demeanour as they walk about the city. The 'interchangeable character of camp and settlement'[31] is further enhanced by the normalization and inclusion of militarism in everyday life.

A permanent "state of emergency" has legally been in place in Israel since its foundation in 1948. Whether the external threats justify such a condition or not, the "state of emergency" has often permitted overstepping of the democratic law and the public's best interests in the name of national security. By the power of habit the public has grown comfortable with anxiety.

Morales makes an argument for the power of resistance, as opposed to submission or delinquency, to counteract this condition of emergency and the architecture of colonization it harbours:

"An architecture and an art of resistance go beyond the formalism of the thousand reflected images of deconstructivism's spaces, beyond the silent voids of minimalism. In both, it is from the outside, from the text

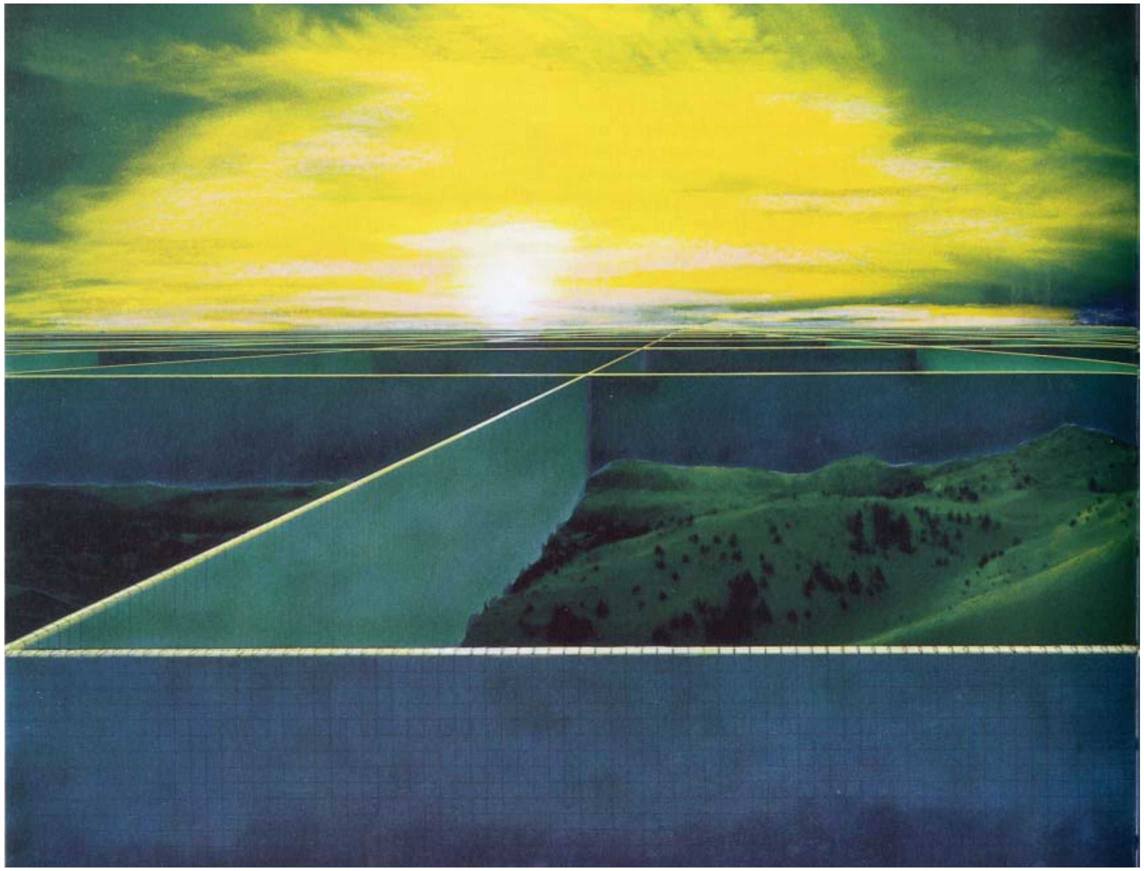

fig. 1.19 Superstudio- The twelve ideal cities

or the object, that alternative worlds are generated. In a culture of resistance, the subject, individual or collective, must take the initiative and the risk, using its intelligence to escape, to break, to punish, if only momentarily, Polyphemus's permanently watchful eye."[32]

In "Thesis in the philosophy of history" Walter Benjamin also comments on the condition of emergency and how we might react to resist it:

"The tradition of the oppressed teaches us that the "state of emergency" in which we live is not the exception but the rule. We must attain to a conception of history that is in keeping with this insight. Than we shall clearly realize that it is our task to bring about a real state of emergency and this will improve our position in the struggle against fascism."[33]

This 'real state of emergency' in the context of the Negev is the necessity to face the environmental challenges imposed equally by the nature of the desert landscape as well as by past human interventions.

1.5 Aftermath and Purpose

In 1953 Ben-Gurion, at 67 years old, resigned his political roles and joined Kibbutz Sde-Boker in the central Negev, so as to set a personal example of desert pioneering. He chose to live in the same quarters as all other Kibbutz members and to be integrated into the daily work schedule. Ben-Gurion was later buried in Sde-boker, beside his wife Paula, overlooking a spectacular panorama of Wadi Zin. Sde-Boker College and the institutions for desert research were founded in fulfilment of his will, and as means to advance his legacy of ever pushing forward the desert frontier.

Ben-Gurion's vision, although propagated through a series of localized initiatives, some of which were successful and inspiring, did not achieve the sufficient momentum necessary for its full realization. Most settlement efforts in the Negev remain esoteric at best, and are concentrated along the borders, creating a living buffer of outposts.

This thesis argues, however, that a genuine appropriation of the desert land, through ecological understanding of its operations and the ability to bring this knowledge to prosperous realization, is a challenge not yet overcome. Furthermore, the emphasis on political and military occupation is a hindrance to the advancement of such vision. A vision which recognizes that diversity is essential to the healthy operation of any system as a whole, and should therefore be encouraged.

The purpose of this work is to revisit this mythical vision of the Negev and adapt it to a current, ever shifting context of values, crises and emerging challenges. The thesis will explore the role of architecture and urban planning in re-forming a contemporary vision of Negev settlement. It aspires to progress Ben-Gurion's vision in acknowledgment that this community cannot be based only on a common ground of religion, nationality or political affiliation. It could only succeed based on a common need to survive in this harsh and barren environment, and the foresight to do so in a long standing prosperous manner.

Throughout the years, the state of Israel has taken on numerous major infrastructural projects, both in terms of finance and technological feat, significantly transforming the terrain and the environment. The national water carrier, which transports water from the Sea of Galilee to centers of population across the country, is one such example. The electrical system, that produces energy solely from imported fossil fuels is another. The next chapter will survey these projects and their consequences.

fig. 1.20 David and Paula Ben-Gurion's burial ground in Sde-Boker

fig. 1.21 Ben-Gurion in Sde-Boker, 1966

fig. 1.22 View of wadi Zin from Sde-Boker Institutes

ENDNOTES

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2 David Ben-Gurion and Peninah Ben-Gurion, *Letters to Paula* (Pittsburgh: University of Pittsburgh Press, 1972), 78.

3 Shabtai Teveth, *Ben-Gurion : The Burning Ground, 1886-1948* (Boston: Houghton Mifflin, 1987), 494-495.

4 Ibid., 612-613.

5 Ben Gurion, *Israel: Years of Challenge*, 211.

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8 Martin Ira Glassner, "The Bedouin of Southern Sinai Under Israeli Administration." *Geographical Review* 64, no. 1 (1974): 31-60.

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17 Aryeh Sharon, *Kibbutz + Bauhaus: An Architect's Way in a New Land (*Stuttgart: Israel: Kramer Verlag ; Massada, 1976), 61.

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24 Ibid.

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26 Doron Gill, "Heterotopia and the Dead Zone," in *Heterotopia and the City: Public Space in a Postcivil Society, eds.* Michiel Dehaene and Lieven de Cauter (London ; New York: Routledge, 2008), 196.

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28 *Merriam-Webster Online Dictionary*., s.v. "Territory." http://www.merriam-webster.com/dictionary/territory (accessed September 18, 2009).

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32 Ignasi de Sola-Morales Rubio, "Colonization, Violence, Resistance," in *Anyway*, ed. Anyway Conference: Barcelona, Spain (New York: New York: Anyone Corporation in association with Rizzoli International Publications, 1994), 123.

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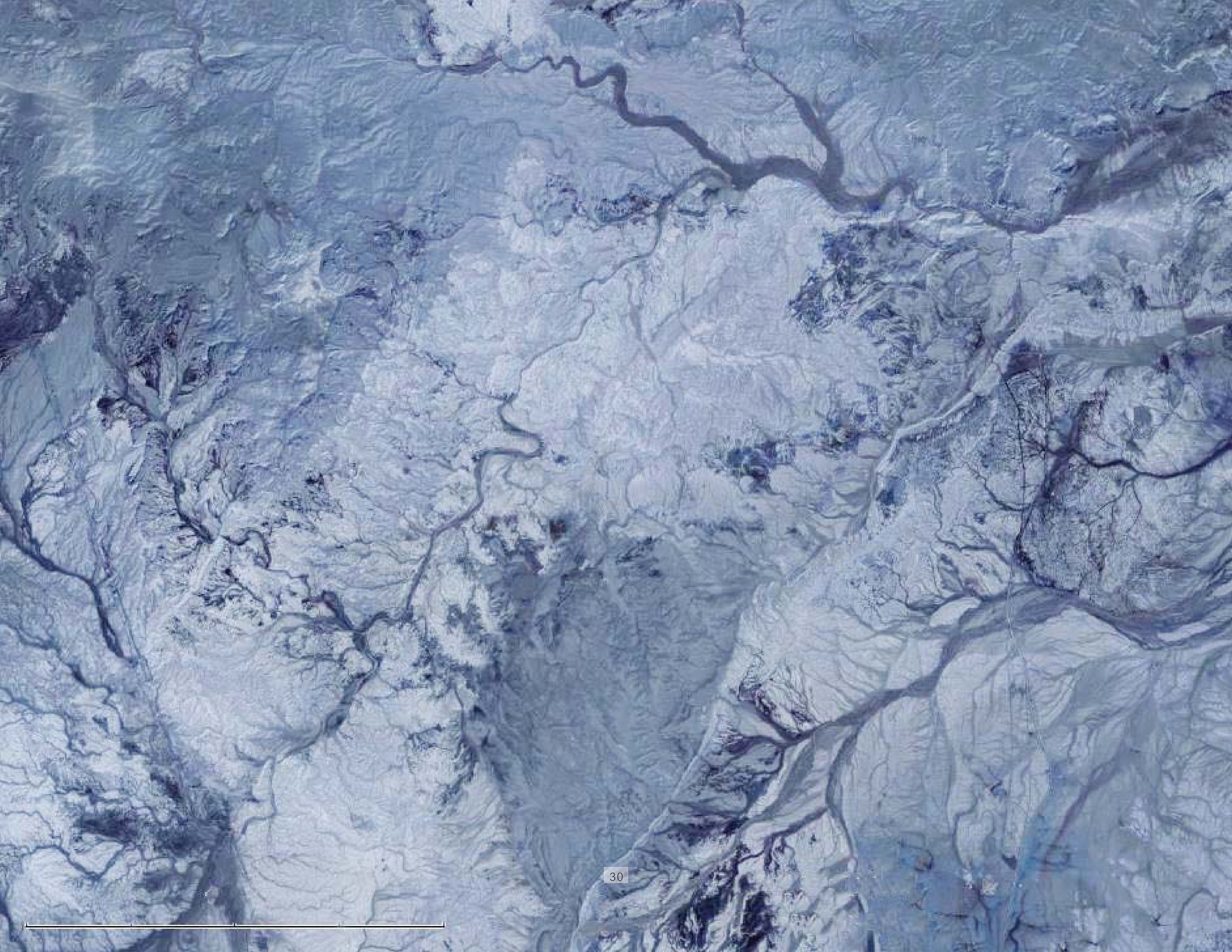
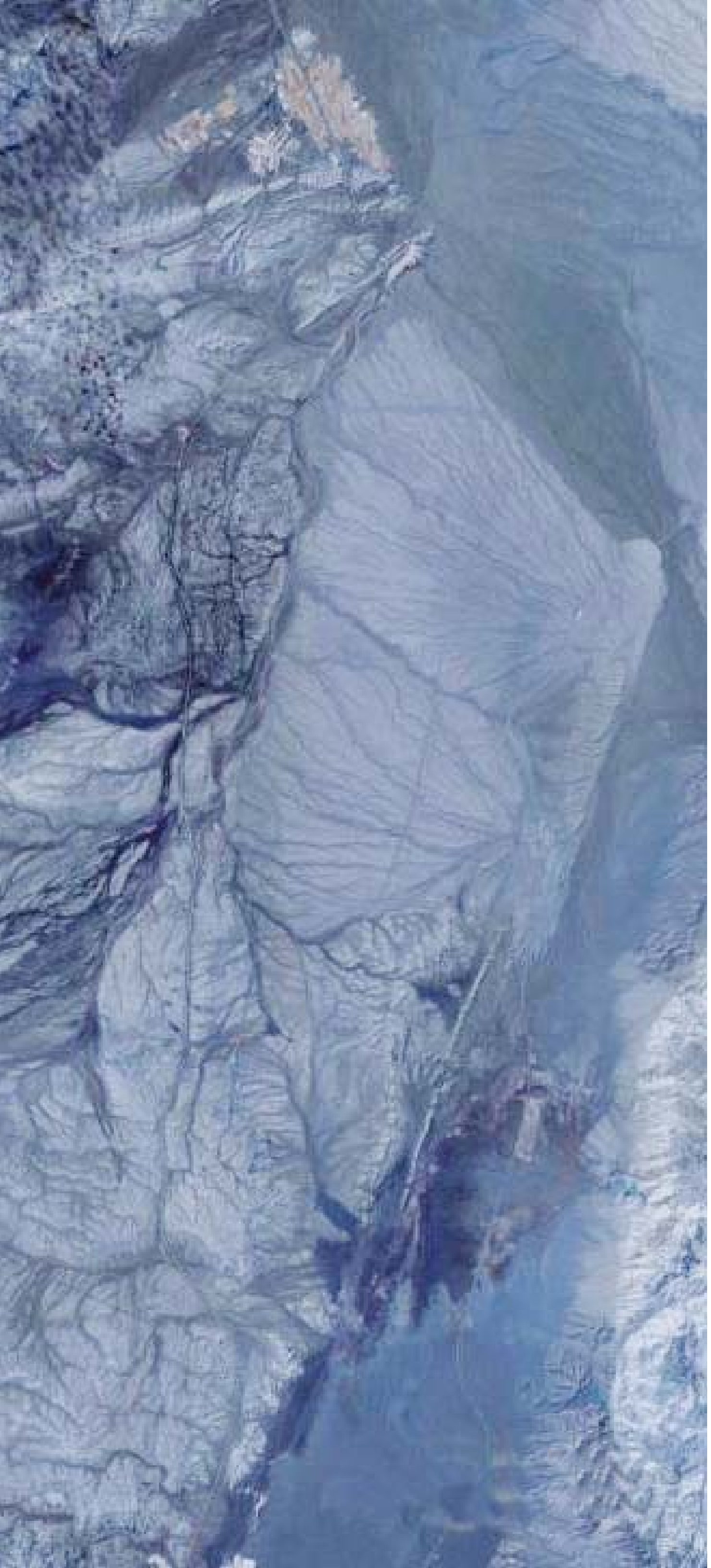




02.

Ephemeral Flows

fig. 2.1 Ephemeral streams in the Negev

2.1 Complex Ecosystem Analysis

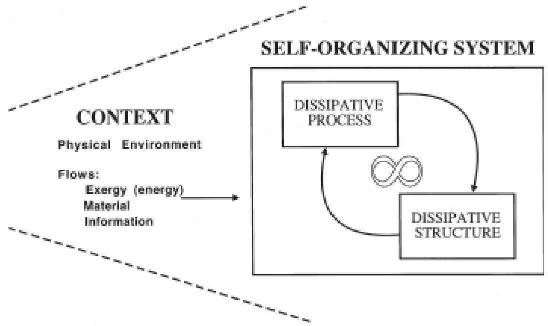


fig. 2.2 SOHO diagram by James J. Kay

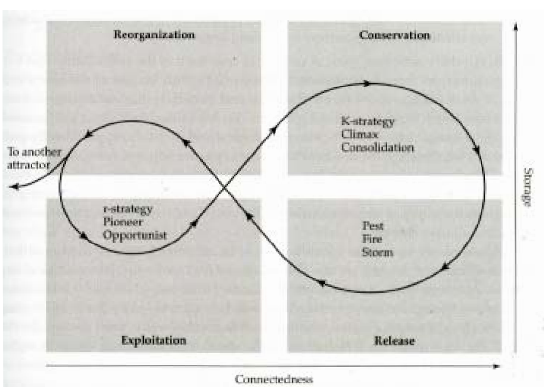


fig. 2.3 Holling's figure 8 model of ecosystem dynamics

In order to gain a thorough understanding of the complex systems in question, an ecosystem mapping analysis is performed, based on the 'ecosystem approach,' a methodology developed by James J. Kay. The ecosystem approach defines both human and ecological systems as Self Organizing Holarchic Open (SOHO) systems. They are characterized by a range of temporal and spatial scales, flows of high quality energy (exergy), positive and negative feedback processes, periods of coherent organization and chaotic/emergent behaviour induced by a catastrophe.[1]

SOHO systems (see fig. 2.2) follow a cyclical process of dissipation supported by the influx of exergy. The processes are determined by constraints of the environment or the context, which favours the stabilization of certain processes over others. The processes form structures which become part of the environment and determine a new context. The context informs new processes and so forth. As a result, a complex SOHO system emerges, within which nested dissipative processes and structures are contained.[2]

Each system experiences behaviours demonstrating a tendency towards a temporary equilibrium. The system's attraction towards a specific state of organization is determined by an 'attractor' influencing it. Along a cyclical dissipative process, a system will experience spontaneous shifts between attractors,[3] catalyzed by a drastic event (release of exergy). It will then enter a renewed state of re-organization as described by Holling's model of ecosystem dynamics (see fig. 2.3).

The following analysis is used in the narrative development for the SOHO system of the Negev desert. This analysis defines the spatial and temporal scales of the system; describes the physical environment (the context); and identifies attractors and exergy flows. The specific parameters investigated are; climatic, energy, water and population flows. The developed narrative is then used to inform decision making during the design process, which is interpreted as a new phase of system reorganization.

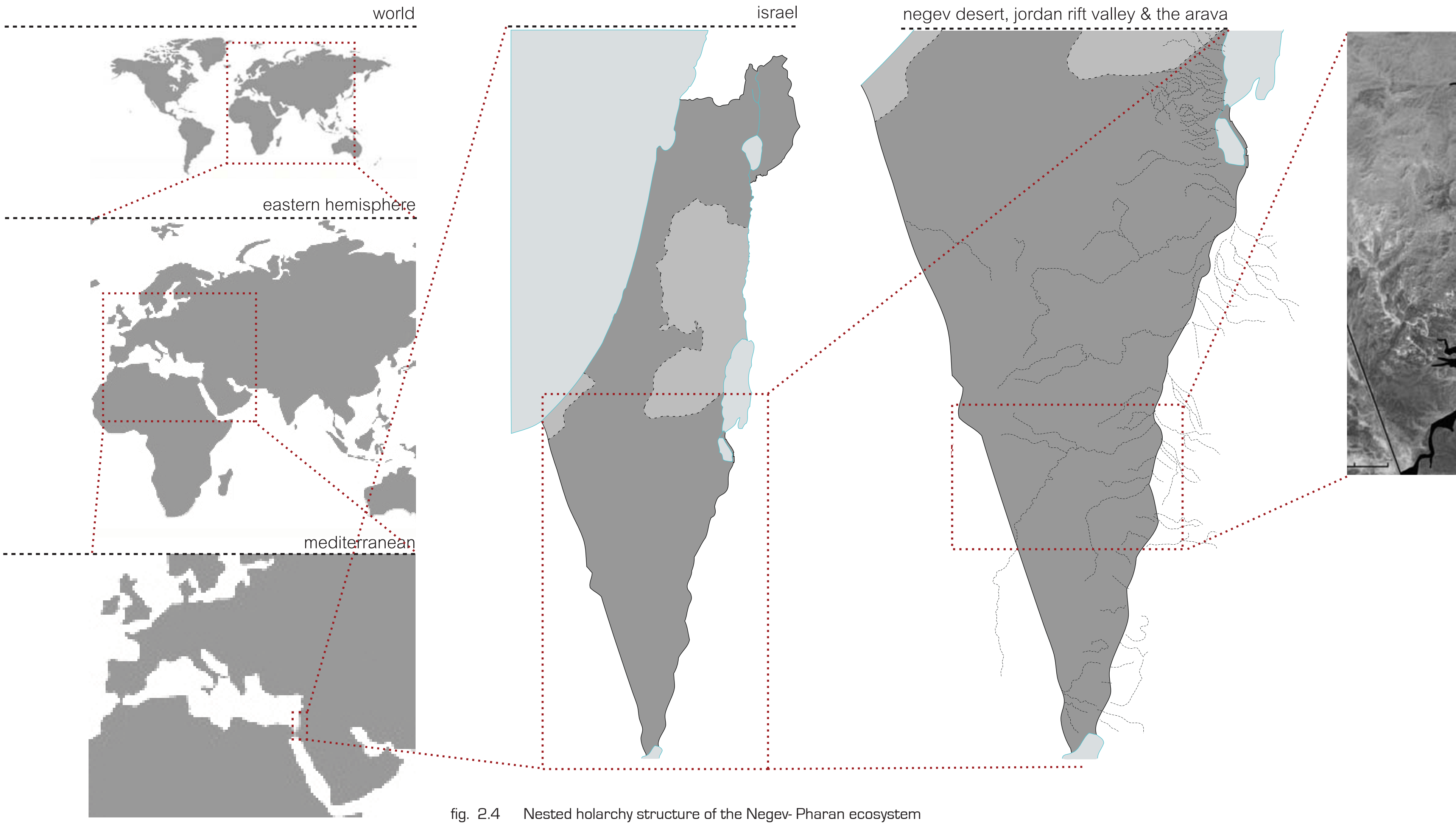
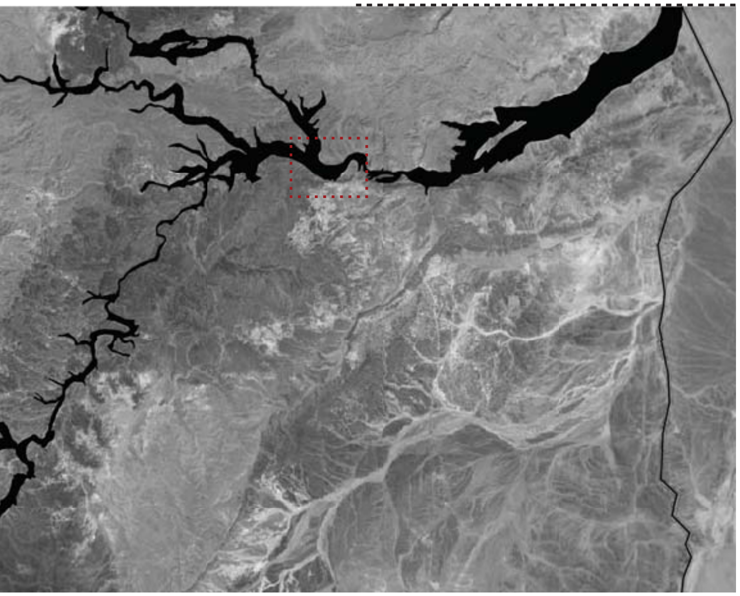


fig. 2.4 Nested holarchy structure of the Negev- Pharan ecosystem

wadi pharan watershed



Any given system operates on a variation of scales. In this method each scale is defined as a holon. Multiple holons are nested within each other to form the holarchy of the system. Holarchy by definition differs from hierarchy in that it allows interactions between holons across scales and types of phenomenon in all directions: top down as well as bottom up.[4]

For an individual holon, there is a unique set of attractors, that pushes it toward possible states of equilibrium. The physical environment is an influential factor that also contributes to a diversity of energy flows, to and from the system. Certain trends operate on a particular scale, while others operate across scales and are affected by the interactions between holons.

During the sixties Buckminster Fuller develops similar ideas regarding a broad system understanding across scales. In 1969, he discusses his general systems theory In “The operating Manual for Spaceship Earth”:

“We begin by eschewing the role of specialists who deal only in parts. Becoming deliberately expansive instead of contractive, we ask, “How do we think in terms of wholes?” If it is true that the bigger the thinking becomes the more lastingly effective it is, we must ask, “How big can we think?”

“Interaction of the unknown variables inside and outside the arbitrary chosen limits of the system are probably going to generate misleading or outrightly wrong answers. If we are to be effective, we are going to have to think in both the biggest and most minutely-incisive ways permitted by intellect and by the information thus far won through experience... If we could start with the universe we would automatically avoid leaving out any strategically critical variables.”[5]

To define the pertinent issues for this investigation, a system frame is defined. The system analysis starts on the largest scale deemed relevant, to avoid overlooking processes of the larger picture. The definition of the system is crucial, since it directly affects the problem definition and consequently the realm of possible solutions. It is acknowledged that any such system definition is ultimately rooted in perceived value and is subjective.[6]

This analysis focuses on trends of import or export, which are explored across the relevant scales. Trends are then assessed to determine their viability to the system’s integrity and health.

2.2 Climatic flows

Desertification and World Deserts

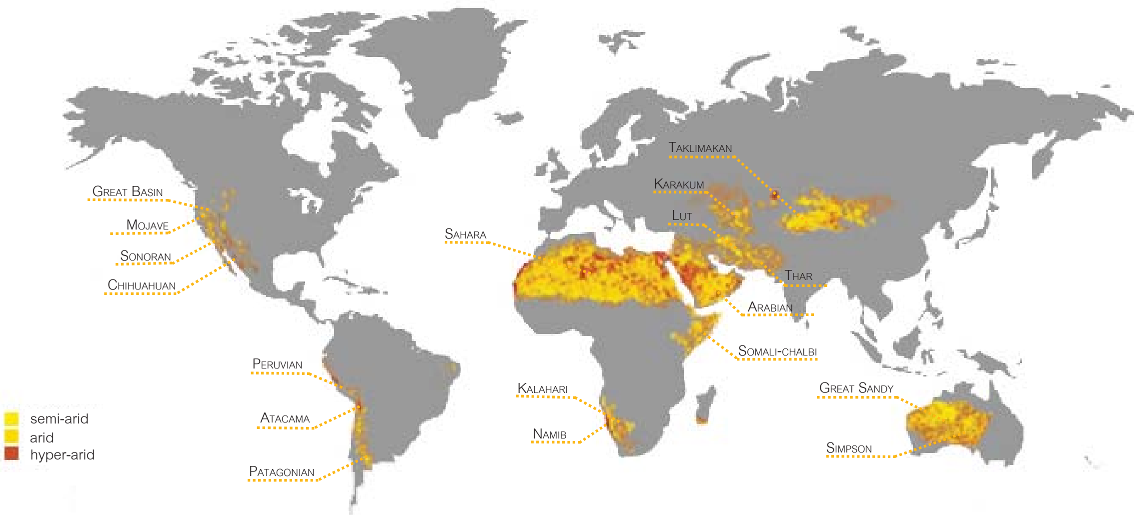


fig. 2.5 World deserts by level of aridity

Desertification is defined by the United Nations Conventions to Combat Desertification (UNCCD) as: "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors including climate variation and human activities."[7] The world's arid systems are mostly concentrated along two belts, one to the north of the equator (10-50 degrees latitude) and the other to the south (20-30 degrees latitude).[8]

The level of aridity is defined not only by amounts of rainfall an area receives annually but more accurately by the ratio of precipitation (P) to evaporation (E). While precipitation is easily measured, potential evaporation is less easy to gauge,[9] though it is generally proportional to average temperatures prevalent and is influenced by seasonal variations. Semi-arid regions experience P/E ratios of 0.2-0.4, arid regions - between 0.03-0.2, while hyper arid regions are characterized by P/E lower than 0.03.[10] This means that for every 3mm of rainfall, 100mm could potentially evaporate, resulting in a substantial humidity deficit. Generally, hyper-arid regions experience less than 100mm precipitation annually; arid regions receive 100mm-250mm and semi-arid regions take in 250-400mm of precipitation. In hyper arid zones, almost 30% of pre-

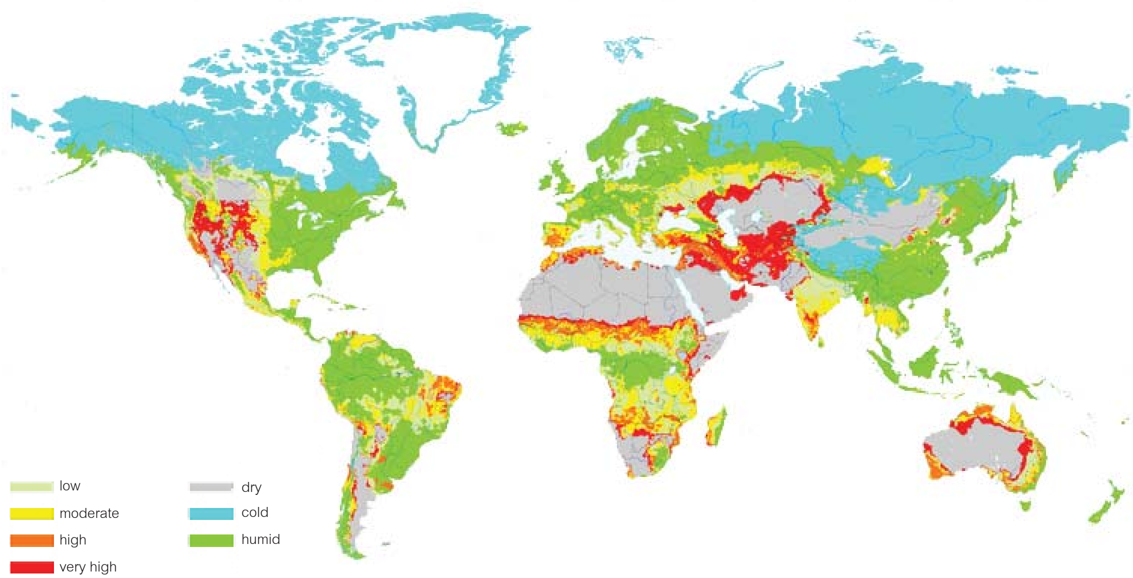


fig. 2.6 World vulnerability to desertification processes

cipitation can originate from dew, evaporating quickly during the daytime, rather than rainfall which can stay on the surface for longer periods of time, allowing for water to be absorbed by the soil.

Soil and land degradation, considered to be the most devastating consequence of desertification, is defined by the UNCCD as: “Reduction or loss of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland or range, pasture, forest and woodlands, resulting from land uses or from a process or the combination of processes.”[11] Consequently, the majority of desertified regions are some of the poorest and most underdeveloped countries in the world. Further desertification would inevitably mean increased loss of income from tourism and agricultural products, dire unanswered demand for freshwater, reduced food production, damages to body and infrastructures induced by flooding, sand storms and other natural disasters and, together, a depreciation in quality of life, and a potential threat to survival.

Arid zones make for almost 40% of the earth’s surface, and directly affect 250 million people, while approximately 1 billion people in over 100 countries remain at risk of becoming affected in the future.[12] While desertification clearly affects equatorial arid zones in a process accelerated by climate change, substantial land surfaces across the world, even temperate regions, are becoming increasingly vulnerable to desertification and land degradation, due to human activity. It is evident that, although not the single cause of desertification, climate change is a major catalyst of the process and the two phenomena are inherently intertwined. While cold and humid areas could possibly withstand a global increase of 2-3 degrees, for some arid lands it could be the end of the little life that still persists in these areas (see fig. 2.6).

Learning how to survive in an increasingly arid world may become a global necessity. Forming sustainable desert inhabitation patterns today, could not only provide invaluable experience for a potentially more arid future, but perhaps help to reverse some of the effects of desertification by restoring the land and its valuable resources.

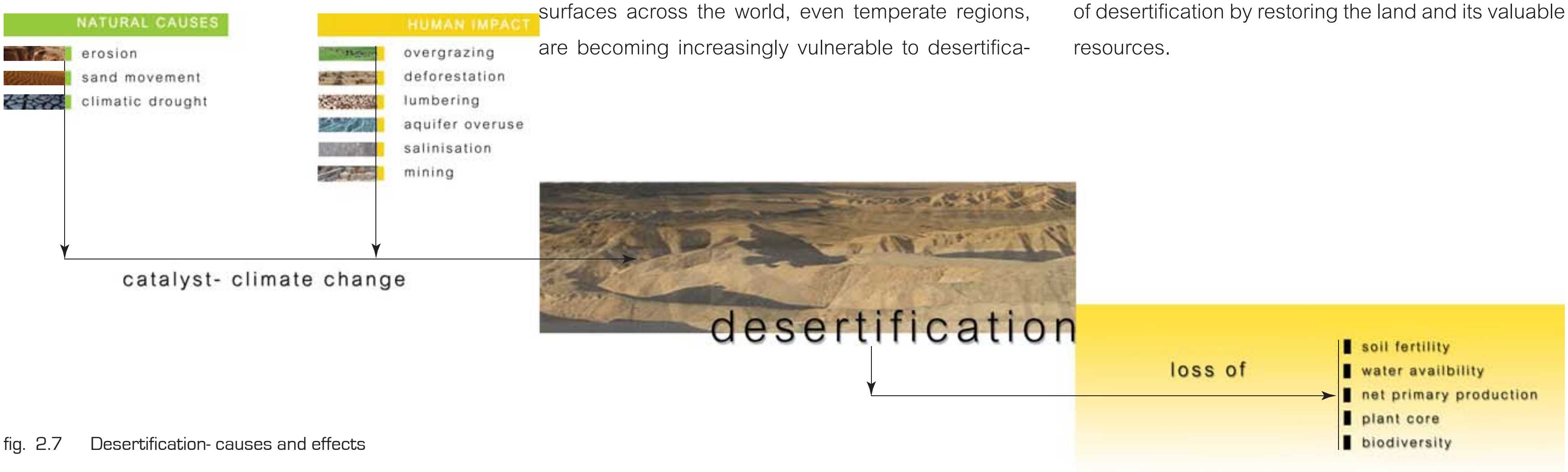
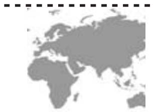


fig. 2.7 Desertification- causes and effects

eastern hemisphere



Incidentally, regions suffering from the harshest arid conditions are also the most suitable for solar energy production.[13] The very same high exposure to solar radiation that causes high evaporation rates and little precipitation, is ideal to harvest energy from the sun. As global energy resources are depleted, and an awareness to the risks associated with fossil fuel dependency rises, struggling countries in Africa and the Middle East have the opportunity to become the avant-garde of an emerging renewable energy industry.

In Israel, the Negev desert occupies approximately 60% of the country's land area. The desert's ecology is characterized by very low humidity, as low as 11% in the southern regions.[14] High temperatures, high evaporation rates and very low precipitation contribute to the arid nature of the region. Annual evaporation averages in the Negev start from 1700mm and can reach as high as 2400 mm in the southernmost area. Annual temperatures average between 16.5-25.1 degrees (see figures 2.10-2.12).

As a result, the Negev experiences very few overcast days yearly, and has for the most part unobstructed solar exposure,[15] highly suitable for solar energy generation.

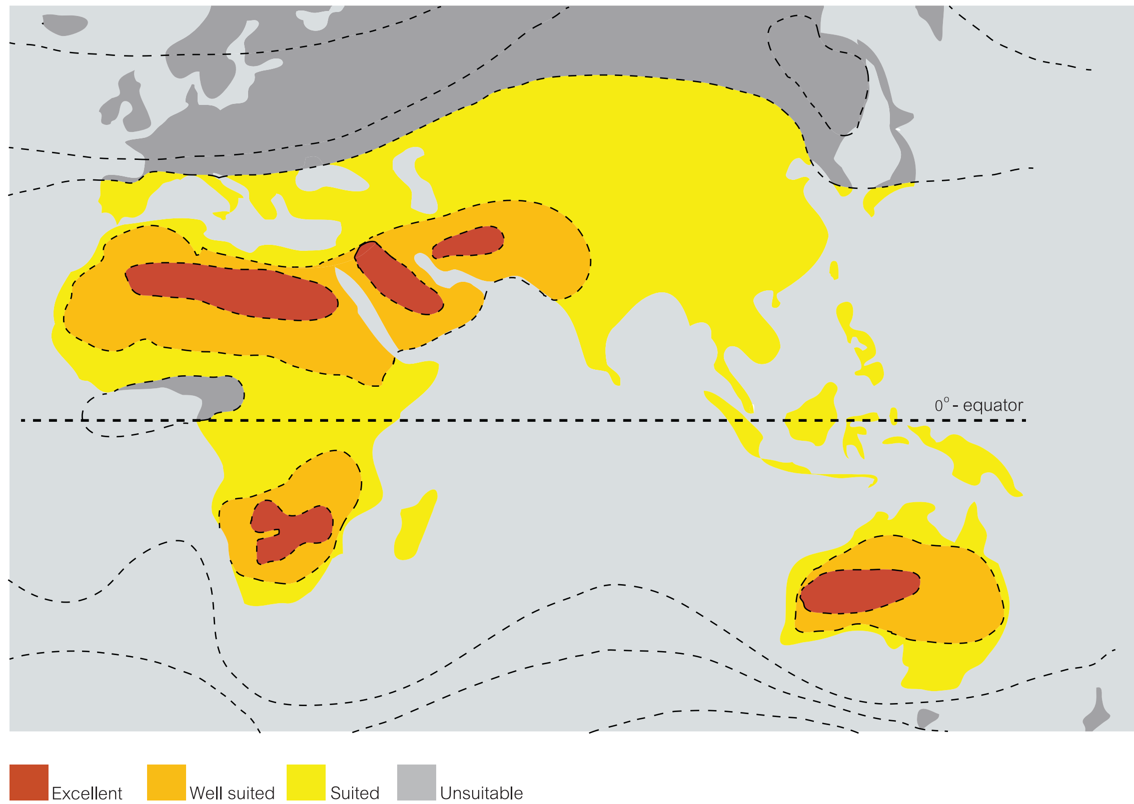


fig. 2.8 Insolation levels as suitability for solar power plants

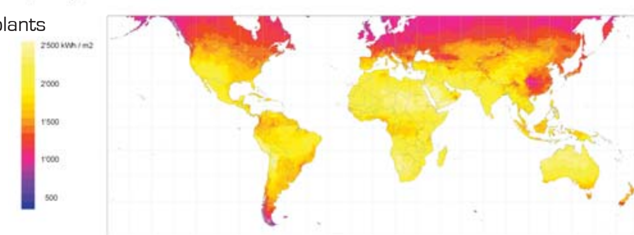


fig. 2.9 Yearly sum of global irradiance

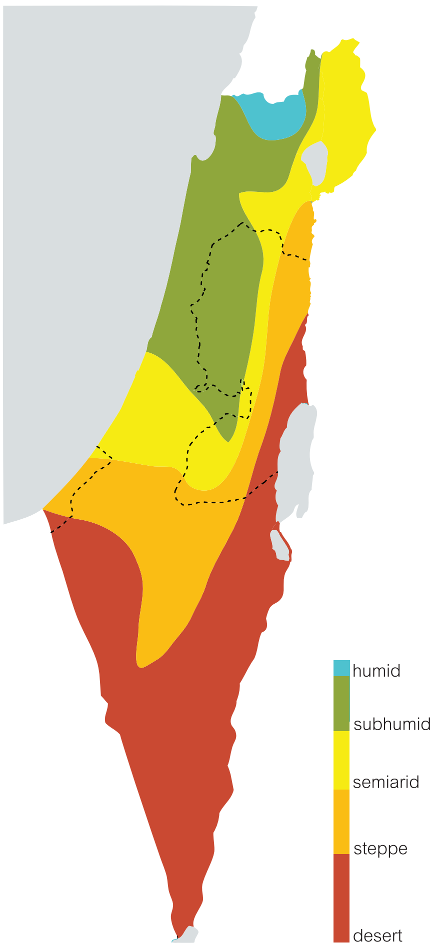


fig. 2.10 Ecoregions of Israel

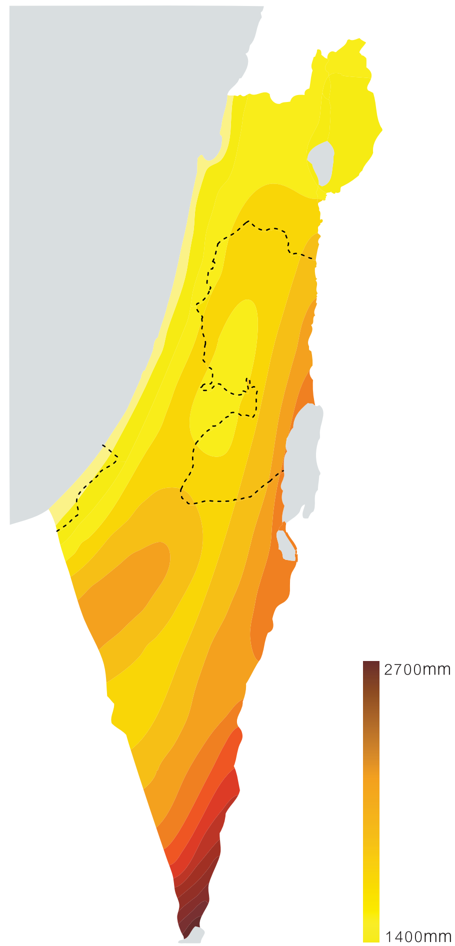


fig. 2.11 Mean annual evaporation (in mm)

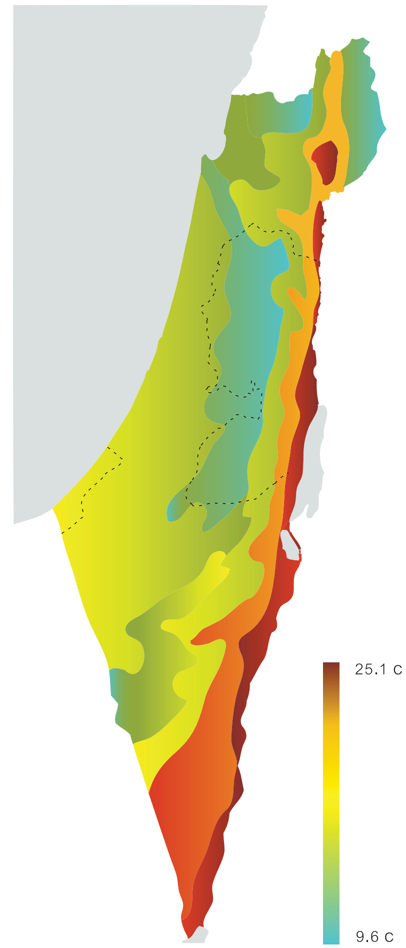


fig. 2.12 Average annual temperatures (in degrees Celsius)

2.3 Water flows

Rainfall occurrences in middle-eastern deserts are highly difficult to predict, both in terms of timing and distribution. Rainfall events are characterized by high volume downpours, causing major flooding, but also by very short and sporadic durations.

Rainfall is often described as patchy, affecting areas of less than a few square kilometers. In these arid regions, reported annual precipitation averages are often inaccurate as annual variation increases with aridity, and can exceed 100%.[16]

Dew can be more common than rainfall and occurs during 50% of the nights. It can account for as high as a third of all available precipitation. Due to high evaporative rates it does not support soil moisture, but could help maintain lower plants and some local fauna.[17]

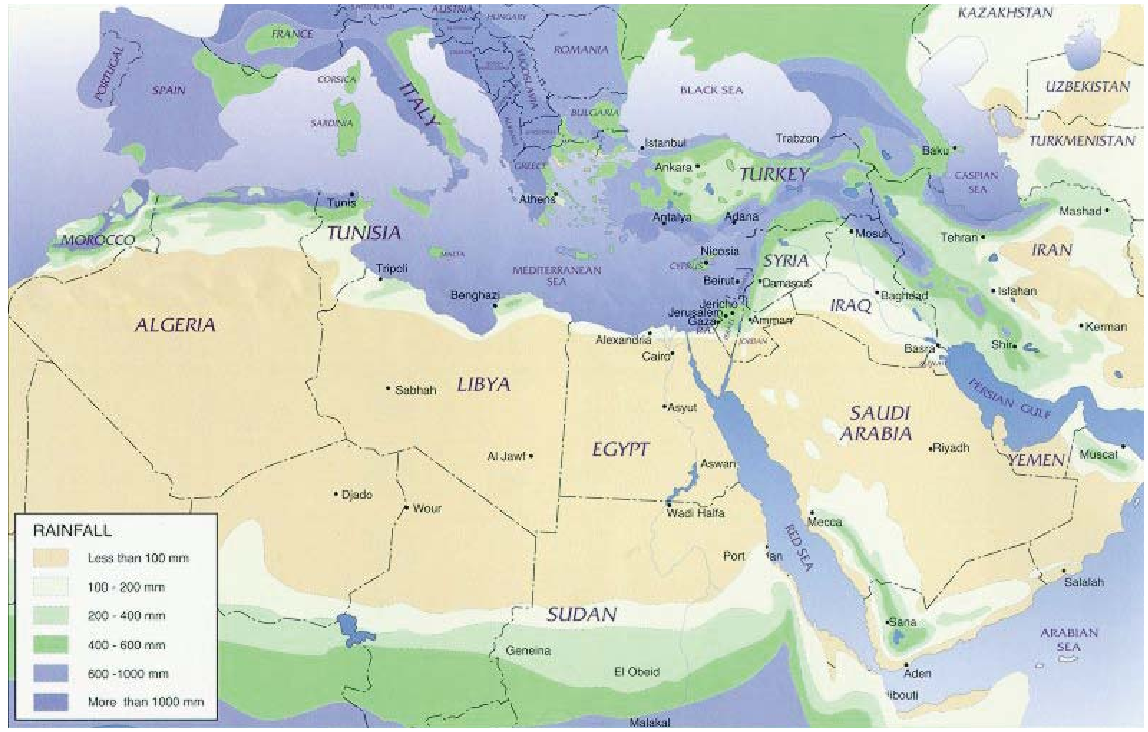
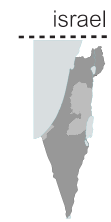


fig. 2.13 Average annual precipitation in the Mediterranean (in mm)



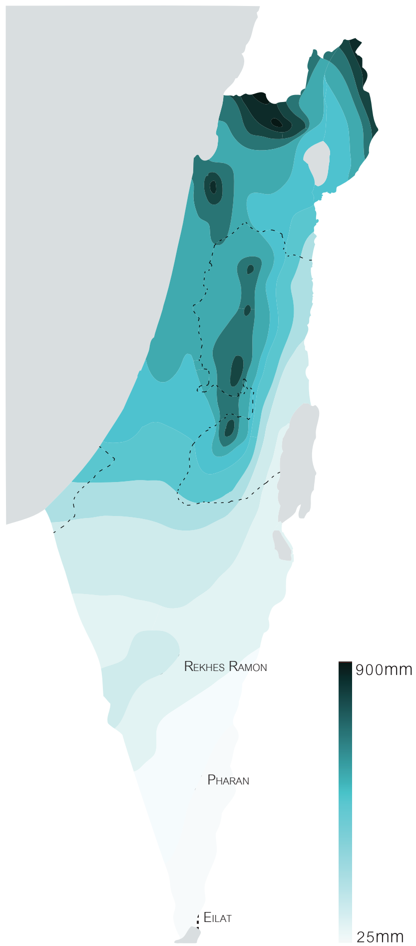


fig. 2.14 Average annual precipitation in Israel (in mm)

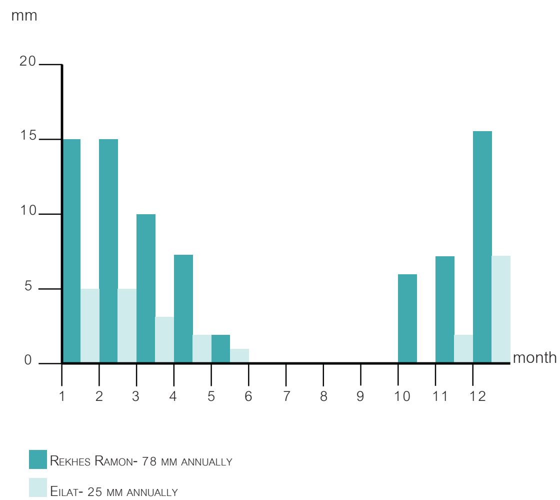


fig. 2.15 Typical monthly precipitation distribution (in mm)

As mentioned, rainfall events are highly unpredictable and become more so as aridity increases. In addition, rainfall measurement capacities are limited in these undeveloped regions, and consist only of data from gauges installed at widely separated meteorological stations. Only two such stations exist in the entire central and southern Negev, one in Rekhes Ramon and the other in Eilat (see fig. 2.14). Typical measured rainfall quantities are brought here for reference purposes (see fig. 2.15). Rainfall in Pharan site is assumed to be approximately an average between the two stations.

Typically light rainfall is to be expected starting in early autumn with light showers possible in September-October. By the end of October-November rain events become heavier and longer. The rainy season usually starts by the end of December, with rainfall peaking in January-February. By mid-May rain events are rarer and volumes are lighter. April-September is considered the dry season with 0% rainfall witnessed.[18]

Israel's watersheds are shown in the following map (see fig. 2.16). Following the direction flow arrows, it is evident that the coastal watersheds drain to the Mediterranean, the Jordan rift valley watersheds drain to the Dead Sea and the south Wadi Arava watershed drains to the Red Sea. Due to low rainfall levels and high evaporation, surface water is not abundant. Nevertheless, in the north the vast majority of it is used and it supplies approximately 35% of the total regional water use.[19]

Only the Jordan River watershed has sufficient groundwater supply to support continuous flow year round. Mediterranean and mountain streams are typically seasonal, wet during the winter and dry during summertime. Streams in the desert and the Arava are almost entirely ephemeral flows and activated during rain storms. In these dry areas, due to scarcity of water, the soil forms a dry crust, which prevents the water from infiltrating through. This effect increases runoff significantly and augments the effect of flash floods. Peak flows are typically observed to be in February-March, a month delay following peak rainfalls.[20] Notwithstanding an occasional spring storm which could keep the stream active somewhat longer, the ephemeral flows dry off shortly after. In both Arabic and Hebrew an ephemeral stream is named a 'Wadi.'

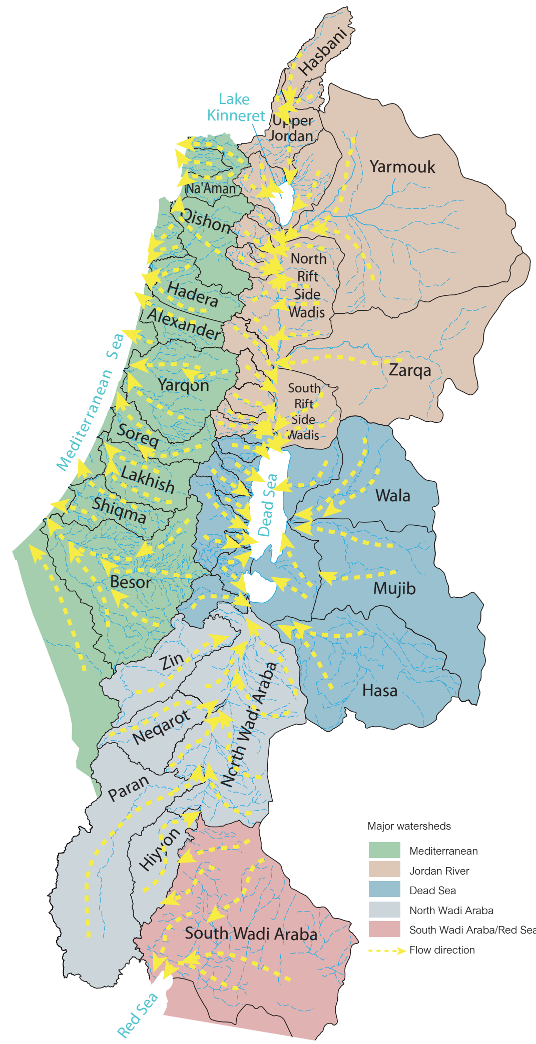


fig. 2.16 Mediterranean, Dead sea and Red sea watersheds

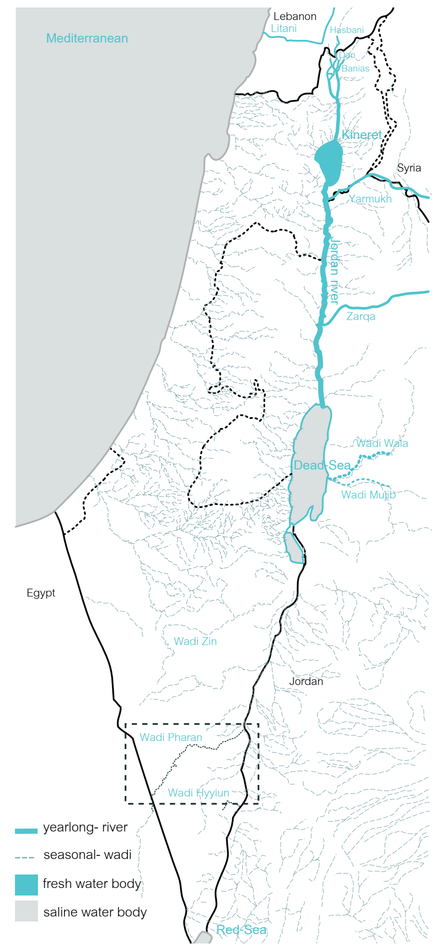


fig. 2.17 Natural water infrastructure

Other than surface water accumulating almost entirely in Lake Kinneret, Israel's water production relies on two major underground water resources: the mountain and coastal aquifers. These aquifers are considered the most viable due to a high level of annual recharge (see fig. 2.19), enabled by high rainfalls in these regions. These aquifers are found in top rock layers, unlike fossil aquifers, a remnant from an ancient more humid era, which are confined to deeper non-permeable layers underground. Recharge rates of renewable aquifers depend also on evaporation rates, runoff and soil permeability.[21]

Although relatively renewable, the coastal aquifer, made of alternating layers of limestone and clay,[22] is vulnerable to two major risks: pollution and saline intrusions. The aquifer coincides with the most densely populated and developed region in the country and is subject to contamination by untreated effluents, industrial waste, chemicals, fertilizers and solid waste. Over pumping will change the pressure balances between freshwater and saline seawater, which could contaminate the aquifer with saline water and cause irreparable damage.[23] On the other hand, currently along the coast there is a practice of draining groundwater from buildings' foundations into the Mediterranean, freshwater that could be reclaimed and used.[24]

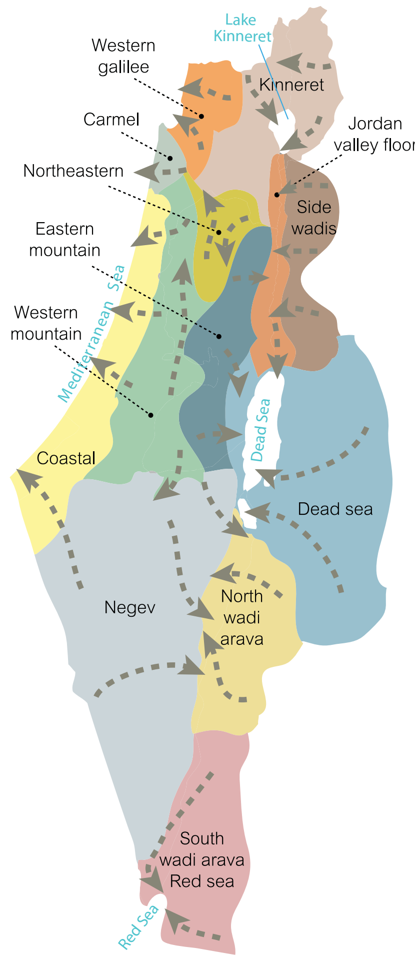


fig. 2.18 Ground water basins and flow directions

The mountain aquifer contains layers of limestone and dolomite rocks with intervening layers of chalk and marl.[25] Although some of the stone material is hard, due to multiple joints between rocks, water penetration and storage is significant, and considered high in quality.[26] This aquifer is also vulnerable to excessive pumping since underneath it lays a saline aquifer. A drastic change in pressures will cause irreparable saline intrusions.

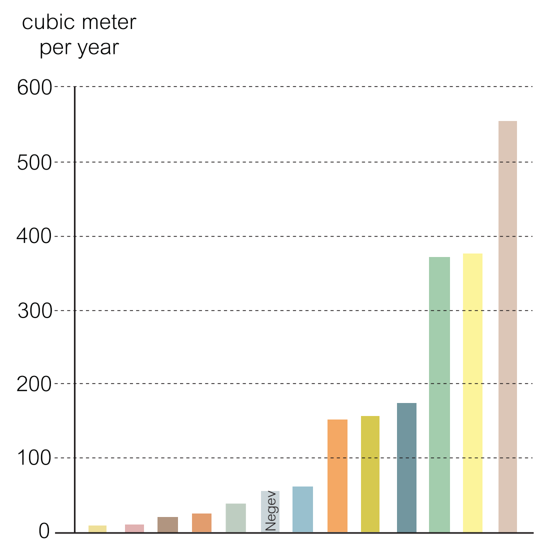


fig. 2.19 Aquifer annual recharge rates. Note: these rates vary relative to annual precipitation.

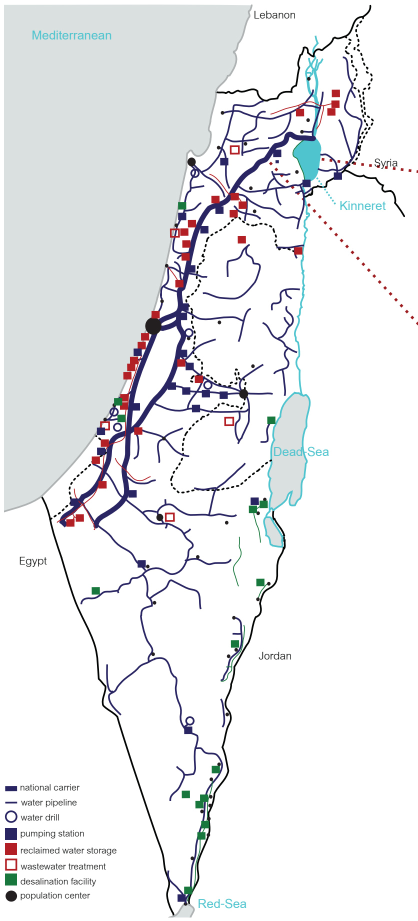


fig. 2.20 Manufactured water infrastructure

fig. 2.21 Lake Kinneret- major source of the NWC

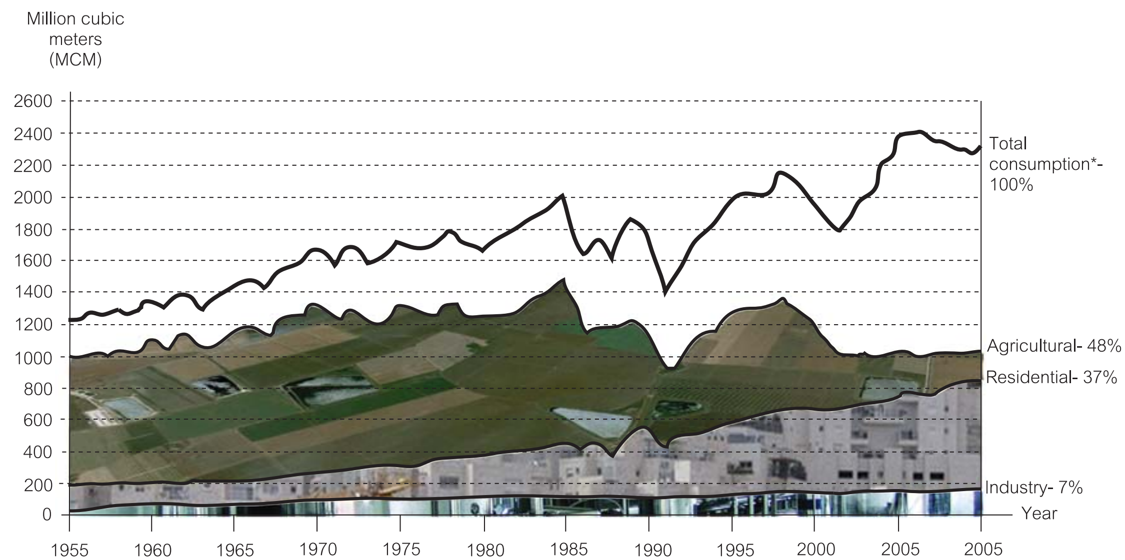
fig. 2.22 The National Water Carrier open canal- transporting water from lake Kinneret to the populated center and arid south

The National Water Carrier (NWC) was realized in 1964, yet appeared as early as 1902 in the Zionist ethos, as a visionary idea in Theodor Herzl's Zionist manifesto: 'Altneuland'.[27] It had since been a major aspect in the Zionist mythical rebuilding of Israel, transporting water from Lake Kinneret and the rainy north of the country to the population centers along the coastal shore and the dry Negev desert. It has been grasped by the public as an incredible engineering accomplishment which will enable the blooming of the wilderness and ensure Zionist existence in the heart of the desert.

Currently, the NWC receives a substantial portion of its water supply from Lake Kinneret while the rest is fed underground water drilled from the depleting mountain and coastal aquifers. Its route starts in an open canal terminating in a pumping station and reservoir at Tzalmon and continues in underground tunnels and pipelines to the distant Eilat in the southern Negev.[28]

450 million Cu.m of water flows through the NWC annually. The Kinneret's water surface is at -213m below sea level, and water is pumped to a max height of 151m, an overall difference of 374m.[29] Through its numerous pumping stations that allow water to overcome gravity, the NWC consumes 13% of Israel's anual electricity consumption.[30]

WATER CONSUMPTION TRENDS



* 8% of consumption goes to external users such as Jordan and the Palestinian Authority

fig. 2.23 Water consumption by sector

Water consumption is dominated by the agricultural sector, followed by residential consumers. Consumption increases steadily with the rise in population.

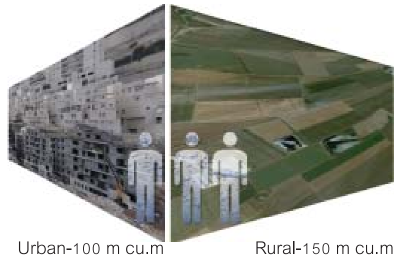


fig. 2.24 Consumption per capita - stays relatively constant throughout the years, yet population increases rapidly.

FUEL IMPORTS

fig. 2.25 Origins of imported fossil fuels for electricity production

Over the past four decades, Israel has relied entirely on imports for its energy demands. Following the 1973 oil embargo, it searched for alternative sources of fuel, and found import opportunities from a diverse range of friendly countries. During the late 1970's, the country shifted to an energy market heavily supported by coal. In 1980, the government appointed, The National Coal Supply Corporation (NCSC), to coordinate coal imports. Coal is imported to Israel from around the world with its major suppliers being South-Africa, Columbia, and the United States.[31] Israel has imported on average 13 million tonnes of coal annually and imports are expected to rise with increasing electrical consumption. Coal prices vary from 30-70 per tonne, which brings coal expenditure to an average of 650$ million annually.

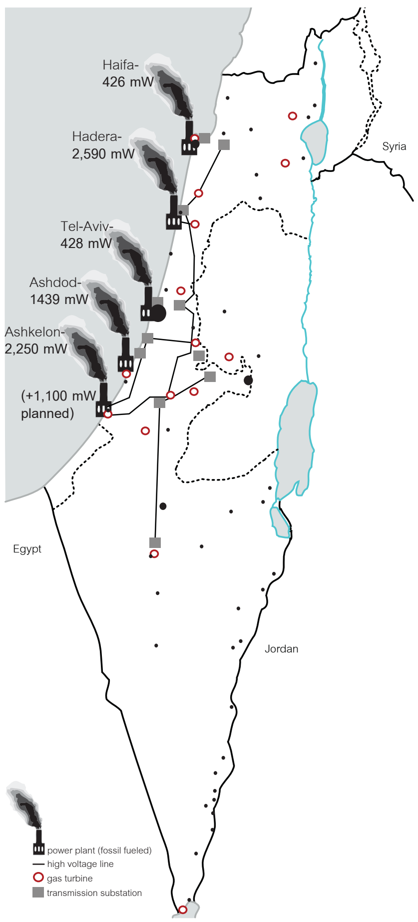


fig. 2.26 Electrical Infrastructure

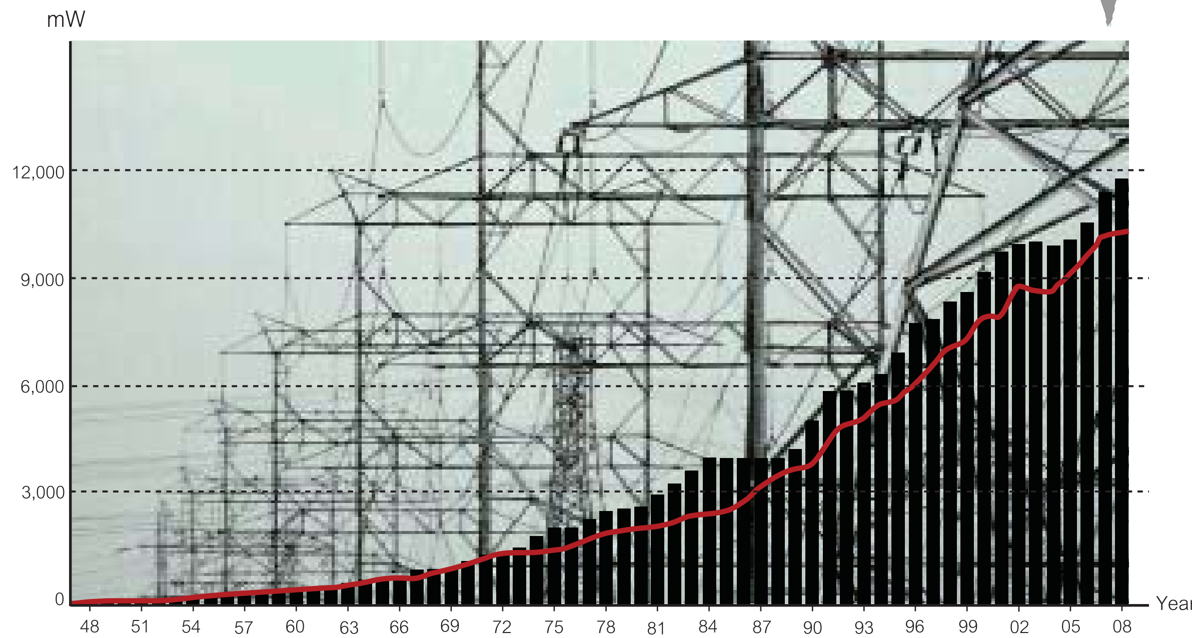


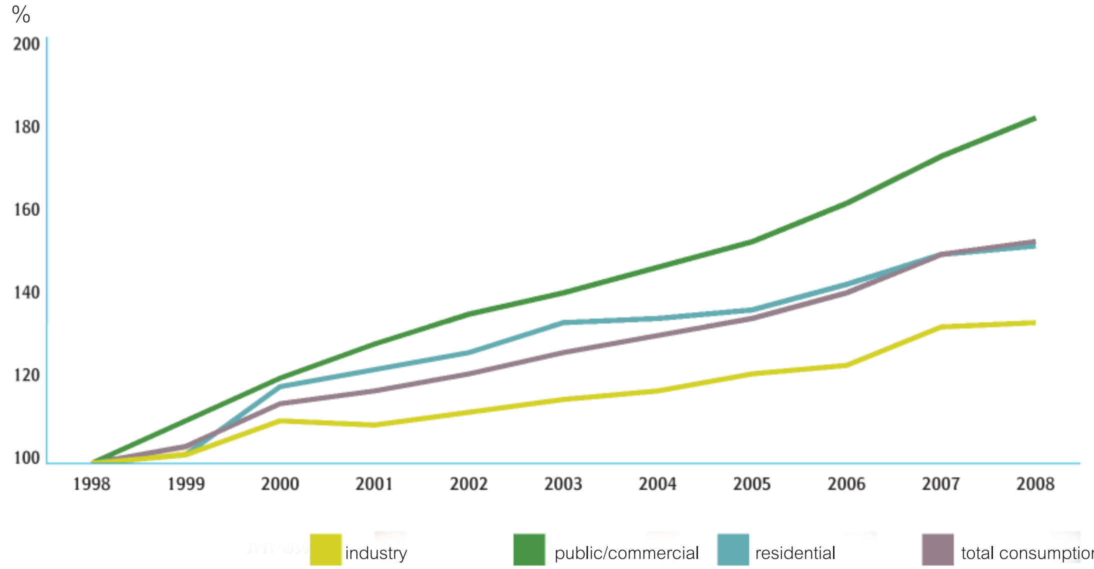
fig. 2.27 Development of peak demand and installed capacity

As population grows (at a rate of 1.67% annually)[32] and life quality significantly rises, electricity consumption grows rapidly. To satisfy this demand, installed capacity of the Israel Electrical Company needs to remain above estimated peak demands (growth rate of 3.6% annually).[33] Coal and petroleum flow continuously into specialized ports along the Mediterranean shore, adjacent to the major coastal fossil fueled power plants. More recently, combined cycle turbines fueled by a combination of gas and oil have been added to production methods. Electricity is then conveyed into the electrical grid that services population centers and industries. The grid is composed of transmission lines and substations alternating between high voltages of 400 kV for industrial consumers (735.4 km of lines) and low voltages of 161 kV for domestic consumers (4249 km of lines).[34]

In the last decade total consumption experienced a 50% increase (see fig. 2.28). In specific sectors, such as the public/commercial, consumption almost doubled. As electricity consumption continues to grow, so does the demand for raw fuels on which electricity production is dependant. These fuels need to be imported, which compromises Israel's independence and self-reliance in this market. Israel currently has no fossil fuels available for export. Hence, the flow is entirely unilateral, which could be detrimental for its stability and long term viability.

The majority of energy consumed is attributed to the residential and public/commercial sectors. Together they account for more than 60% of total consumption (see fig. 2.29). It should be noted that a minimum of 10% of annual energy production is either self-consumed in the operation of power plants, and/or lost in distribution.[35] This figure is equal or larger than the energy demands of Israel's agricultural communities and energy allocated to the Palestinian authorities combined.

fig. 2.28 Consumption development by sector



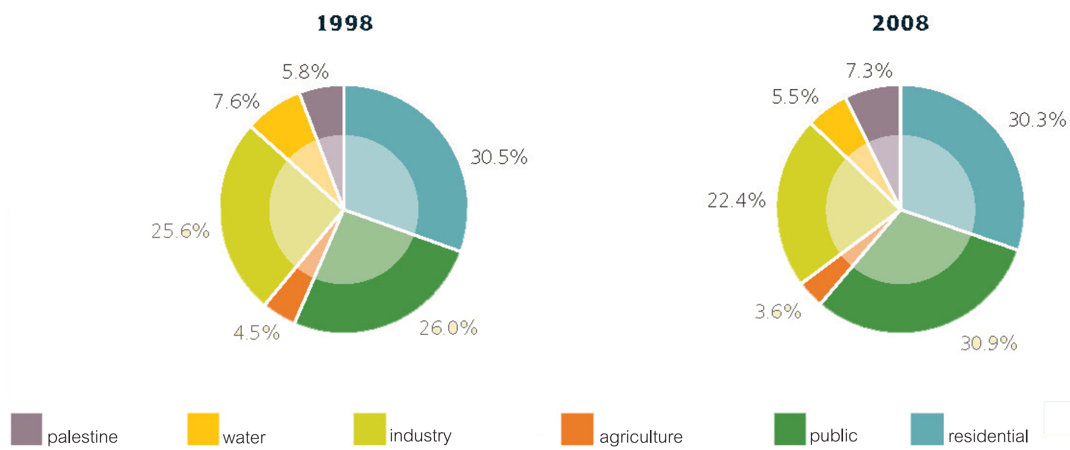
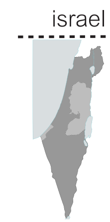


fig. 2.29 Consumption percentage by sector



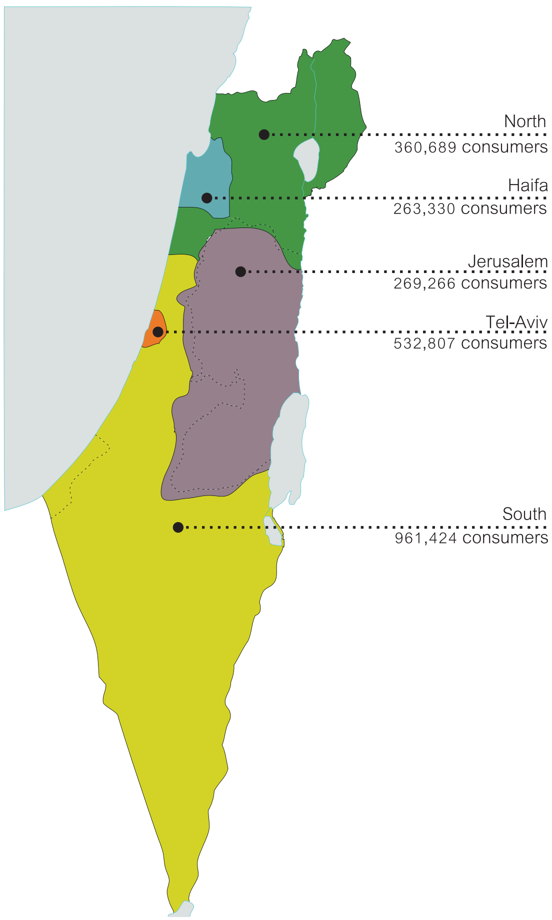


fig. 2.30 Electric Company distribution regions

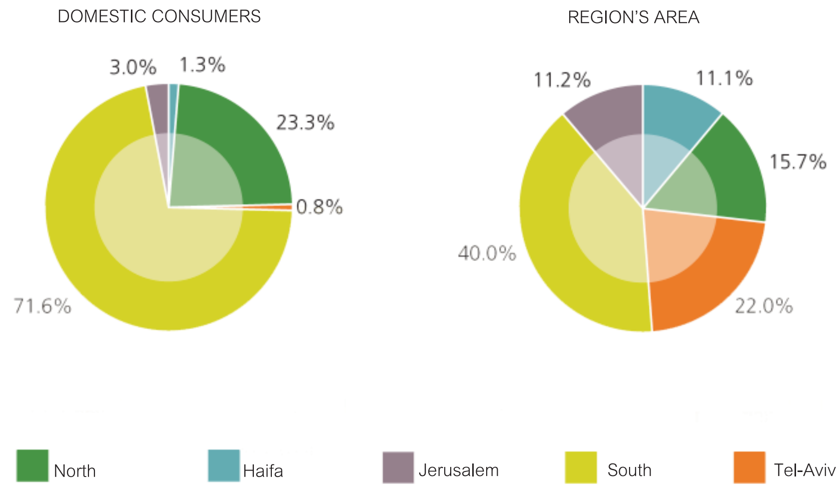
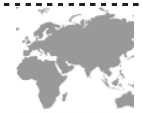


fig. 2.31 Domestic consumption in relation to region's area

The distribution of regions represented here (see fig. 2.30) appears to be arbitrarily defined by the Electric Company. It is important to note that the large 'South' area also contains within it most of the central coastal strip which represents the majority of consumers for that region. If the coastal region was to be separated from the southern Negev desert, the disparity between the region's area and relative number of consumers would be better represented. The dominant trend places the majority of consumers along the coast where population density is the greatest, especially in the metropolitan area of Tel-Aviv, which represents a rather small land area. Consumers in sparsely populated desert communities, remote and mostly rural, are often serviced by extensive infrastructures of electrical grid lines, supplying them with the electricity produced in power plants along the coast.

Solar energy production for these communities could reduce distribution losses, contribute to their self sufficiency and perhaps even become an exportable resource to adjacent population centers.

Fuel mix



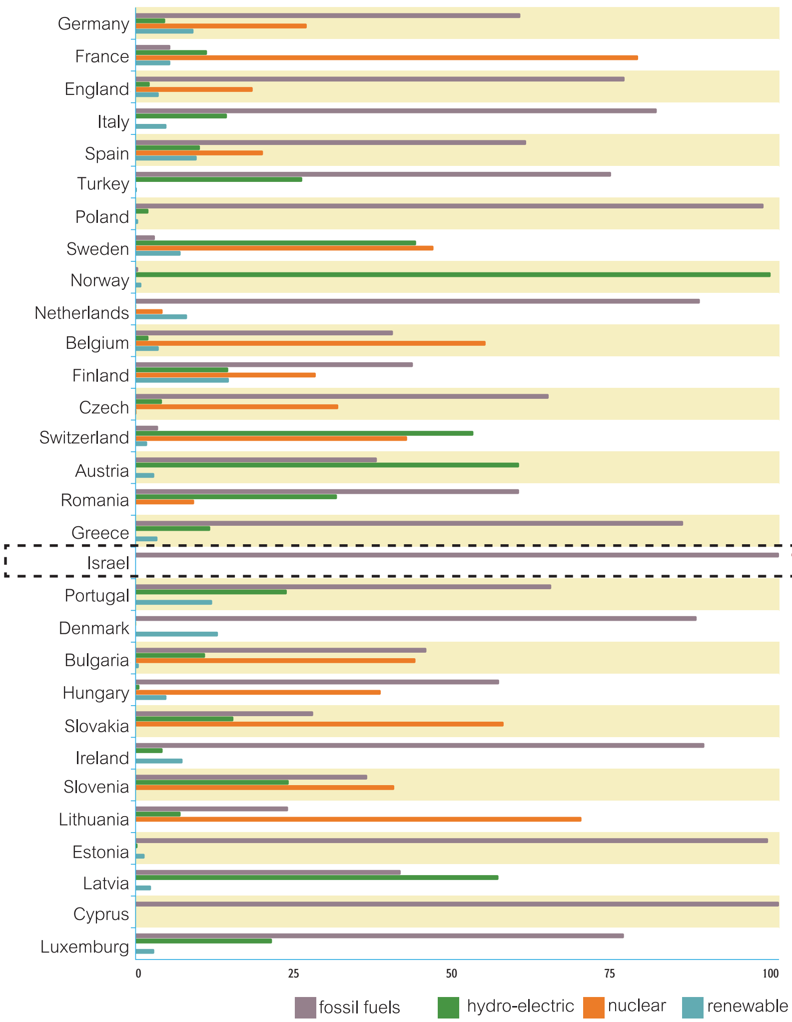


fig. 2.32 European electricity production by energy sources (in percentage)

In comparison to other European countries (see fig. 2.32), Israel stands out as the only one relying entirely on fossil fuels and producing energy only by 'thermal-conventional' methods. Most other countries incorporate additional sources into their energy mix, with a rise in emphasis on renewables.

Recent discoveries of Natural gas reservoirs within the country's borders signify a major shift, from a mostly coal-based market to one based on a mix of coal, oil and gas. Though currently, gas resources are sufficiently abundant and locally found, they are also finite. Moreover, the use of these for electricity pro-

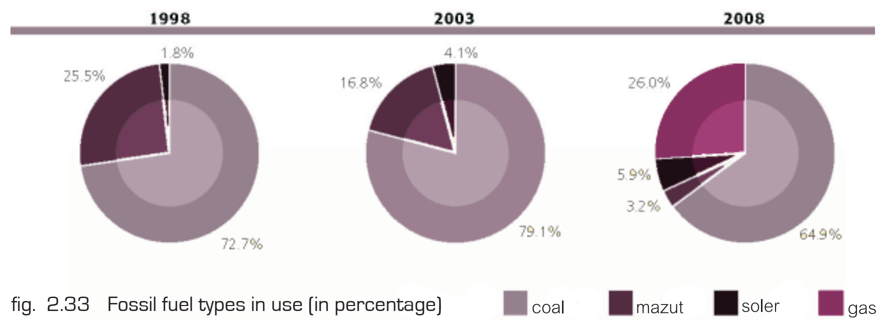


fig. 2.33 Fossil fuel types in use (in percentage)

duction represents its own contribution to rising levels of global carbon emissions, as well as air-born pollutants causing chronic health problems locally: Asthma, Anemia, Bronchitis, lung failure and various cancers to name just a few.

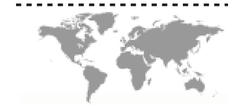
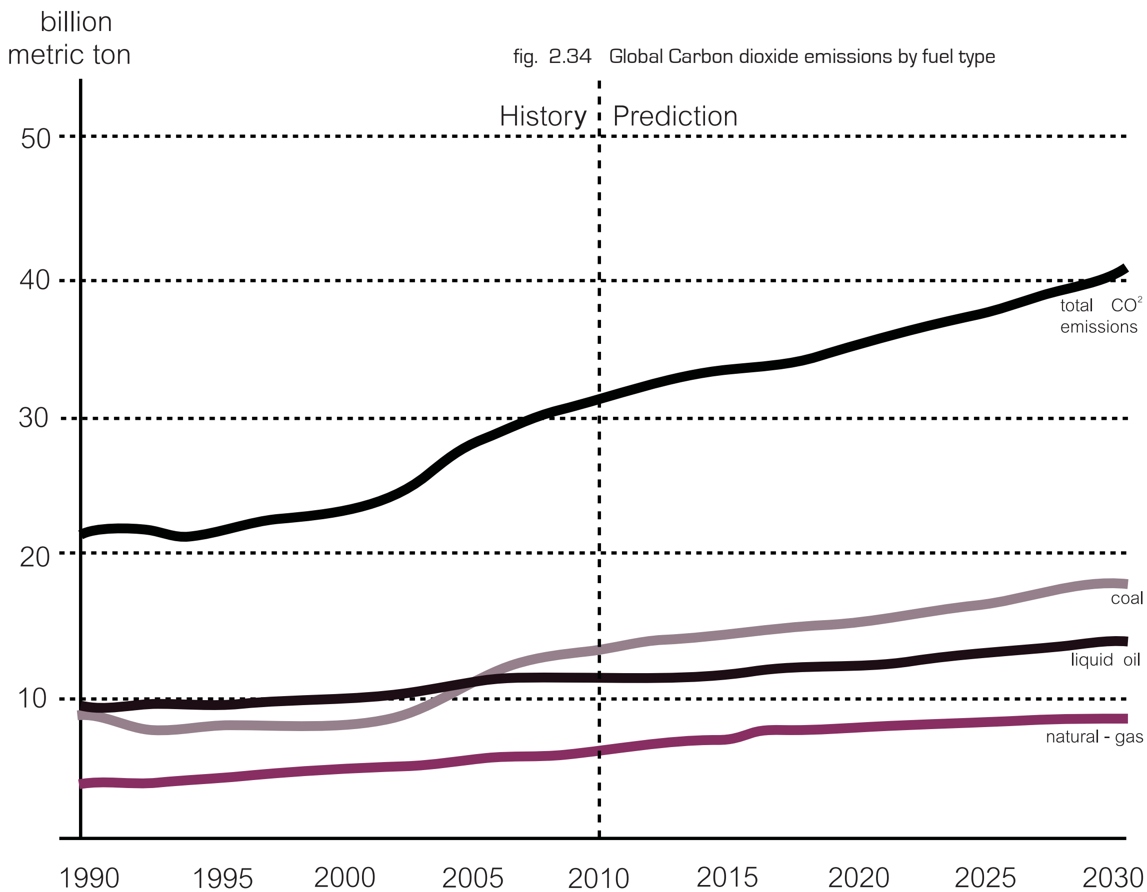


fig. 2.34 Global Carbon dioxide emissions by fuel type



These percentage figures translate into 401 thousand tons Mazut, 690 thousand tonnes Soler, 1,847 thousand tonnes gas and 12,882 thousand tonnes coal, consumed in 2008 alone. This amounts to 15,820 thousand tonnes of fuel consumed in the process of electricity production.[36]

Israel, as a country committed to technological progress and improving lifestyle is developing an environmentally destructive thirst for electricity. As the Mediterranean climate becomes more erratic, to manage demands for both cooling and heating exasperates Israel's significant electricity consumption.

Relative to its area and population, Israel's electricity industry represents a major carbon footprint. Annually, there has been a constant rise in the amount of fossil fuels shipped to Israel, and once arrived, its processing emits significant levels of pollutants including Hydrocarbons, CO, CO_2, SO_2, NO_x, and particulate matter.

While many developed countries make international commitments to decrease their emissions and pursue clean renewable energy sources, Israel plans to build a new coal fueled power plant in Ashkelon. Notably, Coal is known to be the highest polluting fuel in combustion followed by liquid oils and natural gas (see fig. 2.34). Israel's plan to shift its primary energy source to natural gas is merely the least of all evils. In a country where solar energy is abundant, to the point where 10km^2 in the Negev receives as much potential in solar energy as the energy produced daily by the electrical company and 252km^2 can supply the entire country's needs through solar power[37]; local, free and clean, the current trends represent an alarmingly short sighted problem solving approach.

2.5 Population flows

The coastal areas of Mediterranean countries are of a more humid and mild climate than their inland counterparts. As such, these regions are the most fertile and of the best quality land type in their surroundings. This advantage, as well as the easy sea access and attractive scenery makes the coastal region popular for most human uses: agricultural cultivation, industrial development and urban settlement. In Israel, the coastal strip has certainly been the most populated since the very early days of settlement, and this trend has become increasingly pronounced in the last few decades. The Tel-Aviv metropolitan area today comprises more than 3.2 million residents, approximately 44% of Israel's population. The Negev in comparison is home to less than 9% of the population, yet occupies more than 60% of Israel's land area.

Recently, the critical mass surrounding the Tel-Aviv metropolitan has become so substantial that the attraction towards the center has even increased. Real-estate is in higher demand than ever before and more families and individuals move from the periphery to Tel-Aviv area. Industries servicing this sprawling urbanization are also fighting for a foothold. The electrical company deploys its power plants along the coast, and upcoming desalination initiatives are also threatening to further industrialize the shore line.

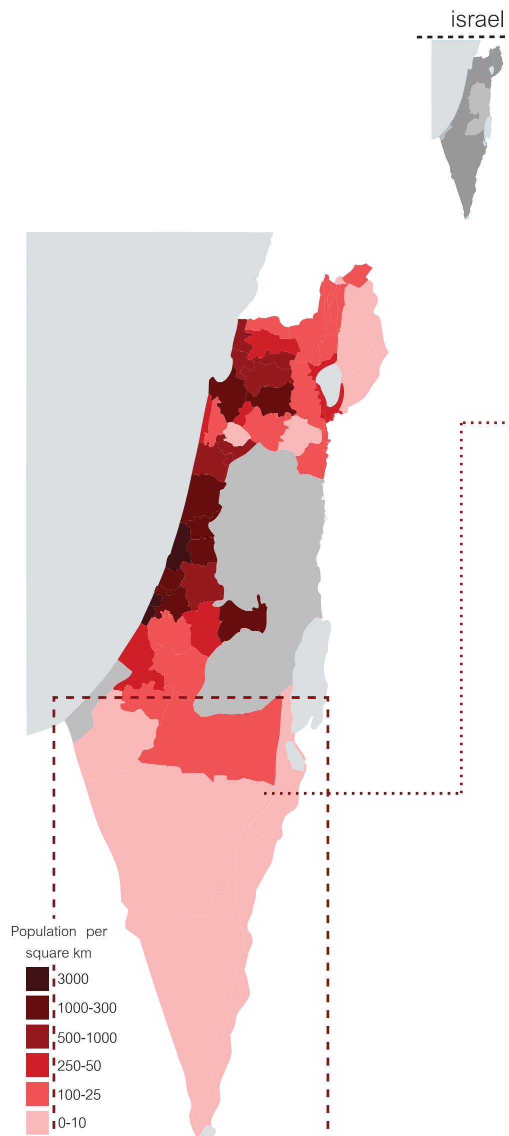


fig. 2.35 Population density distribution

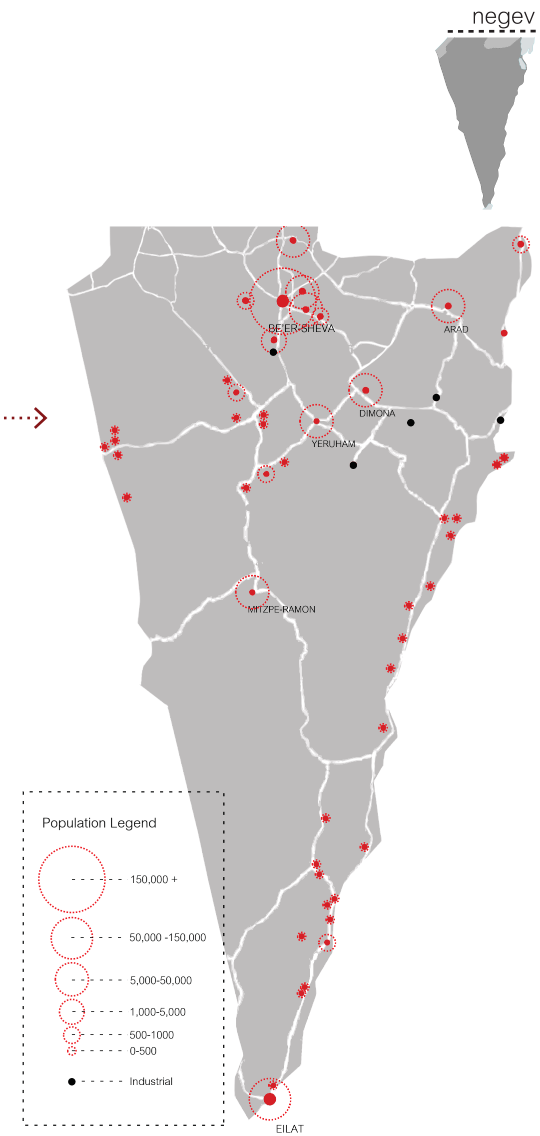


fig. 2.36 Negev communities population

Agricultural production, imports and exports

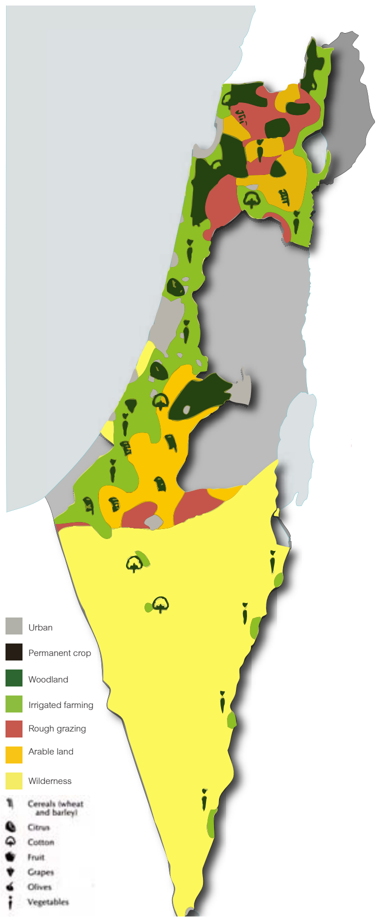


fig. 2.37 Agriculture by zone

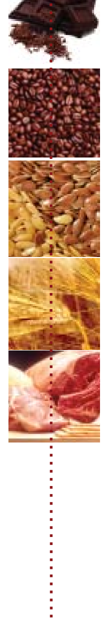


fig. 2.38 Production, imports and exports

In the area known in ancient times as "The fertile crescent" agricultural land is overtaken by urbanization and industries and cultivation needs to be pushed to less fertile regions of the country.[38] Today, Israel prides itself in self-sufficiency, in terms of supplying its own food needs. The warm Mediterranean climate is conducive to local growing of vegetables, flowers, field crops, fruit and citrus. The majority of which is consumed in the local markets, while some percentage of each crop contribute to a thriving export industry. In contrast, only 5% of Israel's food needs are being imported. Israel today imports mostly sugars, cocoa, coffee, oil seeds, grain and meat, as well as specialized processed foods. In order to sustain this prosperous self-sufficiency well into the future, the question of land allocation for agriculture will need to be addressed. Abundant land availability in the Negev and successful practices of irrigated greenhouse agriculture in the Arava wadi communities may prove to be a viable alternative.

The Israeli military (Israeli Defense Forces-IDF) has under its jurisdiction a widespread array of camps and facilities, which comprise the Infrastructure of the Israeli security system. These facilities vary greatly in size and overall, occupy almost half of the country's land area, an unprecedented geographical-spatial phenomenon.[39] About 30% of the country's area is occupied by IDF training and field experiment zones, 5% are IDF security camps, 11% has construction restrictions and only 54% of the area is under civilian jurisdiction with no military implications.[40]

The majority of military training and experimentation zones is located in the Negev desert and occupies 85% of its area. These areas include: mine fields, firing range zones, heavy artillery experimentation, ground maneuvers and strategic exercises coordinating multiple forces. Many of the military zones are spread across the country in such a way that if need be, a territorial continuity could be achieved by gaining temporary exclusive access to the gap regions.[41] Military zones are closed to the public on a regular basis, except by special permission, since they represent a conceived or actual danger to a civilian by passer. It is also preferable for the army to operate far from the public's observing eye. The existence of such extensive pockets of restricted access, nearly half of the country's area, is a topic hardly mentioned in the public discourse.

Many of these restricted military areas coincide with regions defined as nature reserves, especially in the Negev, where the extent of both influences is the greatest. For many decades, the environmental impact of military activities was a non-issue. The importance of security in a war learned place like Israel, has given the military a free hand and an overriding right to make use of whatever resource it finds necessary. Even in cases where protection was given to specific areas in recognition of their environmental value, the military in most cases remained exempt from these restrictions.

Only in recent years, the extent of the military's impact on widespread open areas in Israel has been questioned and criticized. The state comptroller audit report from 2004 determined that due to its geographical extent, the IDF has potential to cause significant harm to the environment through: solid and liquid waste, effluents, hazardous materials, noise, radiation and pollutants.[42]

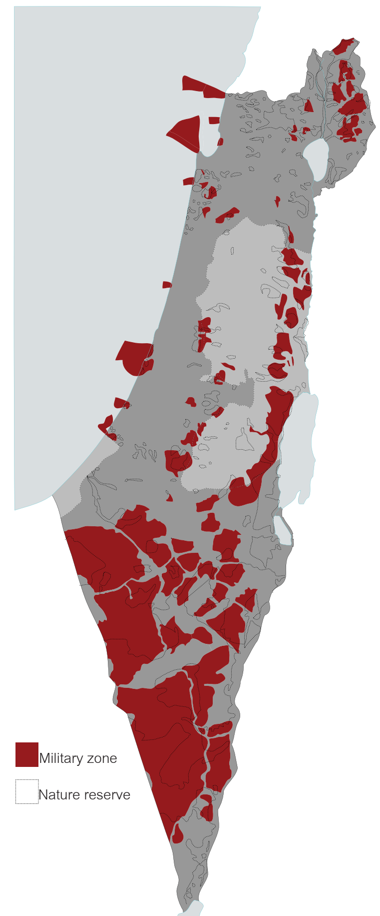
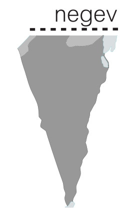


fig. 2.39 Military zones and nature reserves



The Bedouins have resided in the Negev and in the Sinai for hundreds of years.[43] They have lived as nomadic tribes, making their subsistence mainly through sheep and cattle herding. Later, many Bedouins became semi-nomadic, traveling to limited distances in search of pasture lands. At the same time, dry-farming agricultural practices were developed and contributed to livelihood.

Starting in 1948, the state of Israel defined the majority of the Negev as enclosed military zone, limiting access to large open areas. In 1950, the "black goat law" was legislated prohibiting grazing on lands outside one's private property. In 1979, following the recognition of extensive areas in the Negev as nature reserves,[44] herd grazing was further compromised. As a result of these policies, many Bedouin herders found themselves further severed with no grazing lands for their herds and no lands available for agricultural cultivation.

The state of Israel has attempted to provide substitute in the form of legal townships for Bedouin settlement. Unfortunately, these townships represent a great departure from the way of life the Bedouins are accustomed to. Bedouins living in the townships are restricted to the area defined as the 'Syiag' (fence).[45] The townships offered no alternative to the livelihood they once practiced as herding and agriculture have been virtually rendered impossible. Furthermore, the planning of these towns did not take into account the Bedouin family structures and life habits, nor was based on any economic rational.[46] The government was set to 'urbanize' the Bedouins, and they, despite their own judgment, have had to adapt to occupations of laborers and service givers and to adopt a modernized life style. Many however, have experienced unemployment and great hardship adjusting to this way of life.

A large amount of Bedouin families, however, who stayed in their villages have also encountered hardship. Their villages were declared 'unrecognized' retroactively, all new construction deemed illegal and subject to demolitions. Unrecognized villages have no access to roads, water, electricity, sewage removal, education and health care.[47] These families build their habitats from scraps of plastic and corrugated metal sheets, partially because this is what they have at their disposal and partially to maintain an appearance of impermanence.

Currently, the Bedouin population numbers almost 160,000 people, a quarter of the Negev's population. Their legalized jurisdiction entails 1% of the Negev.[48]

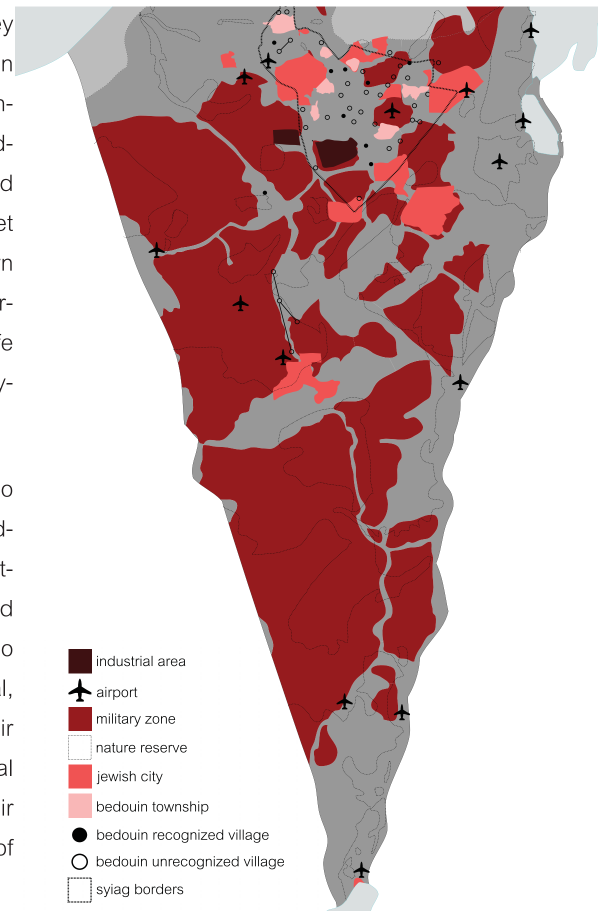


fig. 2.40 Bedouin settlement patterns in the Negev

2.6 Linked flows

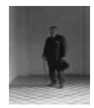
1901
JNF-KKL fund is established during the congress with the goal to purchase lands in Palestine for Jewish settlement.

1901
5tth Zionist congress in Basel, Switzerland.

1903
JNF purchases its first land parcel- 50 acres in Hadera.

1905
JNF purchases land near the sea of Galilee, at Ben-Shemen and Hulda. Plants its first olive grove and thus commences its afforestation activities.

1919
Pinkhas Rutenberg immigrates to Israel. Plans to develope an integrated irrigation & energy system using local water sources.



1920
Rutenberg propses 13 hydro-electric plants.

1920-1921
Palestine riots. Diminished trust between Jews, Arabs & British authorities is a catalyst to independent infrastructure & security initiatives within the Jewish population. ‘Haganah’ is founded.

1921
Land purchased by JNF is quadrupled, reaching 25,000 acres. Land is acquired for the benefit of the first ‘Kibbutzim’ and workers’ communi-ties. JNF becomes invovlved in education and agriculture R&D.

1923
Rutenberg fails to purchase Yarkon river as a source for Hydro-electrical plant.

He then founds the firt power plant in Tel-Aviv: diesel powered 300 kW capacity

Rutenberg founds Palestine Electric Company Ltd.

1923

British Mandate established in Palestine.
First questions of water rights arise.

1925
Haifa & Teveria power plants open: Diesel powered 1 mW capacity

1926
Rutenberg gains rights for hydroelectrical production in Naharyim, harnessing the Jordan river.

1927

4 of the 13 proposed plants are built between the sea of Galilee and the Dead sea. Providing electricity & water to nearby settlements.

1926
JNF-US opens. Activity areas: ecology, afforesta-tion, water & community development.

Land purchased by JNF reaches 50,000 acres, supporting 50 new communities.

1928

Jerusalem electric company is founded, independently from Rutenberg's.

1929

Another wave of riots. Jewish immigrant population settles along the coast. Strategic shift from hydro-electric plants along the Jordan river, to steam power plants along the populated coast.

1932

Naharyim Hydro-electric plant opens with a capacity of 18 mW.
The plant provided workers community housing and aided agricultural development of the region.

1935

1.7 million trees are planted over an area of 1,750 acres. JNF is partaking in land reclamation for agriculture and swamp drainage. JNF ownes 89,000 acres- settling 108 communities.

1935

First steam turbine electic plant opens: 'Haifa 1'. Plant capacity is 30 mW.

1936-1939

The Arab Revolt.

1937

'Mekorot' water company is founded.

1938

Second steam turbine opens in Tel-Aviv: 'Reading 1'.

1939

10% of jewish population lives on JNF land. British mandate prohibits establishment of communities in new areas. JNF initiates operation Wall&Tower, 10 new towns break ground overnight.

1942

JNF commitment to settle the south. New communities built in the Negev. 1945-1948 JNF runs a Negev settlement operation, despite british ban.

1948

Naharyim site is appropriated by Jordan during war. 25% of electrical production is lost. 3rd unit added to Reading 1 in Tel-Aviv- 12 mW capacity.

1948

'Mekorot' becomes a government owned company.

1948

Jewish population reaches 650,000, living in 350 towns of which 233 are on JNF owned land.

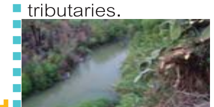
1948

The state of Israel declares independence.

The war of independence ensues.

1951

Jordan plans to divert water from the Yarmukh river, one of Jordan river's tributaries.



1951

2 units added to Haifa power plant- 30 mW each.

1951

Israel's population is doubled by immigration. JNF's role evolves to include immigration abbsorbtion infrastructure development and employment in land reclamation.

1952

'Tahal' water planning government company is founded.

1954

The electric company is bought by the government due to financial difficulties. Company headquarters is transfered from London to Tel-aviv to be run by local israelies.

1953-1954

2 units added to Haifa Tel-Aviv- ‘Reading 2’. Capacity of 50 mW each.

1955

‘Johnston Plan’- American development plan for the Jordan river system, incorporating Jordanian & Israeli intrests.

1956

The Sinai War- Suez crisis.

1958

Agricultural production reaches peak of 13.5% of national production.

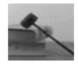
1958

Local water enterprises produce 800 million Cu.M per year, for half shekel per Cu.M.

1958

Ashdod 1 plant opens with 2 units of 50 mW capacity each. Reading 3 opens with 2 units of 20 mW each.

1959



Legistlation of the Water Law-

“This law establishes the framework for the control and protection of Israel's water sources and includes water pollution prevention provisions.

The law states that all sources of water in Israel are public property and that every person is entitled to use water, as long as that use does not cause the salination or depletion of the water resource.”

1960

Legistlation of the Land Law-

Land owned by the Jewish people and maintained by JNF cannot be sold, only leased for 49 years at a time.

1960

Haifa 2 opens with 2 units of 75 mW each.

1962-1963

‘Orim’ near Haifa opens with 20 mW capacity. It is the first industrial gas turbine.

Another 50 mW unit added to ‘Ashdod 1’ plant.

1964

The National Water Carrier is initiated.

Legistlation of regulations pertaining efficient water use.

1964

Jerusalem electric company united with the national Israel electric company.

1964-1967

The War over water- following the completion of the national water carrier, Arab league launches “Head water diversion plan” diverting Jordan tributary waters before they reach the sea of Galilee, rendering the carrier obsolete. A series of battles over water sources control ensues.

1965

JNF director orders to settle the frontiers along the Negev eastern border, to create security zones. Planting of Yatir forest on the desert edge.

1966

First warning signs regarding mountain aquifer overpumping.

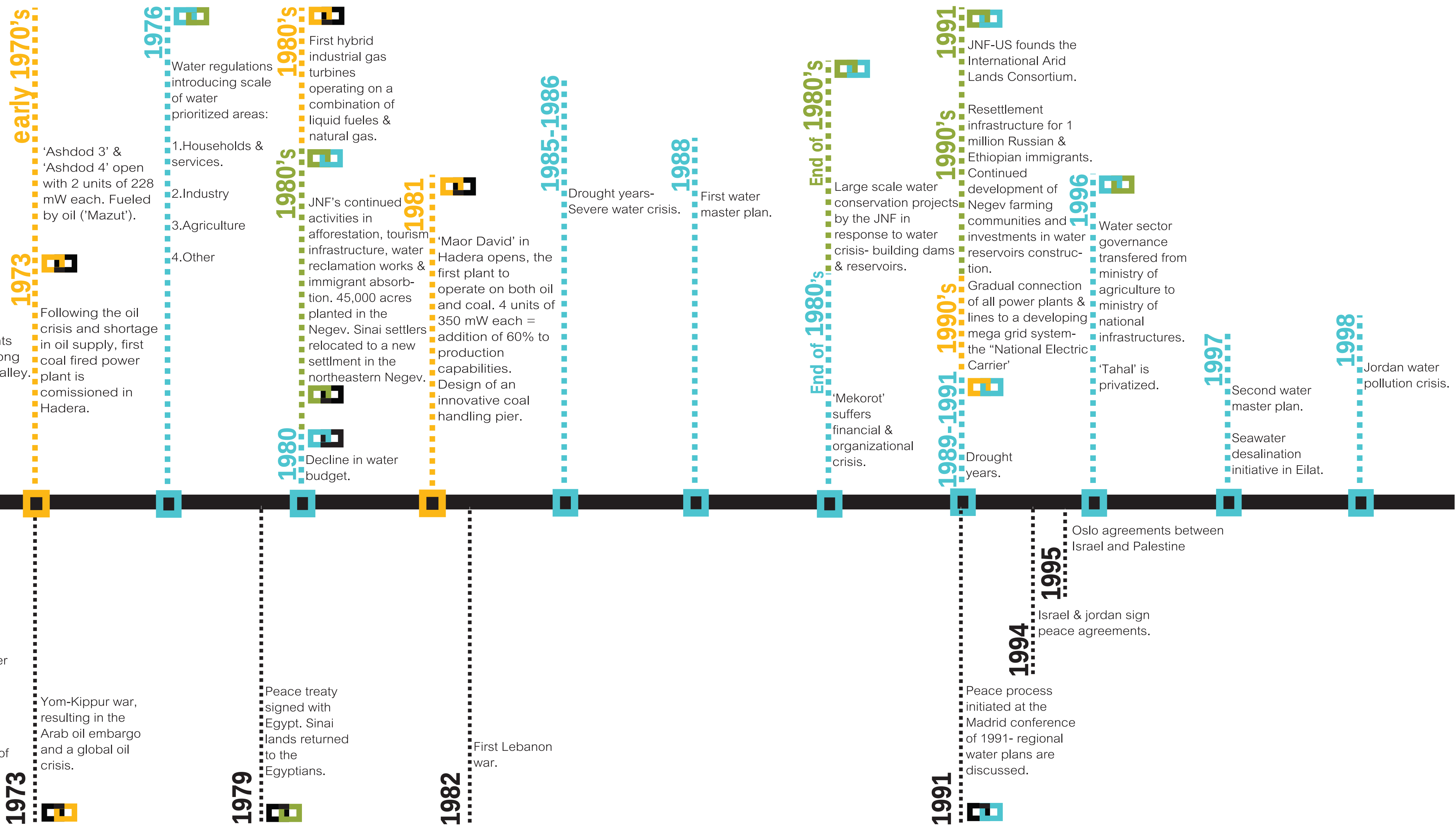
1967

New settlemen established alo the Arava rift v

1967

Six-Day war- Arab-Israeli wate crisis a major factor.

1967-1970: war o attrition.


early 1970's
'Ashdod 3' & 'Ashdod 4' open with 2 units of 228 mW each. Fueled by oil ('Mazut').
1973
Following the oil crisis and shortage in oil supply, first coal fired power plant is comissioned in Hadera.
1976
Water regulations introducing scale of water prioritized areas:
1.Households & services.
2.Industry
3.Agriculture
4.Other
1980's
First hybrid industrial gas turbines operating on a combination of liquid fueles & natural gas.
1980's
JNF's continued activities in afforestation, tourism infrastructure, water reclamation works & immigrant absorb-tion. 45,000 acres planted in the Negev. Sinai settlers relocated to a new settlment in the northeastern Negev.
1980
Decline in water budget.
1981
'Maor David' in Hadera opens, the first plant to operate on both oil and coal. 4 units of 350 mW each = addition of 60% to production capabilities. Design of an innovative coal handling pier.
1985-1986
Drought years- Severe water crisis.
1988
First water master plan.
End of 1980's
Large scale water conservation projects by the JNF in response to water crisis- building dams & reservoirs.
End of 1980's
'Mekorot' suffers financial & organizational crisis.
1991
JNF-US founds the International Arid Lands Consortium.
1990's
Resettlement infrastructure for 1 million Russian & Ethiopian immigrants. Continued development of Negev farming communities and investments in water reservoirs construc-tion.
1990's
Gradual connection of all power plants & lines to a developing mega grid system- the "National Electric Carrier'
1989-1991
Drought years.
1996
Water sector governance transfered from ministry of agriculture to ministry of national infrastructures.
'Tahal' is privatized.
1997
Second water master plan.
Seawater desalination initiative in Eilat.
1998
Jordan water pollution crisis.
1973
Yom-Kippur war, resulting in the Arab oil embargo and a global oil crisis.
1979
Peace treaty signed with Egypt. Sinai lands returned to the Egyptians.
1982
First Lebanon war.
1991
Peace process initiated at the Madrid conference of 1991- regional water plans are discussed.
1994
Israel & jordan sign peace agreements.
1995
Oslo agreements between Israel and Palestine

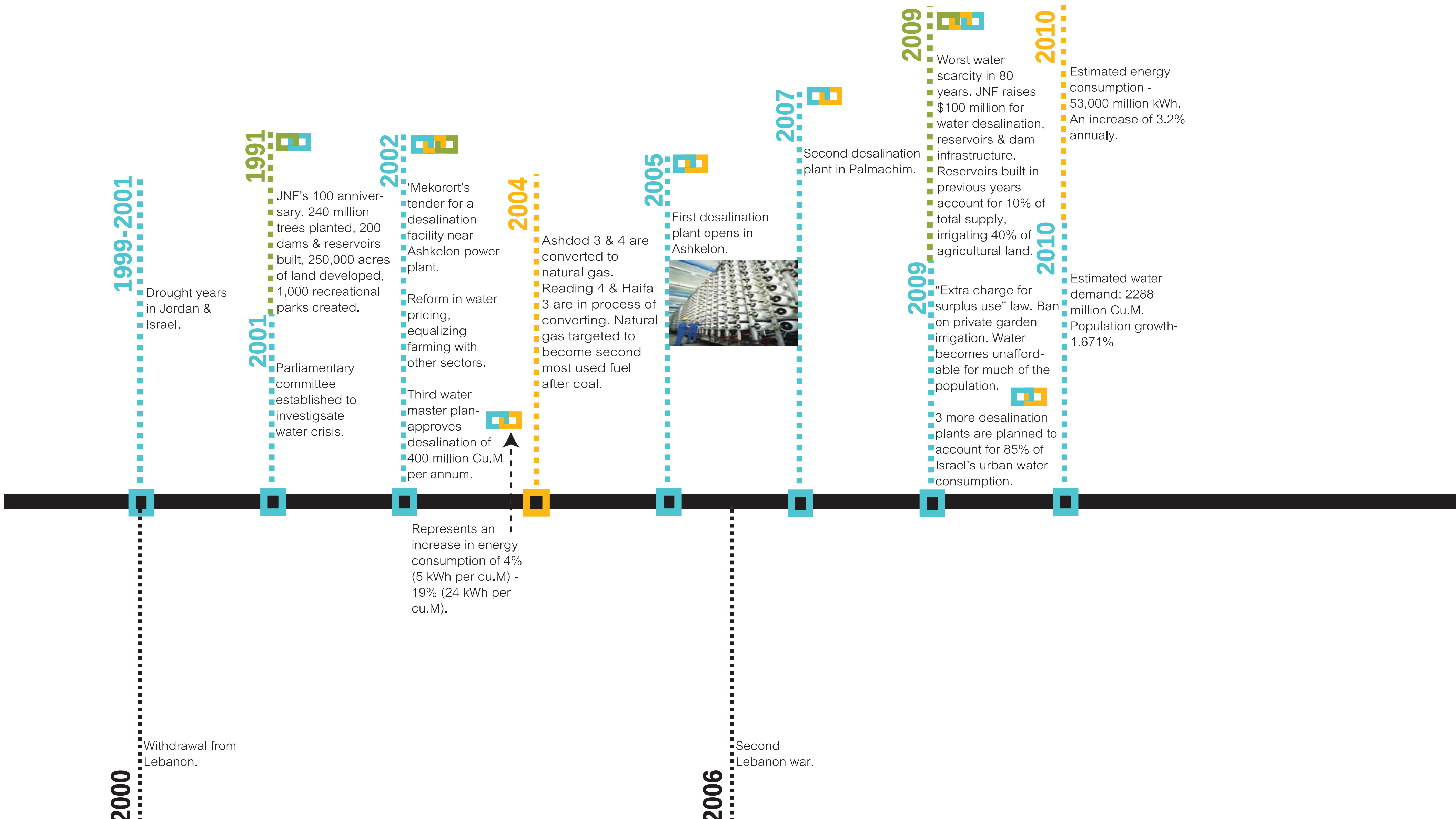


fig. 2.41 Water, energy and land-use linked timelines

2.7 Synthesis

Israel is accustomed to crises. Through the ages, the inhabitants of the Negev desert have also been no exception to this reality. In this chapter, the specifics that define the Negev's current crisis have been investigated. Through the patterns of climate, the desert is continuously in deficit of water caused by evaporation rates greater than rainfall levels. On the national level, existing surface and underground water resources are rapidly depleting. Energy production is reliant on fossil fuel imports, which are of limited quantities and prove to be harmful to the local residents' health as well as in the long run, globally.

Population is continuously rising and with it a staggering demand to both water and energy resources. Another resource in demand is fertile land area on which to reside, grow food, and support industries. The coastal plane is crowded with competing sprawling urban centers and growing industries, pushing out agricultural cultivation. Land resources in the southern Negev desert have been taken from the public realm to be occupied and abused by the military with little regard to their environmental integrity. The Bedouins, who have managed their existence within this ecosystem for hundreds of years and learned how to live by it, are denied access to their traditional way of life.

Through the linked timeline, it becomes clear that the patterns of water, energy, climate, population and land use are inherently linked. Flows in one aspect affect the other and vice versa. Many of the resources discussed in this chapter are heavily exploited and, therefore, ephemeral; short-lived. Shortage of resources is often a catalyst for political instability, not foreign to this region, which causes further resource degradation, bringing about a state of permanent crisis.

It is also shown through this timeline that the dominant actors of this system are resilient, capable of changing and adapting to new paradigms as needed. The electrical company has seen many technological changes, the water company Mekorot has explored various avenues of water extraction and the Jewish National Fund saw shifts from land purchased for settlement to recreational and environmental stewardship. They may be able to corroboratively adapt to future conditions. A linked problem requires a linked solution. A synthesized approach weaving long term resource management of water, energy and land on both a national scale and locally may prove to be a viable re-organization strategy.

1 James J. Kay, Henry A. Regier, Michelle Boyle, and George Francis, "An Ecosystem Approach for Sustainability: Addressing the Challenge of Complexity." *Futures* 31, no. 7 (1999): 722-723.

2 Ibid., 724.

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4 David Waltner-Towes, James J. Kay and Nina-Marie E. Lister, *eds., The Ecosystem Approach: Complexity, Uncertainty, and Managing for Sustainability* (New York: New York: Columbia University Press, 2008), 68.

5 Buckminster R. Fuller, *Operating Manual for Spaceship Earth* (New York: New York: E. P. Dutton, 1971), 67-68.

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7 "The problem of Land Degradation," UNCCD, http://www.unccd.int/convention/text/leaflet.php (accessed March 9, 2010).

8 Daniel D. Evans and John L. Thames, *Water in Desert Ecosystems. US/IBP Synthesis Series; 1* (Stroudsburg, Pa.: Dowden, Hutchinson & Ross, 1981), 3.

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10 Michael Evenari, Imanuel Noy-Meir, and David W. Goodall, *Hot Deserts and Arid Shrublands. Ecosystems of the World; 12A-12B* (Amsterdam: Elsevier, 1984), 1.

11 Lindsay Stringer, "Can the UN Convention to Combat Desertification Guide Sustainable use of the World's Soils?" *Frontiers in Ecology and the Environment* 6, no. 3 (04/01, 2008): 140.

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13 Jörg Schlaich, *Solar Chimney: Electricity from the Sun* (Stuttgart: A. Menges, 1995), 11.

14 Aryeh Bitan and Sarah Rubin, *Climatic Atlas of Israel for Physical and Environmental Planning and Design* (Hebrew), (Tel Aviv: Ramot publishing), 1991.

15 Daniel Hillel, *Negev: Land, Water, and Life in a Desert Environment (*New York, N.Y.: Praeger, 1982), 74.

16 Evenari, Noy-Meir, and Goodall, 3.

17 Ibid.

18 Ibid.

19 US Geological Survey. *Overview of Middle-East Water Resources* (Executive Action Team, 1998), http://exact-me.org/overview/index.htm (accessed October 26, 2009), *28*. This report compiled by the US geological survey to support the Middle-east Water Data Banks Project in 1998. The project was one of the initiatives taken following the Israel-Jordan peace process discussions in 1992. The report was prepared using contributions from Palestinian, Jordanian and Israeli water experts.

20 Ibid.

21 Ibid.

22 Israel ministry of national Infrastructures, water commission, demand management division. *Water Consumption and Production Report* (2001), http://gwri-ic.technion.ac.il/pdf/wcom/demand.pdf (accessed March 22, 2010), 17.

23 Ibid.

24 Tzur Shezaf, *End of the road- Death of a country, a critical travel in Israel* (Hebrew), *(*Tel-Aviv: Am Oved Publishing House, 2007), 44-65.

25 Israel ministry of national Infrastructures*, Water Consumption and Production Report*, 18.

26 Ibid.

27 Ibid.

28 Ibid.

29 The lower red line (-213.18m) signifies the lowest level of the Kinneret from which water extraction is still viable. The upper red line (-208.8m) is a warning sign that the end is near. The level of the Kinneret is a country wide topic of concern

and is known to affect national mood levels. During the recent water scarcity last summer it had dropped under the lower red line to -214.37m. During that period, sever water taxes were put in place. Following a relatively rainy winter the water level increased to -212.84m during March 2010.

30 Israel ministry of national Infrastructures, *Water Consumption and Production Report*, 18.

31 Thomas R. Yager, "The Mineral industry of Israel," US Geological Survey, 2000 Mineral Yearbook, http://minerals.usgs.gov/minerals/pubs/country/2000/ismyb00.pdf (accessed March 25, 2010), 37.

32 CIA factbook Israel, https://www.cia.gov/library/publications/the-world-factbook/geos/is.html (accessed March 26, 2010).

33 Israel Electric Company, "Electrical company statistical report 2008," http://www.israel-electric.co.il/Static/WorkFolder/IRR/StatReport2007.pdf (accessed February 23, 2010), 62.

34 Ibid., 19.

35 Ibid., 18.

36 Ibid., 11.

37 David Faiman, Artuz Sheva; "Israel to Build World's Largest Solar Power Plant," 16 June, 2003, quoted in Bustan-water and electricity publication, http://www.bustan.org/rep.asp?id=47&publication=4 (accessed September 21, 2009)

38 Ibid.

39 Amiram Oren and Rafi Regev. *Land in uniform- Territory and defense in Israel* (Hebrew), (Jerusalem: Karmel, 2008), 198

40 Ibid., 11

41 Ibid., 192-198

42 Ibid., 422

43 Rebecca Manski, *The Nature of Environmental Injustice in Bedouin Urban Townships: The End of Self Subsistence.* 2007, http://www.bustan.org/Publications.asp?publication=4, accessed: September 21, 2009. The report was prepared for the local activist organization Bustan. Bustan is a: "Sustainable Community Action for Land and People is an NGO that works in the Bedouin and Jewish communities of the Negev. Through analysis, education, and action, it is the mission of Bustan to work for fair resource allocation, as well as social and environmental justice for all peoples in the region".

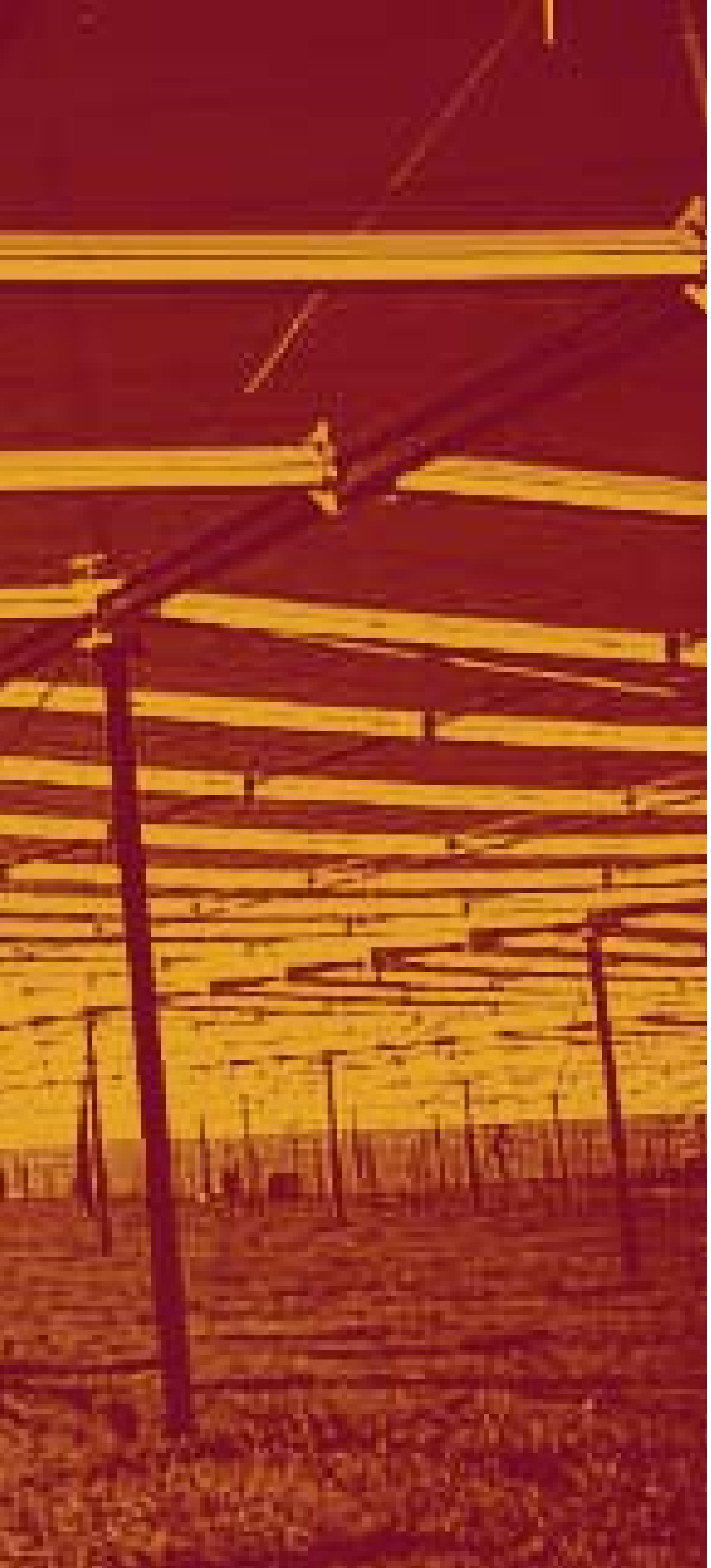
44 Ibid.

45 Sa'id Abu Sammur, *Unrecognized villages map*, The Regional council for the Unrecognized Arab Bedouin villages in the Negev. 2006, http://www.bustan.org/subject.asp?id=25 (accessed May 4, 2009)

46 Manski, *The Nature of Environmental Injustice.*

47 Ibid.

48 Sa'id Abu Sammur, *Unrecognized villages map.*

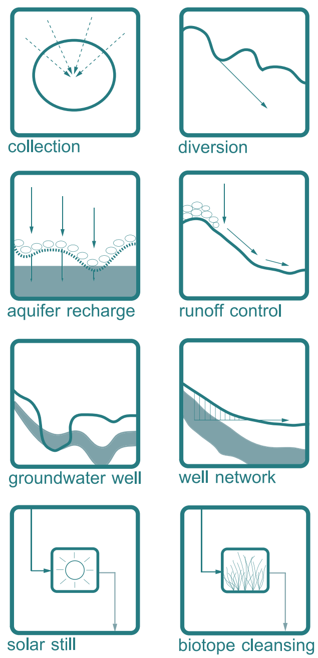


03.

Vital Signs

fig. 3.1 Greenhouses under a solar chimney canopy

3.1 Water management



Rainwater harvesting:

- direct through collection cisterns
- indirect by diversion channels into terracing fields

Runoff control:

- aquifer recharge by increased soil infiltration
- induced runoff directed into regulated basins

Aquifer usage:

- wells at locations where water table is close to the surface, springs etc
- well and channel network bringing aquifer water to where it is needed

Water treatment:

- purification through solar distillation and sediment basins
- cleansing by biotope: living machines, constructed wetlands, etc.

Cisterns have been one of the earliest means of collecting rainwater, notably in arid regions. The earliest ones appear to be imitations of natural hole formations[1] within wadi banks or along hillsides where rainfall would collect during floods.

Such open-pit cisterns were covered with branches or fabric to prevent evaporation and would hold water storage for the entire duration of the dry season. To prevent seepage these cisterns were often lined with stones and plastered with burnt lime which acted as waterproofing cement. Such methods were not always effective therefore the next generation of cisterns was dug directly into the bedrock. Chalk and Marl rock composites were preferred over limestone since they were easier to carve into, yet more resistant to water infiltration.

The cisterns typically had a sediment basin near the collection opening through which slope runoff was channeled in. Sand and heavy sediments would sink in while the distilled water would overflow into the cistern. An additional opening was provided for water withdrawal.

Clusters of cisterns were often constructed along the banks of a wadi to be filled by floodwater rather than runoff from hill slopes.

fig. 3.4 Bedrock cistern in Massada by Herod

fig. 3.2 Typical cistern sections in Nahal Avdat

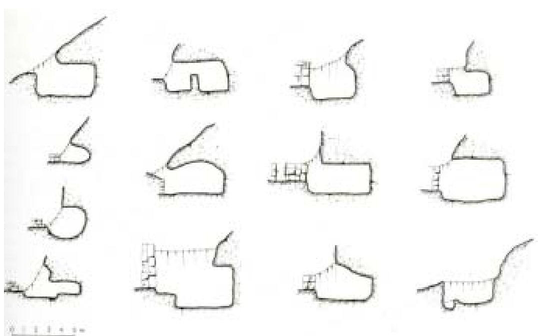


fig. 3.3 Bedouin women by a cistern's opening

Diversion Channels

Vernacular

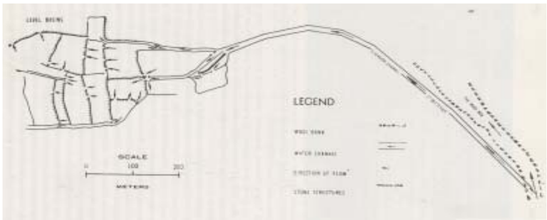


fig. 3.5 Nabatean diversion pools system in plan

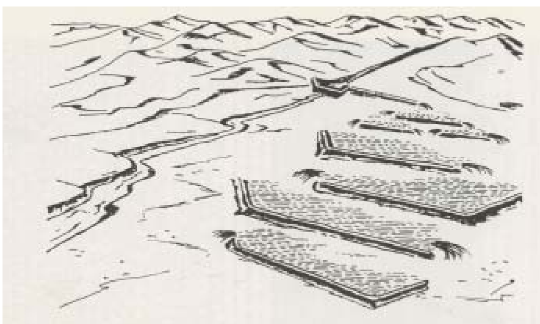


fig. 3.6 Earthen dykes system

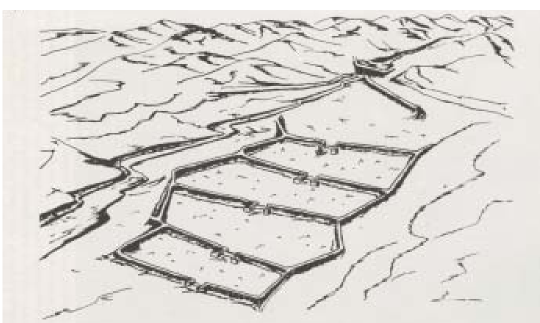


fig. 3.7 Level basins and concrete spillways

Complex diversion systems have been discovered in the vicinity of wadis near ancient centers of population such as the Nabatean cities of Shivta, Ovdat and Mamshit. These diversion systems often utilized mid-sized wadis of up to a 100 km^2.

The system had an overflow diversion dam to redirect the flow from its original course onto a diversion channel. The diversion channel would then direct the water onto a plain of terraced fields. The fields were varied in size and any surplus water overflowed downward from the higher tiers to the lower ones through constructed spillways.

A typical area of such irrigated system would be 10 hectares, which presupposes a water supply of 25,000-40,000 Cu.m annually as it is known that in order to yield crops, 1 hectare of land requires 2,500-4,000 Cu.m of water.[2]

The two typical terracing methods consisted of either non-levelled earth dikes, which due to erosion were only suitable for perennial soil-conserving vegetation, or defined levelled basins with concrete waterproof spillways. Such a system enabled cultivation of annual or orchard crops.

A similar concept was used by contemporary artists Jody Pinto and Steve Martino in a landscaping project to mark the boundary line in Papago Park in Phoenix, Arizona. A structured channel diverts rainwater onto seven tiered terraces. The terraces act as basins detaining water and encouraging regeneration of indigenous vegetation. In the images below (see fig. 3.8): the project is depicted directly following completion (top image) and two years after completion (bottom image).

fig. 3.8 Jody Pinto and Steve Martino- land art

Qanat systems are known to have been in use as early as 4000 BC by the early Sumerian civilizations in Mesopotamia. The system channels underground aquifer water through a moderately sloped tunnel towards an arid plain of irrigated cropland. The canal is linked with a chain of interconnected vertical shafts (or “chain of wells”) which unique formation is visible on the surface. The array of such traces is often the only indication to the existence of a Qanat system. The shafts originally provided ventilation and access since the system had to be regularly maintained.[3]

The Qanat imitates the condition of a spring, bringing aquifer water to the surface where it is needed, using gravitation rather than contemporary pumping technologies.An irrigation system such as the Qanat was advantageous in arid regions since it was covered; preventing evaporation and it lent itself to interconnectivity.

Qanat systems of independent city-states joined into a regional water management network handling flood control, irrigation and large scale water storage. Systems like the Qanat are found in varying names and configurations in many desert civilizations around the world, introduced by the Arab populations as far as China in the east and Spain in the west, and later introduced by the Spanish to South American civilizations.

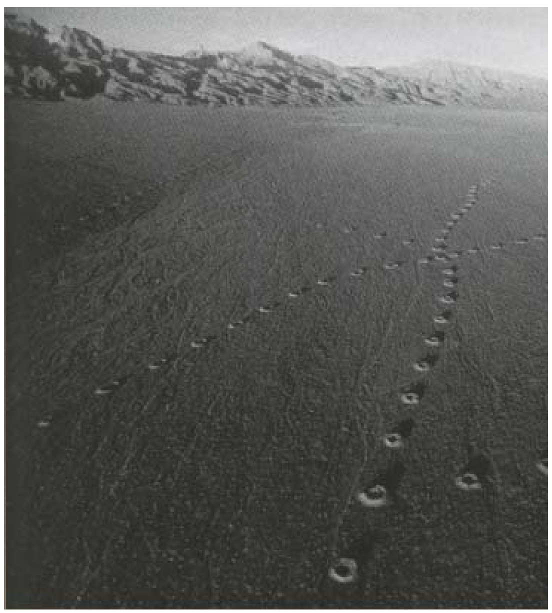


fig. 3.9 Chained well system as seen on ground surface

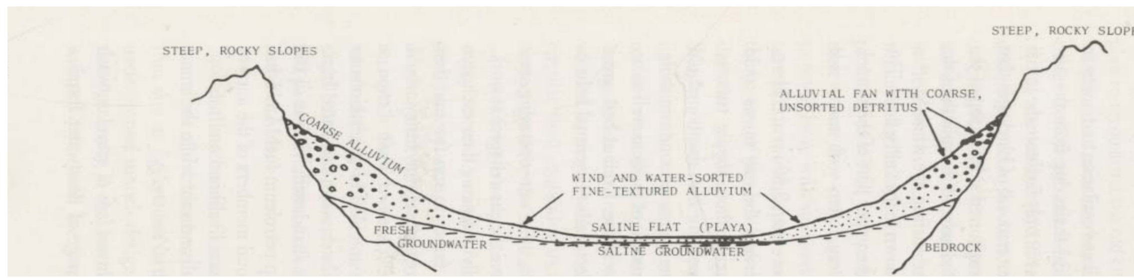


fig. 3.10 Cross- section of an alluvial valley basin

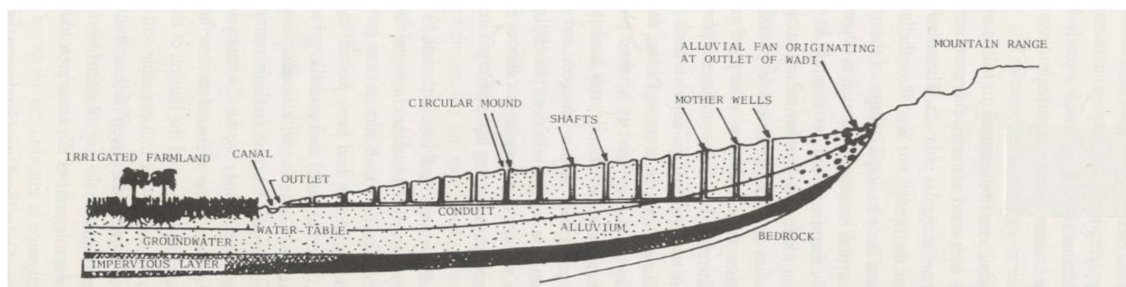
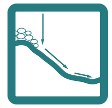


fig. 3.11 Cross- section of a Qanat system

Gravel Mounds

Vernacular



Ancient Negev populations relied heavily on hillside runoff for irrigation and cisterns replenishment. It is believed that the extensive patterns of gravel mounds and strips spreading along many square kilometers near Nabatean towns were proactively devised to induce such runoff.

Typically, in some regions of the Negev, desert soil is covered with loose gravel mulch and stone fragments which encourage water infiltration into the soil. This inevitably reduces the amount of runoff which could be collected downhill in constructed cisterns. Once the gravel is collected into mounds, the bare soil, which is exposed to water, then forms a hard surface crust which prevents infiltration and induces runoff. The Bedouins name these mounds 'Tuleilat el-Einab, meaning grapevine mounds, as they are believed to have facilitated the operation of ancient vineyards.[4]

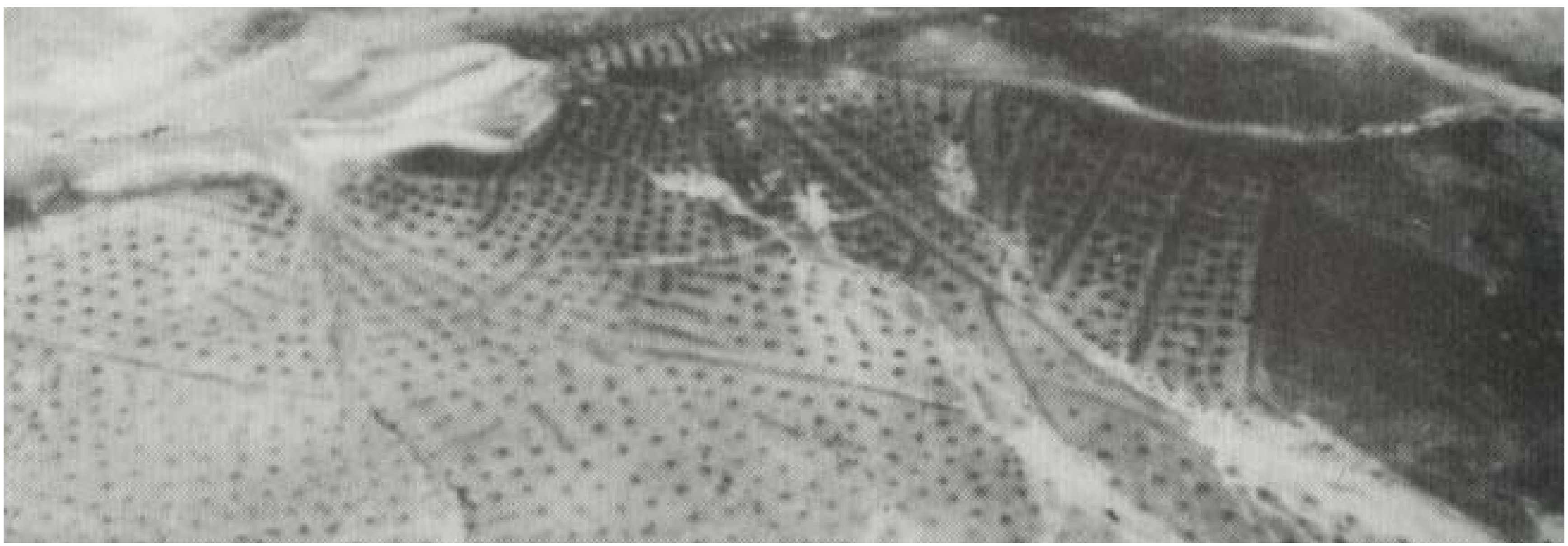
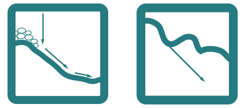


fig. 3.12 Aerial view of extensive areas of gravel mounds in the Negev



Desert runoff, either encouraged by intervention, as shown in the previous example, or naturally formed by an existing impermeable desert crust, helped sustain ancient desert farming in the Negev. Starting in 1954, Michael Evenari et al. unveiled structures of farming systems that collect runoff from hillsides and direct it to terraced farming units.[5] Through a series of 70 field trips and a close investigation of aerial photos of the area, they discovered patterns in the landscape which were later defined by one of three categories: individual terraced narrow wadis, terraced fields with farmsteads or diversion systems on floodplains.[6]

Terracing within wadis was mostly practiced in secondary tributary wadis, where flow volume was not as great as in the larger wadis and the structures could withstand the forces of flash floods. The terracing functioned as erosion and flood-control measures, while the wet soil of each terrace could be used for agriculture.[7]

Groups of terraced fields and farmsteads were found nearby ancient cities, also in the smaller wadis and were surrounded by hillsides. Stone channels run along the hillsides, which functioned as catchment areas to direct runoff into the cultivating fields. These systems were operated by a single family and adjoining them was a farmstead with a farmhouse, a watchtower and an underground cistern.

Ancient farmers discovered that the larger the catchment basin, the greater the water volumes collected by their fields, up to a limit, beyond which, higher water volumes erode the terracing and channeling structures.[8] They then started to devise more complex diversion systems that took advantage of the catchment basins of primary larger wadis. This method used engineered channels to divert water that passed through the wadi during a flash flood into extended systems of terracing fields along the wadi's floodplain.

fig. 3.13 Terraced fields with adjoining farmsteads

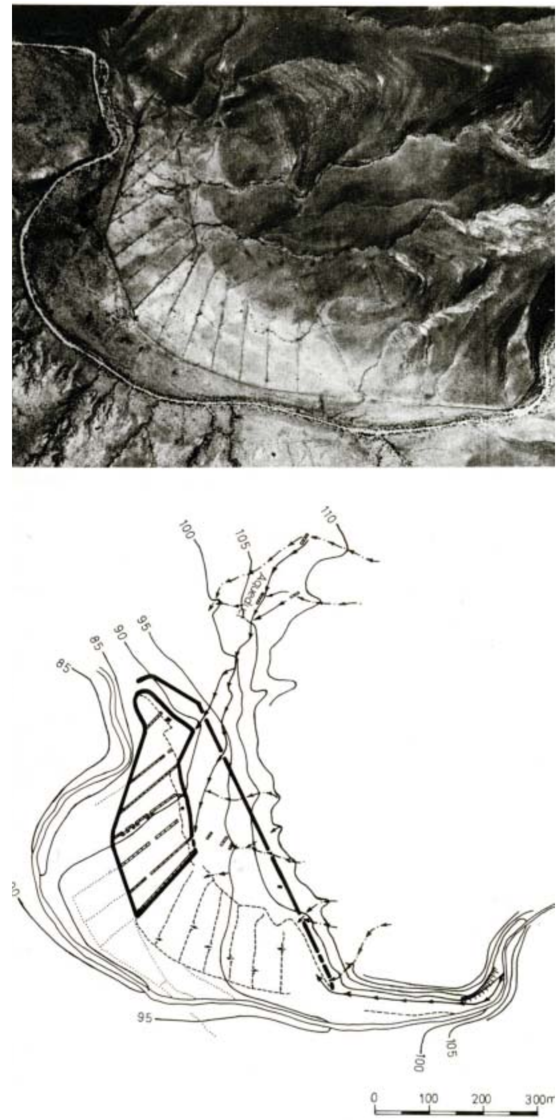


fig. 3.14 Diversion system and runoff farm in Wadi Kurnub

In 1961, Evenari et al. started experiments on Microcatchment systems for growing trees, vines and shrubs, following a precedent developed in North-Africa.[9] A separate microcatchment is allocated to each plant that works as its own 'microwatershed.'[10] The strategy, known also as a 'Net and Pan' system, consists of an interconnected series of these berms and depressions in the ground (see fig. 3.15). They are applied on a hillside with a slight slope, and direct runoff from one microcatchment to another.

Evenari experimented on various crops and yielded successful results with olives, apricots, pomegranates, almonds, carobs, grapes and saltbush for pasture. The experiments included varying plot sizes, between 15.6 m^2 and 1000m^2, with the goal of determining the optimal size for the most efficient use of land and available runoff. During earlier studies of the wadi runoff systems, they discovered that the smaller the catchment, the higher the water yield per unit surface area, since loss to evaporation is minimized.[11] The empirical results showed some fluctuation, in that optimal catchment size varied between the different crop types, and in some occasions there was no clear preference between a few consecutive sizes of the lower end of the size range. Generally however, smaller microcatchments had higher yields. In any event, the results clearly determined that crop yields within a microcatchment system were 20-30 times higher than crops with zero microcatchment. They also discovered that emergent plant stock, developing spontaneously along microcatchmnet edges, bring the yield to a 50-fold increase.[12]

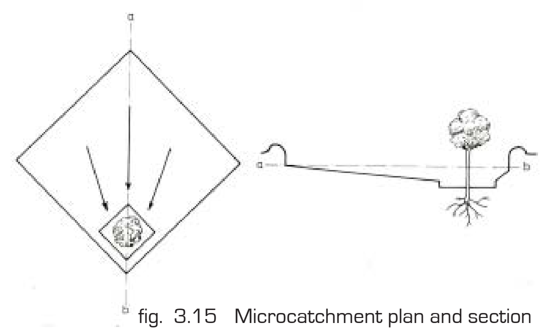


fig. 3.15 Microcatchment plan and section

fig. 3.16 Young Apricot tree in microcatchments in Botsanawa

Solar Distillation

+ Air born moisture Collection

Vernacular

This system exists in many variations, and is used for collection of airborne humidity, plant moisture and soil moisture. The solar still in its most basic format is composed of a pit covered with a plastic sheet. The sheet is fastened tightly to the edges of the pit. A stone is placed in the middle of it allowing the sheet to slope towards the center. Within the pit a container is placed centered with the stone location.

As the sheet is heated by the sun, moisture from the ground, air or any plant material within the pit evaporates and condensation is collected at the bottom of the sheet. The moisture is directed by the slope downwards and is collected in the container. An evacuation tube allows for the water to be used without disassembling the entire device.

As the water evaporates, all saline and impure content remains at the bottom of the pit, while clean water is collected within the container. Therefore the solar still can double both as collection and treatment system, using the sun's energy.

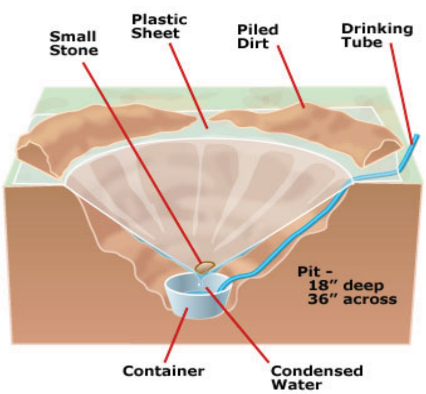


fig. 3.17 A simple solar still

fig. 3.18 Experimental solar stills in India

Down To Earth

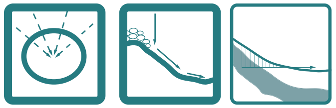
Negev Desert, Israel

Ruth Kedar

This project, inspired by the Qanat network of vertical wells and Nabatean runoff management systems, is a prototype for a water catchment and distribution network. It makes use of the existing topography, by the catchment capacity of wadis, to collect and divert water as needed for households and irrigation purposes.

Modular pre-cast concrete cisterns, proportionally sized according to the desired catchment area, are deployed across the terrain. The cisterns are linked through an underground pipe network and allow a system of water management according to predetermined regional priorities.

Each cistern is fitted with three outlets: the bottom one directed to household needs, the middle outlet to the piping network and the highest outlet directs overflow down the hill to the next available cistern.



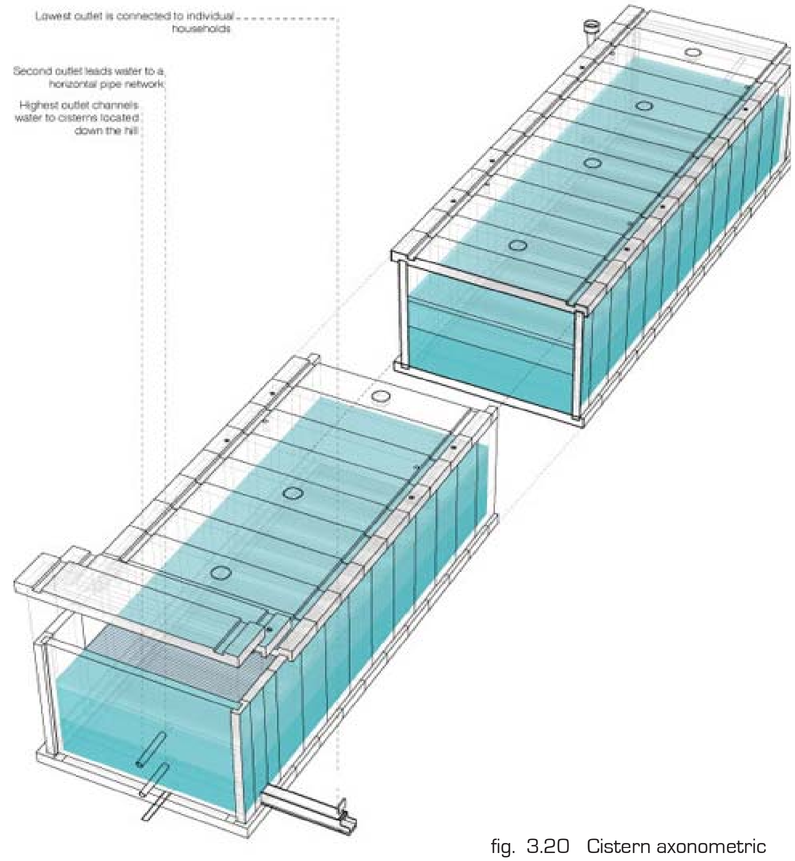


fig. 3.20 Cistern axonometric

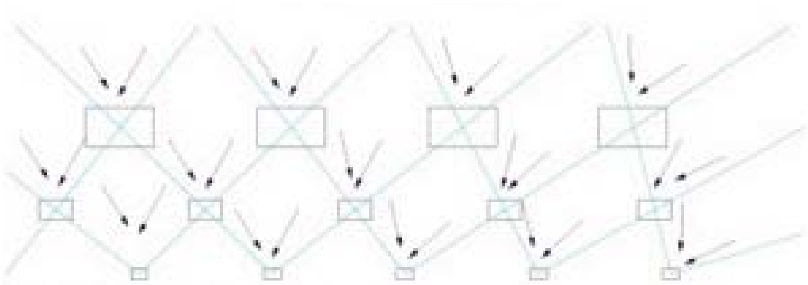


fig. 3.19 Catchment area sizes

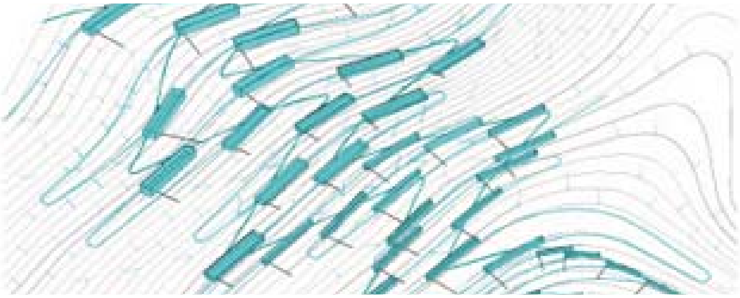
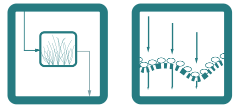


fig. 3.21 Cistern layout and underground piping system

Drop Structures

Shop Creek, Aurora, Colorado, USA

Wenk Associates + Muller Engineering + Black & Veatch



This project employs a system coupling water treatment and storm water management. Runoff water from nearby suburban development was contaminated by high phosphorus concentrations. Runoff is now treated through the creek in a two phase process; first by a settling pond, where pollutants sink to the bottom and are absorbed by sediments and secondly by a wetland system that removes pollutants through a biotope cleansing process, using cattails and willows.

To control water flooding and eroding the wetlands, six drop structures are spread throughout the creek. The drop structures are made using local sand and soil mixed with Portland cement. They are designed in the form of a wide stepped crescent in order to slow down the stream by turning it against its flow direction. The material is designed to withstand the forces of the flow, yet allows for localized and controlled erosion to occur.[13]

fig. 3.22 Drop structures aerial view

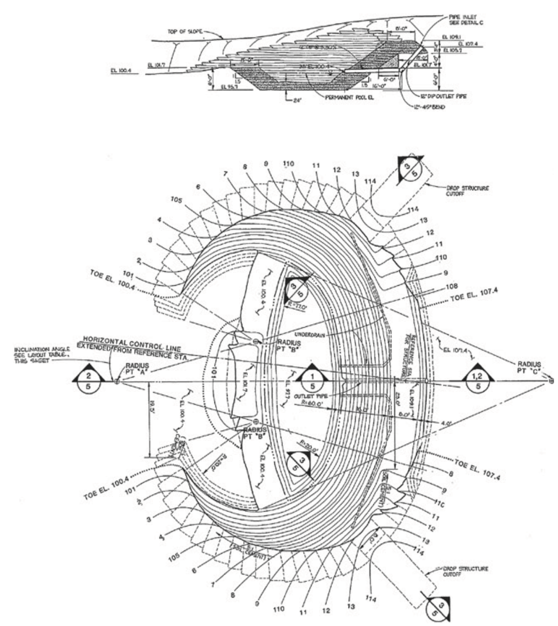


fig. 3.23 Drop structure typical plan and section

Effluent Wetlands

Besos River, Barcelona, Spain

Barcelona Regional Agencia Metropolitana

In the past the Besos River was characterized by intermittent occurrences of dry river beds in the summer time, due to high urban water consumption, and dangerous flooding during torrential rainfall. Often effluent discharge from adjacent water treatment plants had been the determining factor of flow quantity and velocity.

The restoration project, commissioned in 1996, introduced a layering of amenity and recreational functions embedded within an ecology restoring infrastructure. A series of 60 sub-surface constructed wetland beds act to purify wastewater, accounting for the majority of river's water flow during the dry season. The wetlands also minimize bad odors, mosquitoes and evaporation, and are positively accepted by local flora and fauna.

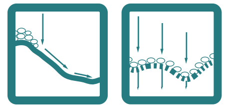
Water treated through the wetlands is directed through a controlled drainage system and is used for irrigating vegetation on the riverbanks. Biomass residue is used as substrate.[14]

fig. 3.24 Constructed wetlands integrated with the flood plain of the Besos River

fig. 3.25 Besos River aerial view

Detention Swales

Coffee Creek, Chesterton, Indiana USA



Coffee Creek is a master plan for a model community incorporating sustainable principles such as: energy efficiency, water management, high density and pedestrian and cyclist oriented environments. Rainwater is channelled from streets and parking lots through trenches into terraced infiltration zones. These areas are planted with highly absorbent local prairie vegetation and are able to withstand extreme rainfall conditions.

fig. 3.26 Coffee Creek model community- sustainable water management as part of community planning.

fig. 3.27 Incorporating water infrastructure with natural stream and pond landscapes.

Once the storm water is channeled into the detention swales it is biologically purified and allowed to infiltrate groundwater for aquifer recharge. This approach to water management, along with preserving the water resources of the region (about 260 hectares), and aiding in flood prevention and erosion control, is advantageous in that it couples infrastructure with open recreational public spaces in the form of streams, ponds, cascades and natural parks.

Airport to Pond

Fornebu Airport, Oslo, Norway, Atelier Dreiseitl

Due to airport relocation, Fornebu Island became ideal real estate for an upcoming housing and business development in the vicinity of Oslo city center. The previous heavy usage of the site necessitates extensive measures for soil remediation and an ongoing strategy for water management of the 200 hectare site. The plan introduces a central park for recreational purposes to which an artificial pond was added to enhance the park experience while doubling as a collection reservoir for the surrounding community.

The design scheme proposes a water axis to connect the pond with the previous control tower and act as a channel to which runoff from streets, sidewalks and roofs is directed. The pond itself also functions as a storm water catchment basin collecting runoff from the radial streets via a system of "green fingers." Overflow from the pond is accounted for and released through a biotope cleansing wetland onto the Oslo Fjord.

fig. 3.28 Fornebu Island

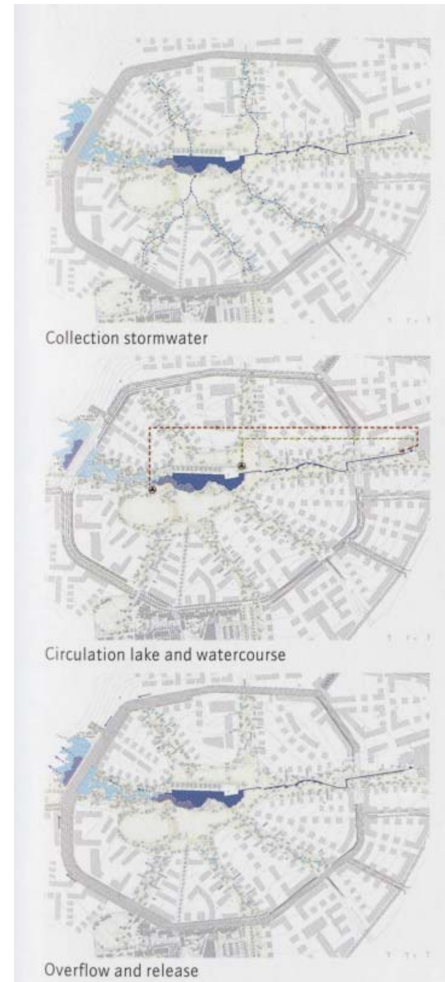


fig. 3.29 Water conveyed to a central lake through a network of park systems

3. 2 Solar Power Generation


solar chimney

NATURAL CONVECTION

1. Solar chimney / Updraft Tower


power towe.

CONCENTRATED SOLAR POWER (CSP)

1. Power Tower (Helio-stat field)


parabolic dish


parabolic trough

2. Parabolic dish- engine
3. Parabolic Trough / CLFR

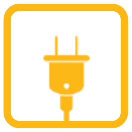

photovoltaic


thin film

PHOTOVOLTAIC TECHNOLOGIES

1. Conventional PV
2. Thin film PV

SMART GRIDS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UPDRAFT TOWER

The Solar Chimney

Experimental station, Manzanares, Spain

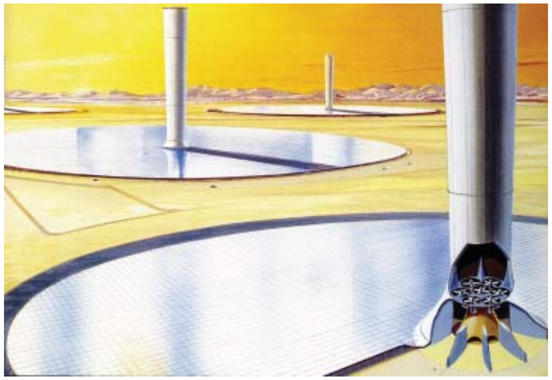


fig. 3.30 Solar chimney base cutout

The updraft tower (aka. the solar chimney), operates on the principle of natural convection by which hot air rises upwards. The solar chimney employs the following three components: the glass roof heat collector, the chimney and wind turbines with generators.[15] Cold air that penetrates through the collector edges, is warmed up by the ground, and then conveyed upward through the chimney. As this air moves upward, it accelerates and propels the turbines within the chimney, which activate the generators.

The first system component, the collector, is made of either a simple glass or plastic film covering, which form a circle at the base of the chimney. It stands at a height of 2-6 meters above ground, lowest at the outside perimeter and sloping upward as it meets the base of the chimney (see fig. 3.31). The ground under the collector, acting as a natural latent energy storage, is heated and then transmits its energy to the air, which flow is directed into the chimney.[16]

The chimney is most often made of reinforced concrete, but can also be built as a guyed structure of corrugated metal sheet, cable-net with cladding or membranes.[17] The efficiency of the chimney is highly dependent on the chimney's height as well as the collector's diameter and the ground temperature. A 1000m chimney with a collector of 7000m in diameter can support a production of 1000 GWh/y.[18]

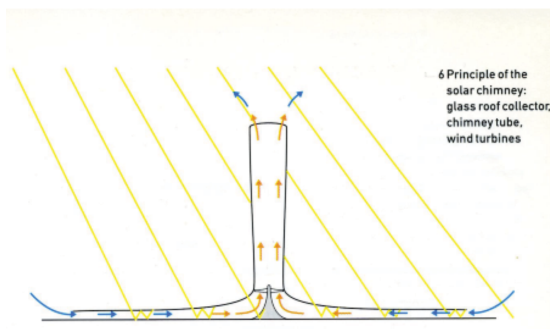


fig. 3.31 The stack effect in the solar chimney

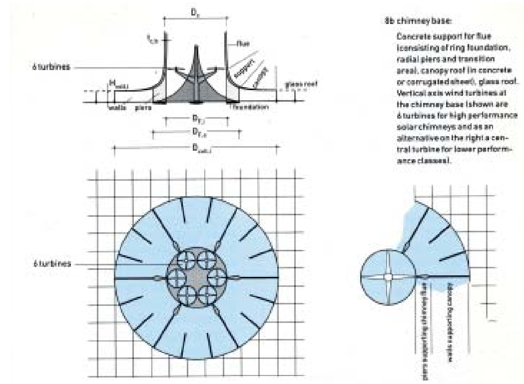


fig. 3.32 Chimney base

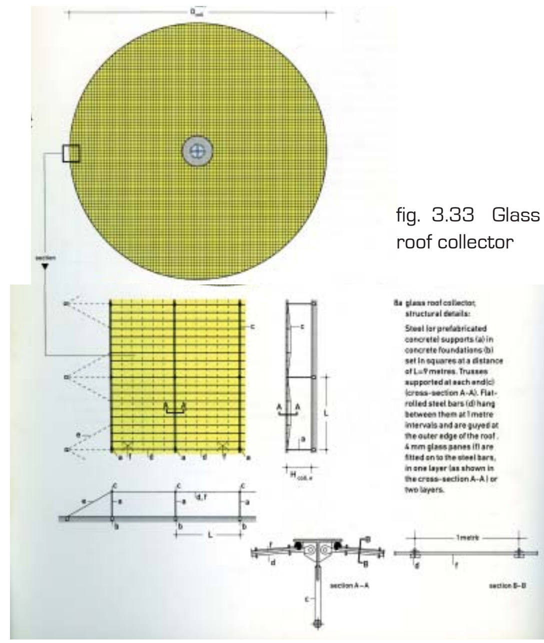


fig. 3.33 Glass roof collector


fig. 3.34 Prototype plant in Manzanares, Spain

The first solar chimney prototype was built in Manzanares, Spain, approximately 150 km south of Madrid. The project was commissioned in 1980 with the goal of empirically verifying the theoretically calculated energy output. Construction was carried through 1981 and the research facility started operation in 1982.[19] The chimney structure was built as a guyed corrugated sheet flue, rising to a height of 195m, with a diameter of 10m. The collector was raised to a height of 2m above ground with a diameter of 240m. The station's output for these dimensions was 50 kW, although not economically viable for a running plant, it was sufficient for experimental purposes.

The chimney's performance was tracked by 180 sensors.[20] Among the variables monitored between 1982-1989 were: ground temperature, ground type, air temperature, speed, humidity, collector translucency, turbine data, and meteorological data.[21] It was discovered that ground made of clay or loess has the greatest storage capacity and allows for peak production during the early evening hours and continued production throughout the night.

As part of the performance experiments carried in the site, various covering materials were also tested. Glass proved to perform better than plastic, due to its higher durability and easier maintenance.

The most meaningful achievement of the experiment was to use measured results to verify and improve the thermodynamic simulation model. This enabled more accurate calculations for future full scale energy production sites, with outputs larger than 200 mW.[22] For the full size plant, glass covering was recommended for the collector, reinforced concrete tubes for the chimney, and six vertical axis turbines at the base of the tower.


fig. 3.35 Conditions under the collector's glass roof are optimal for greenhouses

CONCENTRATED SOLAR POWER (CSP)

Power Tower or Helio-Stat Field

Technology by BrightSource Energy

The Heliostat power plant operates on the concepts of concentrated solar radiation, which is converted into steam to produce energy. The system's components are an array of thousands of Heliostats with tracking capabilities, a central power tower to which the Heliostats reflect solar rays and a power block at the base of the tower, converting steam to electricity.

The Heliostats themselves are composed of two flat glass mirrors, a total area of 14.4 m^2, installed on a support structure which sits on a pylon, directly fitted into the ground. Each Heliostat is connected to a control system, which is networked with other Heliostats in the array. Each Heliostat can track the sun on two axes. After taking into account variables such as sun radiation, wind pressures, beam shape, intensity and tracking accuracy of the individual Heliostat, the Heliostat is aimed in such way that optimizes performance of the system as a whole.

The central metal structure tower is sized according to the size of the Heliostat field. For a plant of 100 mW, 50,000 Heliostats are required.[23] A high efficiency boiler is placed on top of the tower, converting the convergent solar radiation into high pressure steam at a temperature of 550°c.

At the bottom of the tower, a power block is situated. This block is similar to existing power generation blocks used in steam powered conventional fossil fuel powered plants. The block converts steam into electrical energy through the use of a conventional steam turbine generator. It has additional capabilities of heat rejection, water treatment, water disposal and grid interconnection capabilities.[24] For its cooling needs, the system uses air instead of water, thus accounting for 90 percent water savings, an obvious advantage for sites in arid regions.

fig. 3.36 Heliostat field and tower

fig. 3.37 Solar One

fig. 3.38 PS10 and PS20

SOLAR ONE - 1982-1986

Mojave Desert, California, USA

Actors: Department of Energy (DOE), LA Dept. of Water and Power, California Energy Commission and Southern California Edison.

Field size: 1,818 mirrors, each 40 m², total area of 72,720 m².

Generating capacity: 10 mW.

SOLAR TWO - 1995-2009

Mojave Desert, California, USA

Actors: Department of Energy (DOE), LA Dept. of Water and Power and Southern California Edison.

Field size: A second ring of 108 heliostats, 95 m² large was added to Solar One. Total size: 1926 heliostats with a total area of 82,980 m².

Generating capacity: 20 mW.[25]

* Solar Two used molten salts as energy storage medium to allow for continuous energy generation.

PS10 - 2001-2005

Sanlúcar la Mayor, near Seville, Spain

Actors: Solúcar Energía, S.A., an Abengoa Group company, through the regis-tered IPP Sanlúcar Solar S.A.

Field size: 624 heliostats, each 120 m^2, total area of 74,880 m^2.

Generating capacity: 10 mW.

PS20 - 2009- in operation.

Sanlúcar la Mayor, near Seville, Spain

Actors: Solúcar Energía, S.A., an Abengoa Group company, through the regis-tered IPP Sanlúcar Solar S.A.

Field size: 1255 heliostats, each 120 m^2, total area of 150,600 m^2.

Generating capacity: 20 mW.[26]

* PS10 and PS20 employ glass/metal heliostat technology, reducing weight and costs considerably.

The Parabolic Dish-Engine

The science and craft of utilizing the sun's energy in its concentrated and most powerful form are by no means a novelty. As early as the third century B.C. it was discovered that parabolic mirrors focus the sun's rays to a single focal point of a small area, which can induce very high temperatures.[27] Previous to that spherical mirrors of lesser efficiency were used or even simply flat polished metals assembled together into a curve. In those early days the Greeks, followed by the Romans and the Chinese, used the 'Burning Mirrors' mostly for purposes of ritual and warfare.

It was not until the sixteenth century that parabolic mirrors were proposed for power generation purposes. Leonardo da-Vinci was the first to propose a mirror of a 4 mile diameter to supply energy for a dye factory. By the eighteenth century many developments in materials allowed for much smaller mirrors to operate as effectively. Assembly in sections (see fig. 3.39) then provided more flexibility of design.[28] The industrial revolution, a century later, brought about an era when these ideas and designs finally found practical application within developing industries.

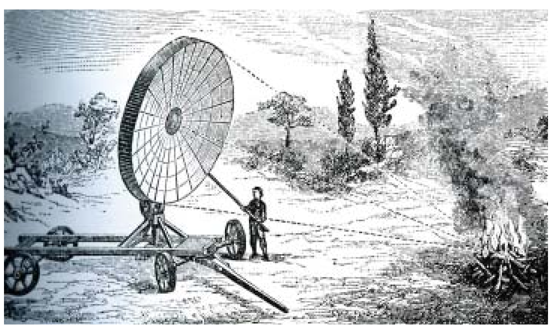


fig. 3.39 Sectioned burning mirror of the late 1700's

Current day technologies are comprised of similar basic components with few minor adjustments. The current parabolic dish system, layered with a reflective mirror surface, is mounted on a double axes tracking device which follows the sun. A central receiver at the focal point is fitted directly with a heat engine converting thermal energy into electricity.

David Faiman, director of the 'National Solar Energy Center' of Israel, developed a powerful PV cell, which can be fitted onto a central receiver of a parabolic dish, similarly to the heat engine system. This cell can withstand the concentrated reflective radiation of the equivalent of a 1000 suns. By using simple cheaper mirrors for the collector and a single PV cell only at the receiver end, this technology claims to be economically competitive to fossil fuel energy generation methods. Faiman believes it could provide pollution free energy for 10% of Israel's population (1,000 mW) with a land area of 12 km^2.[2, 29]

fig. 3.40 Parabolic dish and heat engine

fig. 3.41 Parabolic dish fitted with PV cell

The parabolic trough is a variation of the parabolic dish, operating on very similar principals. The reflective surface in this case is shaped in a trough form. The solar rays are reflected onto a central pipe that runs along the inner curved surface. The receiver pipe is filled with water or oil, heated by solar reflected energy. The steam or thermal energy created is then converted into electrical energy through conventional turbine technologies previously mentioned. The troughs are arranged on North-South axes and have tracking capabilities enabling them to follow the sun's movement throughout the day, so that the reflected rays are always focused on the receiver pipe.

Some systems have heat storage capacities, whereby heat is retained by a latent material, so that generation hours can be extended into the evening. Most systems also offer a hybrid operation method, backing up the solar collector with a natural gas boiler for continuous production during overcast days and throughout the night.

Compact Linear Fresnel Reflector (CLFR) is almost identical to the trough system, the difference being the parabolic trough is replaced by 10 flat mirrors tracking the sun, so as to simulate the parabolic effect. The advantage is that the collectors can be installed closer to the ground which decreases wind loads. The cost of manufacturing the simple flat mirrors is also reduced in comparison to the curved surface parabolic mirrors.

fig. 3.42 Compact Linear Fresnel Reflector

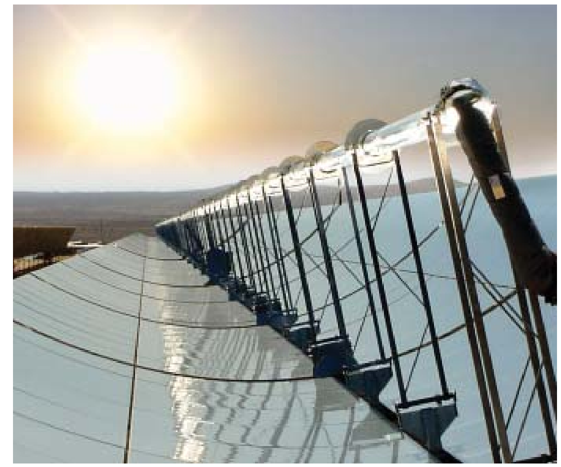


fig. 3.44 Parabolic trough

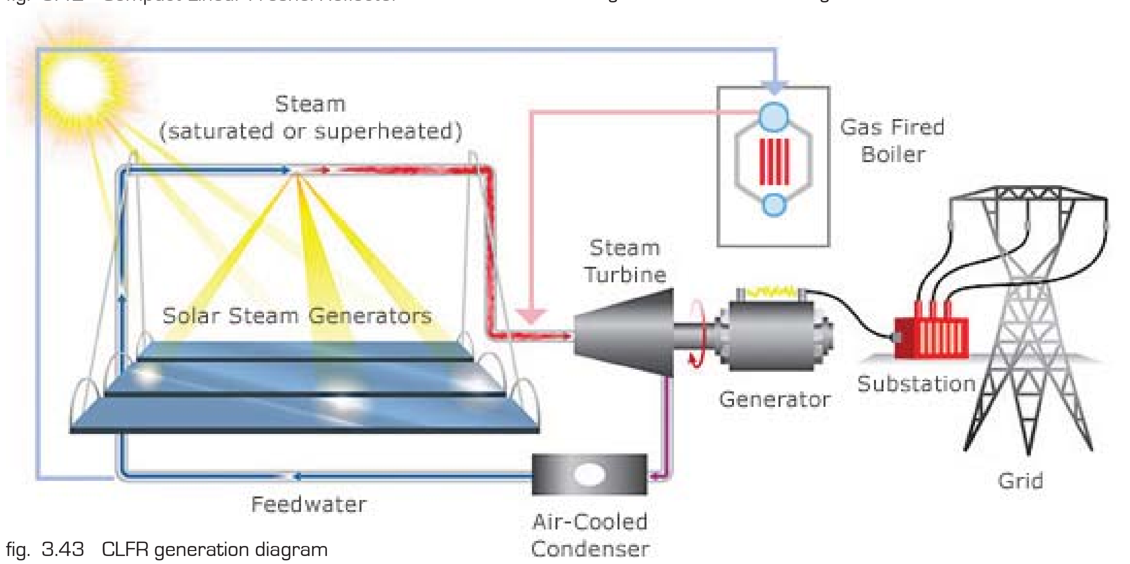


fig. 3.43 CLFR generation diagram

Photovoltaic technologies are perhaps the first which come to mind when considering solar energy production. The basic knowledge of photovoltaic principles has been around for at least the last 50 years, applied predominantly in the space industry.[30] Although the fundamental principles have not changed significantly, major work has been done in the field to advance on issues such as durability, cost and efficiency.

Photovoltaic cells convert photons (light) into electrical energy. This is achieved by creating a p-n junction, made from positively charged semiconductors brought into contact with negatively charged semiconductors. The p-n junction maintains an electrical field, which when exposed to light, produces an electrical current.[31]

Traditionally semiconductors are made of silicon. While the base material, silica, is abundant and not very costly to obtain, the common extraction process into silicon is high in energy expenditure, taking 1-2 years in energy production to offset costs , and is currently a hindrance to bringing the cost of PVs down.

Different processing techniques account for different types of solar cells: monocrystalline, polycrystalline and amorphous. Below (see fig. 3.45) are the stages in the production of a monocrystalline cell, possible arrangements within a string formation, and the assembly of a silicon solar module.[32]

fig. 3.46 Building integrated PV, Solar- Decathlon 2007

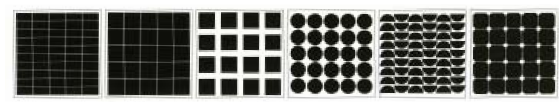


fig. 3.47 Possible string formation in modules

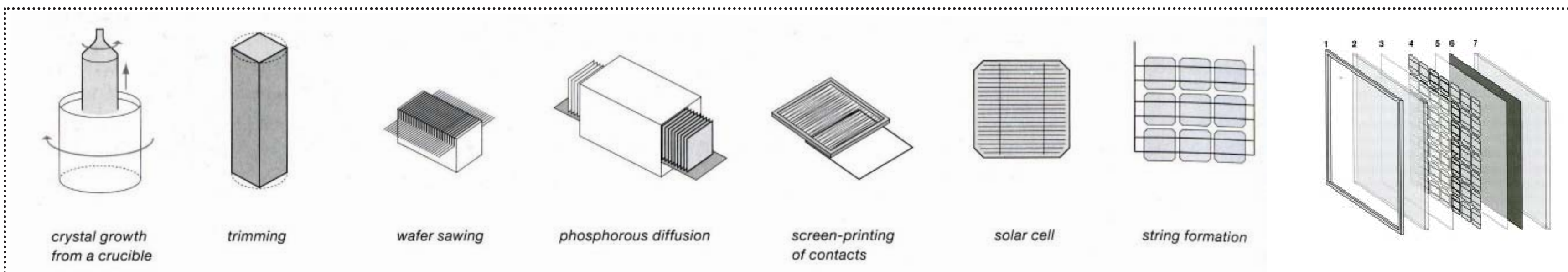


fig. 3.45 The production process of a monocrystalline module

Advancements in the field brought about a second generation of PVs made with a thinner layering of semiconductors of varying materials such as cadmium- telluride (CdTe) or copper-indium-diselenide (CIS).

Thin films are known be energy efficient during the production process and less costly than first generation wafer cells, due to considerable reduction of material. The cells are lighter, flexible and open new horizons in terms of design integration. With thin film technology, solar cells are no longer restricted to rooftops, but can be applied to any curved surface and require simpler support structures, including windows, louvers and facade materials (see fig. 3.49).

Currently, additional researches in the field attempt to further reduce costs, improve the production process and offer a more flexible and well integrated end product such as textiles, tints and spray-on PVs.

Thin film conversion efficiencies are currently peaking at 20% (see fig. 3.51), which puts them at a disadvantage in this regard compared with the crystalline silicon techniques previously mentioned. Another emerging type of solar cells are dye-sensitized cells and organic cells, which currently offer low performance efficiencies (lower than 10%) but are also quite energy efficient during production and very cost effective.

Today the most efficient solar cells under development are multi-junction cells, which achieve 40% conversion efficiency. These technologies use multiple layering of semiconductors of different polarization, which take advantage of the wide spectrum of solar radiation.

fig. 3.49 Semi-transparent crystalline cells integrated with facade glass slats.

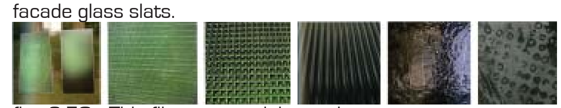


fig. 3.50 Thin film test modules and prototypes

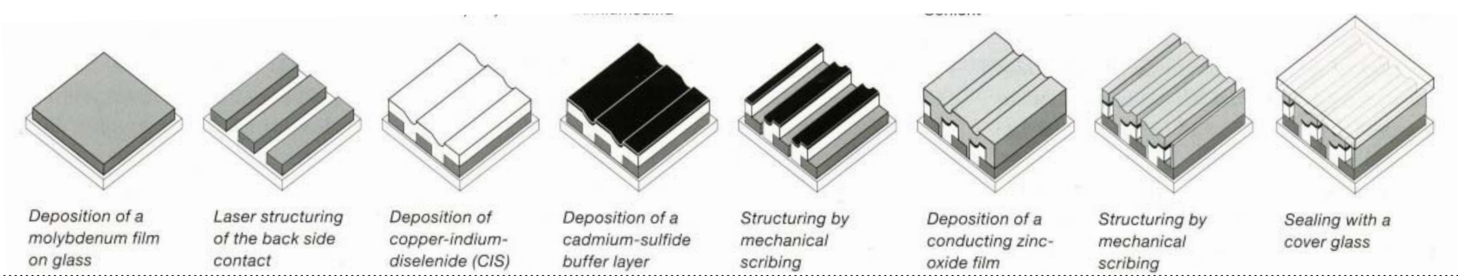


fig. 3.48 The production process of a CIS thin film module

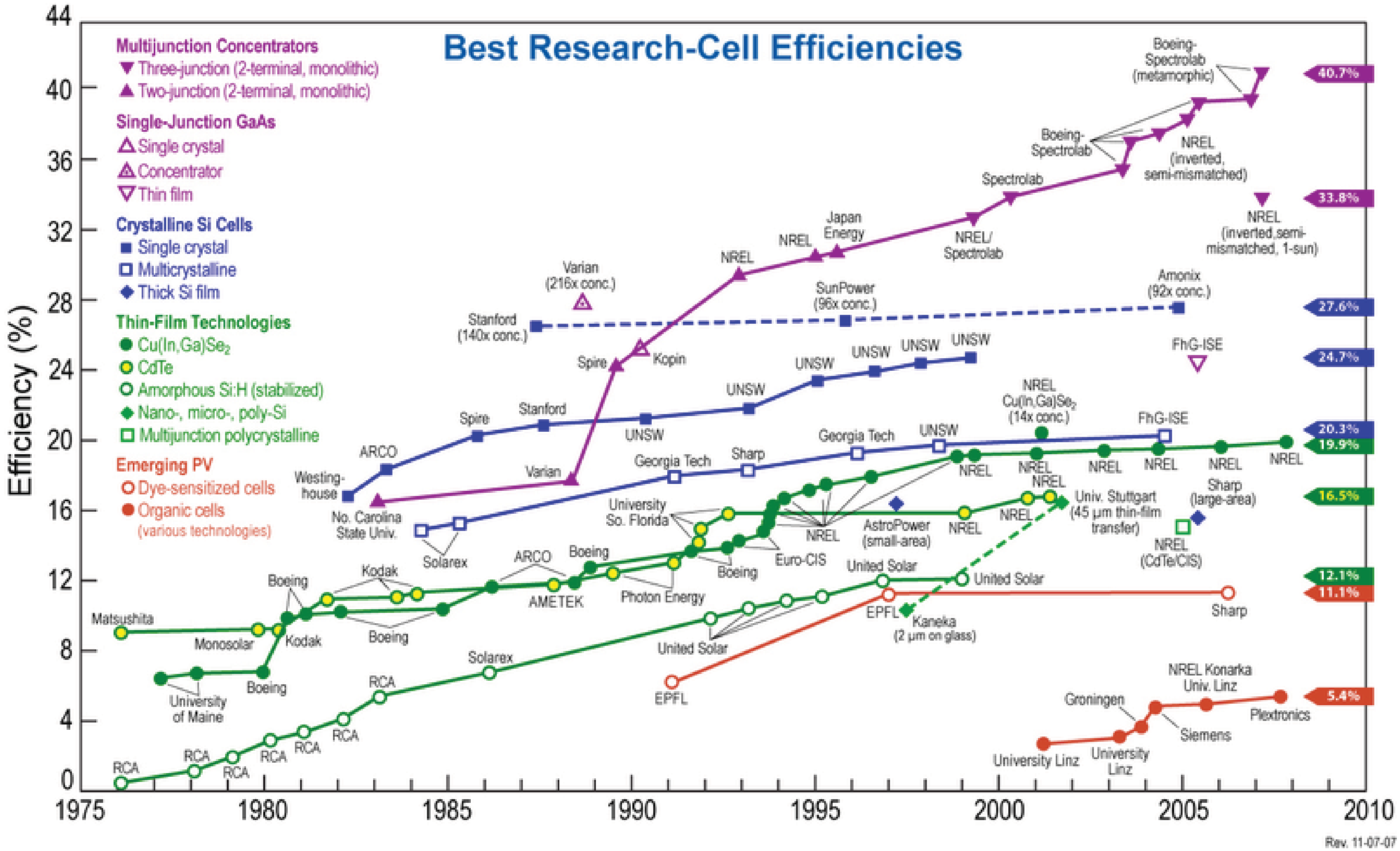
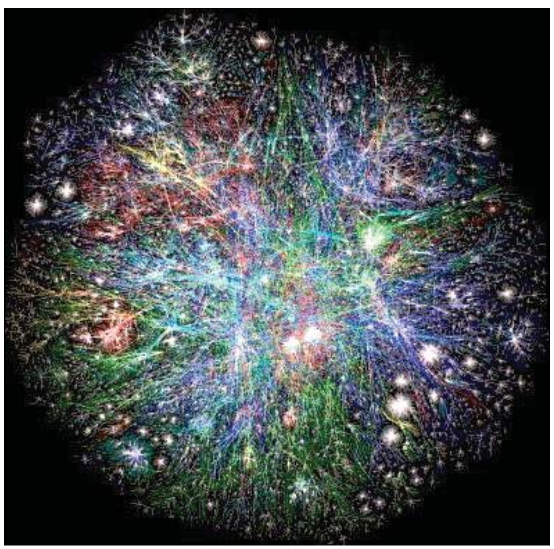


fig. 3.51 Cell type efficiencies development

Smart Grids

Addressing compatibility, storage and connectivity

fig. 3.52 A map of the internet as a possible model for the 'Smart Grid.'



Some of the most difficult challenges for the take off of renewable energies including solar technology, are issues of compatibility with the existing electrical grid. When introducing these new forms of power production, it can be assumed that any change will not be immediate and overarching. Systems that are best able to aggregate within the existing power grid, are likely to be the most successful.

The development of renewable energies comes at an opportune time, when globally the notion of the electrical grid is being rethought and reconfigured. The current system is lacking in terms of efficiency. Production is kept above an estimated consumption peak value to avoid blackouts, which results in generated power going to waste. The system is unable to store surplus, or to manage demands. There is no feedback mechanism alerting utilities when the power is out, keeping live metering data or informing consumers how to make better consumption choices according to electricity pricing variations during the day. Furthermore, a significant percentage of the produced electricity simply gets lost through long transmission lines.

One of the greatest challenges standing in the way of grid performance is energy storage capabilities. Electricity has traditionally been consumed as it was generated with no ability to manage supply and demand. However, since the construction of the electrical grid a substantial progress has been made in the field. Among many, current technologies include chemical, mechanical and thermal storage.

What is known as the 'Smart Grid,' although conceptually elusive, has potential to remedy the ailments of the current outdated system. Ultimately, the 'Smart Grid' is not any single application which will resolve the electrical grid's current problems. The 'Smart Grid' will be an intelligent integration of many existing and evolving technologies and systems of preferably renewable production, storage, distribution and networked feedback communication. The principles guiding the 'Smart Grid' will be decentralization, allowing smaller 'islands' to operate independently as necessary, unprecedented diversity of resources, and successful prioritization and hybridization enabled by a powerful communication network. A gradual deployment of systems, compatible with the current grid, and holding the above mentioned capabilities could be a step in the right direction.

fig. 3.53 Satellite view of Almeria greenhouses in southern Spain


fig. 3.54 Buckminster Fuller's "Dome over Manhattan" would act as an environmental control valve

"From the inside there will be uninterrupted contact with the exterior world. The sun and moon will shine in the landscape, and the sky will be completely visible, but the unpleasant effects of climate, heat, dust, bugs, glare, etc. will be modulated by the skin to provide Garden of Eden interiors." [33]

- Buckminster Fuller

3.3 Controlled environments

Greenhouses, that offer a protected and controlled environment prove to be the main feasible strategy for agricultural production in drylands. They provide protection against evapo-transpiration and allow for temperature moderation.[34] Use of greenhouses also helps avoid land degradation, as much of the crop is on raised tables and the soil is not overburdened. However, in regions where greenhouse farming is a dominant industry, greenhouse deployment can affect the landscape substantially, consuming considerable areas of open land.

The high consumption of land mass is also one of the major objections against solar energy deployment. In the creation of a hybrid system that combines solar energy generation and water management with the expanding greenhouse industry, the effectiveness of each can be increased and land area use optimized.

In comparison to the strategies and systems reviewed over the previous two sections, the following section offers a look into examples of greenhouse projects which provide an added value to growing plants. These precedents start to give an idea of how multiple functions and systems can be synthesized into a hyper-effective hybrid.

BIOSHELTER, CAPE COD, USA- 1971

NEW ALCHEMY INSTITUTE- JOHN & NANCY JACK TODD

John and Nancy Todd were one of the first innovators of the modern era, to envision the merging of ecology, technology and architecture in a single structure. To pursue this goal, they founded together with biologist William O.McLarney, the New Alchemy Institute, in 1969. The mission was to rethink human support systems, inspired by natural processes ecosystem 'design'. They describe their mission as:

"The blending of architecture, solar, wind, biological and electronic technologies with housing, food production, and waste utilization within an ecological and cultural context will be the basis of creating a new design science for the post-petroleum area." [35]

'Bioshelter' was a concept formed by New Alchemy and defined as "an integrative form of architecture that would incorporate renewable energies and biological systems in the form of growing areas for plants and fish." [36] The Bioshelter is designed to nurture and shelter the ecosystem contained within the structure, in which all processes are intertwined, influencing one another.

New Alchemy's work was multi-disciplinary, integrating professionals working in the fields of organic agriculture, aquaculture and renewable energy. Attention was given to the application of integrative design, so that a solar pond doubled as an aquaculture unit, a heat storage unit, and a furnace.[37]

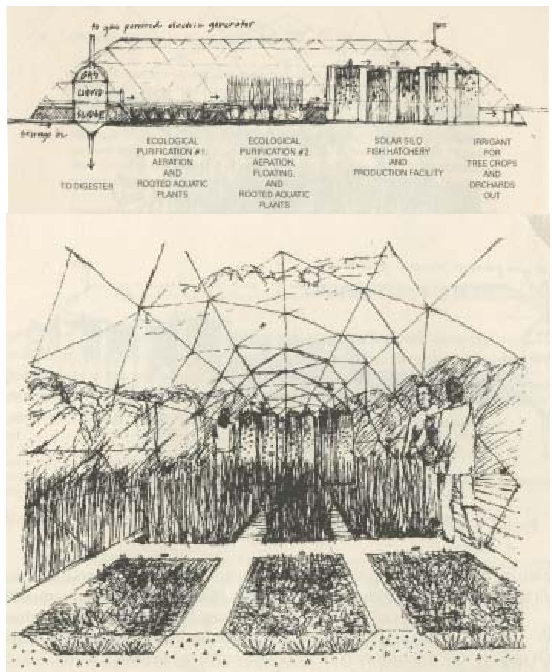


fig. 3.55 The living machine

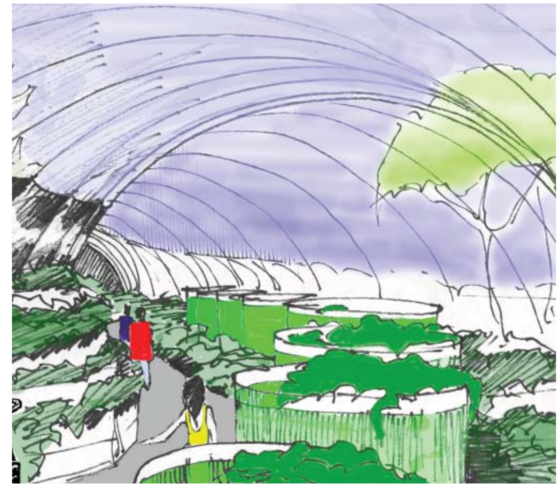


fig. 3.56 Solar silos as part of a continuous meandering biloshelter

New Alchemy researched and tested these ideas in various experimental greenhouses, starting with small scale domes, and mini-arks continuing with their largest projects; the Cape-Cod Ark (1976), which was later refurbished with a housing unit (2000) and the Prince Edward Island Ark (1976) and culminating with the Pillow Dome (1982).

BIOSPHERE 2, ARIZONA, USA- 1991

THE INSTITUTE OF ECOTECHNICS- JOHN ALLEN & MARGRET AUGUSTINE.

Following ideas of a self-contained ecosystem environment, Biosphere 2 was first conceived as a prototype for a space colony. The facility was to operate as an experimental laboratory to test the feasibility of long term survival in an hermetically sealed system. Although the space colony scenario, in itself, is less relevant for this body of work, the design of a man made system to operate like an ecosystem and testing of the limitations of a closed-loop system is very much a part of this discourse.

The strategy chosen to maintain life in Biosphere 2 was to imitate life on Biosphere 1(i.e. Earth), by creating a diverse collection of biomes, which would act as driving and regulating forces. The biomes selected were the ones deemed most productive: tropical rainforest, savannah, desert, ocean, as well as agricultural farming and 'urban' environments.[38]

The system was designed to furnish its own needs by integrating a diversity of cyclical processes. The closed-loop contained air and water used and recycled, food grown and waste restored. The human factor was the one least expected influence in the working of the system as a whole.

The mission stated that eight crew members were to seal themselves in Biosphere 2 for the duration of two years. With survival as the primary objective, the crew members were to play an integral role in the ecosystem mechanism of Biosphere 2, which was to be their life support system. As specified in the mission: "No material would go in or out of the enclosure during the two years." [39]

Although the scientific credibility of the project had been questioned from its inception, it succeeds in providing a valuable lesson on the complexity and variability of supposedly enclosed ecosystems. Monitoring and balancing import and export of materials proved to be equally or even more useful than achieving perfect self-sufficiency. Elasticity and adaptability may prove to be much desired qualities in the creation of a closed-loop ecosystem.

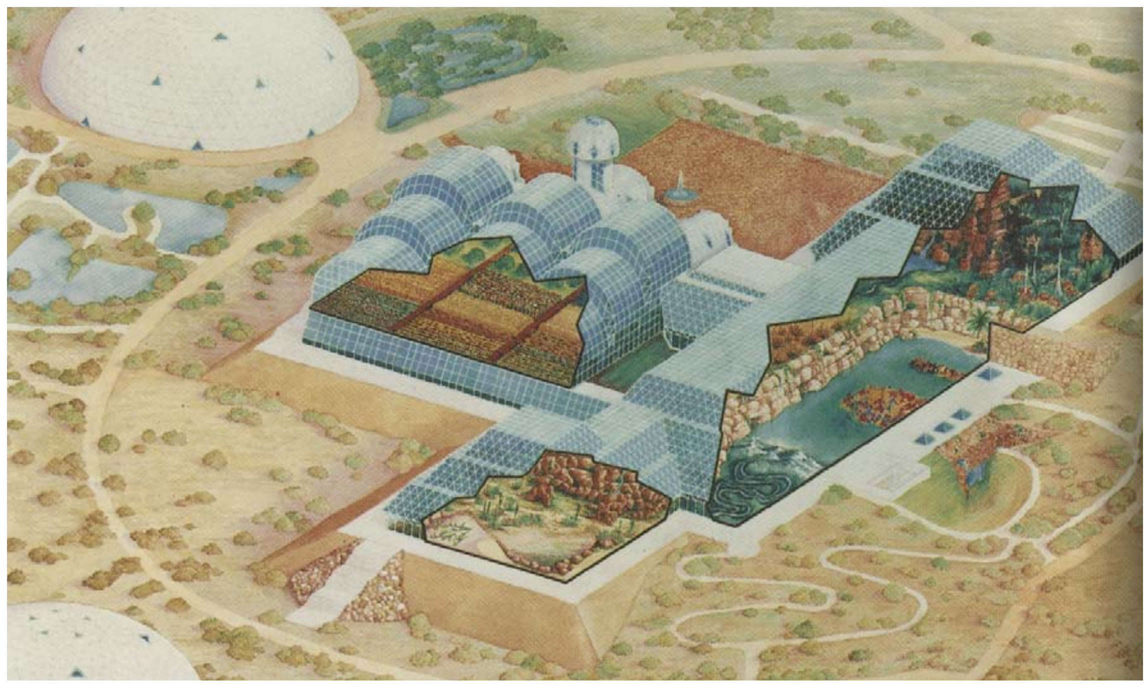


fig. 3.57 Biosphere 2 cutout- showing its five different biomes

Eden Project, Cornwall, UK- 2001

Grimshaw Architects

The Eden project, situated in an abandoned clay pit, first opened its gates to the public on March 17, 2001. The project brief was "to build the largest plant enclosure in the world, but also to do this in the lightest and most ecological way." [40] The greenhouses were to serve as botanical gardens for the pleasure and education of the visiting public: "The aim was to produce a centre which both explains man's dependence upon the plant world and which through its research and conservation programmes, actively helps develop that relationship.[41]

Eden is composed of two linked strings of geodesic domes, a structural system chosen for its lightweight and minimal interference with the site.[42] Much like Biosphere 2, the greenhouses are divided into distinct biomes, emulating different climatic zones. The first cluster of interlinked domes is 'warm temperate' and the second 'humid tropical.' [43]

Ecologically, the project is notable for its reliance on treated rainwater for the majority of its water consumption and use of energy that originates from Cornwall wind turbines.

The use of the existing topography in forming the domes is another noteworthy sensible quality of the project.

fig. 3.58 The Eden project- exterior view on the green houses strings occupying an abandoned clay pit

EXPLORATION ARCHITECTS & SEAWATER GREENHOUSE LTD

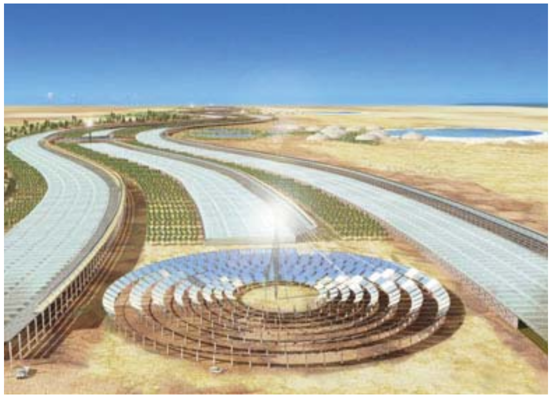


fig. 3.59 Seawater Greenhouses with a CSP heliostat field

The Sahara project is envisioned as a large scale integrative system of water, solar energy and greenhouses. The system will use as inputs seawater, sunlight, CO_2 and nutrients, and will produce as an output freshwater, energy and biomass (see fig. 3.60).[44]

The application will use in tandem two existing technologies: concentrated solar power (previously discussed) and the seawater greenhouse. This technology is based on natural hydrological cycles, scaled down to the greenhouse's controlled environment.

Seawater evaporates into the greenhouse by the passage of air. The air is then cooled as it enters the greenhouse, and as the air's temperature drop the greenhouse's humidity levels rise. This creates an environment more favourable for crops. The evaporated water is then collected, having been distilled by the sun into freshwater, ready for use.

The coupling of solar energy production with water purification and climate control is a very promising strategy for arid zones. Currently, this technology is inspiringly innovative, yet remains to be fully integrative, by applying solar energy generation technology beside the seawater greenhouses, rather than as one integral system.

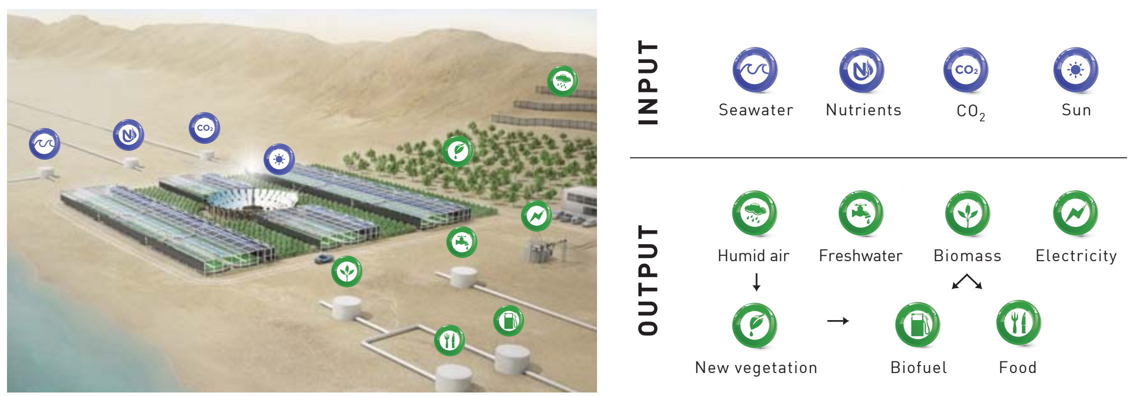


fig. 3.60 System inputs and outputs diagram

1 Daniel Hillel, *Negev: Land, Water, and Life in a Desert Environment* (New York, N.Y.: Praeger, 1982), 129-130.

2 Ibid., 59.

3 Shlomo Aronson, *Aridscapes : Proyectar En Tierras Ásperas y Frágiles = Designing in Harsh and Fragile Lands,* Land & Scape Series (Barcelona: GG, 2008), 105.

4 Hillel, *Negev*, 136.

5 Michael Evenari, *The Negev: The Challenge of a Desert*, edited by Naphtali Tadmor (Cambridge, Mass.: Harvard University Press, 1982), 95.

6 Ibid., 97.

7 Ibid.

8 Ibid., 109.

9 Ibid., 220.

10 Brad Lancaster, *Rainwater Harvesting for Drylands and Beyond*, edited by Joe Marshall (Tucson, Ariz.: Rainsource Press, 2008), 80.

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12 Ibid., 227

13 Liat Margolis, *Living Systems Innovative Materials and Technologies for Landscape Architecture*, ed. Alexander Robinson landscape architect (Basel : Boston: Birkhäuser, 2007), 68-69.

14 Ibid., 106-107.

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16 Ibid., 16.

17 Ibid., 18.

18 Ibid., 22.

19 Ibid., 26.

20 Ibid.

21 Ibid., 13, 30.

22 Ibid., 34.

23 Bright Source, http://www.brightsourceenergy.com/technology/how_lpt_works (accessed February 17, 2010).

24 Ibid.

25 National Renewable Energy Laboratory (NREL), http://www.nrel.gov/csp/solarpaces/by_technology.cfm (accessed October 14, 2009).

26 Ibid.

27 Ken Butti, *A Golden Thread: 2500 Years of Solar Architecture and Technology*, ed. John Perlin (Palo Alto; Palo Alto: Cheshire Books, 1980; Palo Alto : New York: Palo Alto : Cheshire Books ;New York :Van Nostrand Reinhold, 1980), 9.

28 Ibid., 38.

29 CBC interview with David Faiman, http://www.youtube.com/watch?v=_O47RiYJiK (accessed February 18, 2010).

30 Ingrid Hermannsdörfer and Christine Rüb. *Solar Design : Photovoltaics for Old Buildings, Urban Space, Landscape = Photovoltaik Für Altbau, Stadtraum, Landschaft* (Berlin: Jovis, 2005), 131.

31 Ibid., 129.

32 Ibid., 130-132.

33 Buckminster R. Fuller, Michael Hays, and Dana Miller. *Buckminster Fuller: Starting with the Universe* (New York: Whitney Museum of American Art, in association with Yale University Press, 2008), 15.

34 Boris. A. Portnov and Uriel. N. Safriel. “Combating Desertification in the Negev: Dryland Agriculture Vs. Dryland Urbanization.” *Journal of Arid Environments* 56, no. 4, (March 2004): 659-680.

35 John Todd, and Nancy Todd, *Bioshelters, ocean arks, city farming. From Eco-Cities to Living Machines: Principles of Ecological Design* (Berkeley, Calif.: North Atlantic

Books, 1994), 12.

36 Ibid., 5.

37 Ibid., 64-65.

38 John Allen and Anthony George Edward Blake, *Biosphere 2: The Human Experiment* (New York, N.Y., U.S.A.: Viking, 1991), 7.

39 Jane Poynter, *Human Experiment: Two Years and Twenty Minutes Inside Biosphere 2* (New York : Berkeley, Calif.: Thunder's Mouth Press ; Distributed by Publishers Group West, 2006), 95.

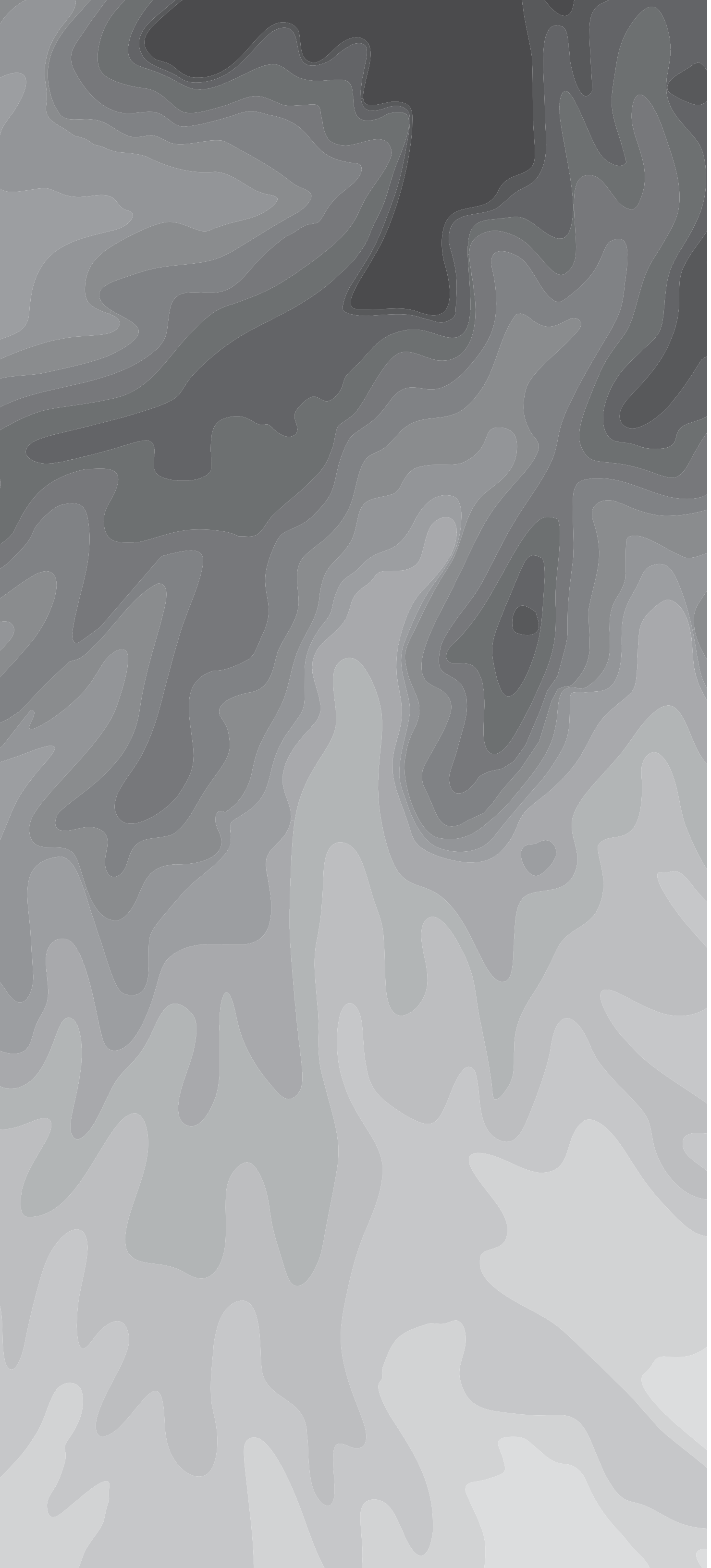
40 Hugh Pearman, *Equilibrium: The Work of Nicholas Grimshaw & Partners*, ed. Nicholas Grimshaw (London: Phaidon Press, 2000), 114.

41 Ibid., 118.

42 Ibid., 119.

43 Ibid., 123.

44 Seawater Greenhouse, http://www.seawatergreenhouse.com/ (accessed November 19, 2009).



04.

Effective Terrains

fig. 4.1 Site topography

4.1 Site Selection

Wadi Pharan is one of the largest watershed systems in the Negev (see fig. 2.17). Its drainage basin extends into the Sinai in the west and the Arava valley in the East. This wadi was selected due to its large capacity to capture and convey water collected along its course from adjacent catchment areas.

The wadi intersects three major highways: Highway 90, Highway 40 and Highway 10. The intersection with Highway 90 is the site of the existing Moshav Paran. The site selected is at the intersection of the wadi with Highway 40. This area is advantageous because it intersects the natural system of Wadi Pharan, at the place where three of its tributaries meet, with the existing man made infrastructure of the regional highway and the electrical grid. The intersection of the wadi with Highway 10 is recommended for future investigations, as the site is more remote.

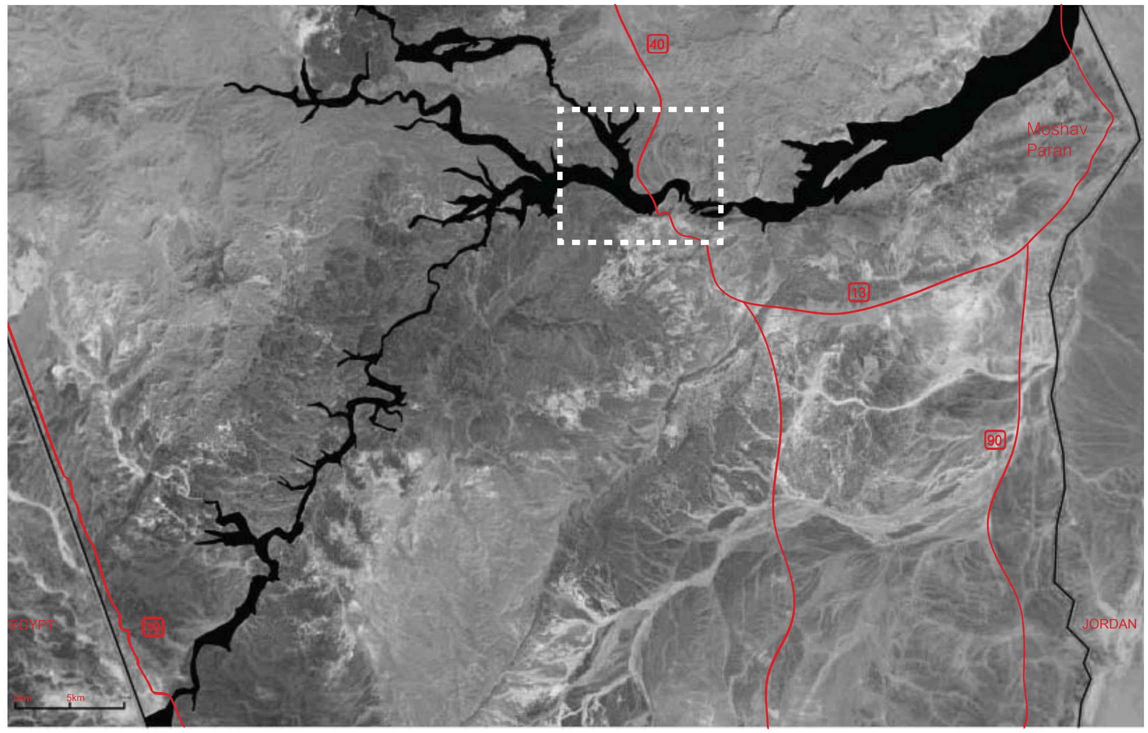


fig. 4.2 Wilderness of Wadi Pharan site

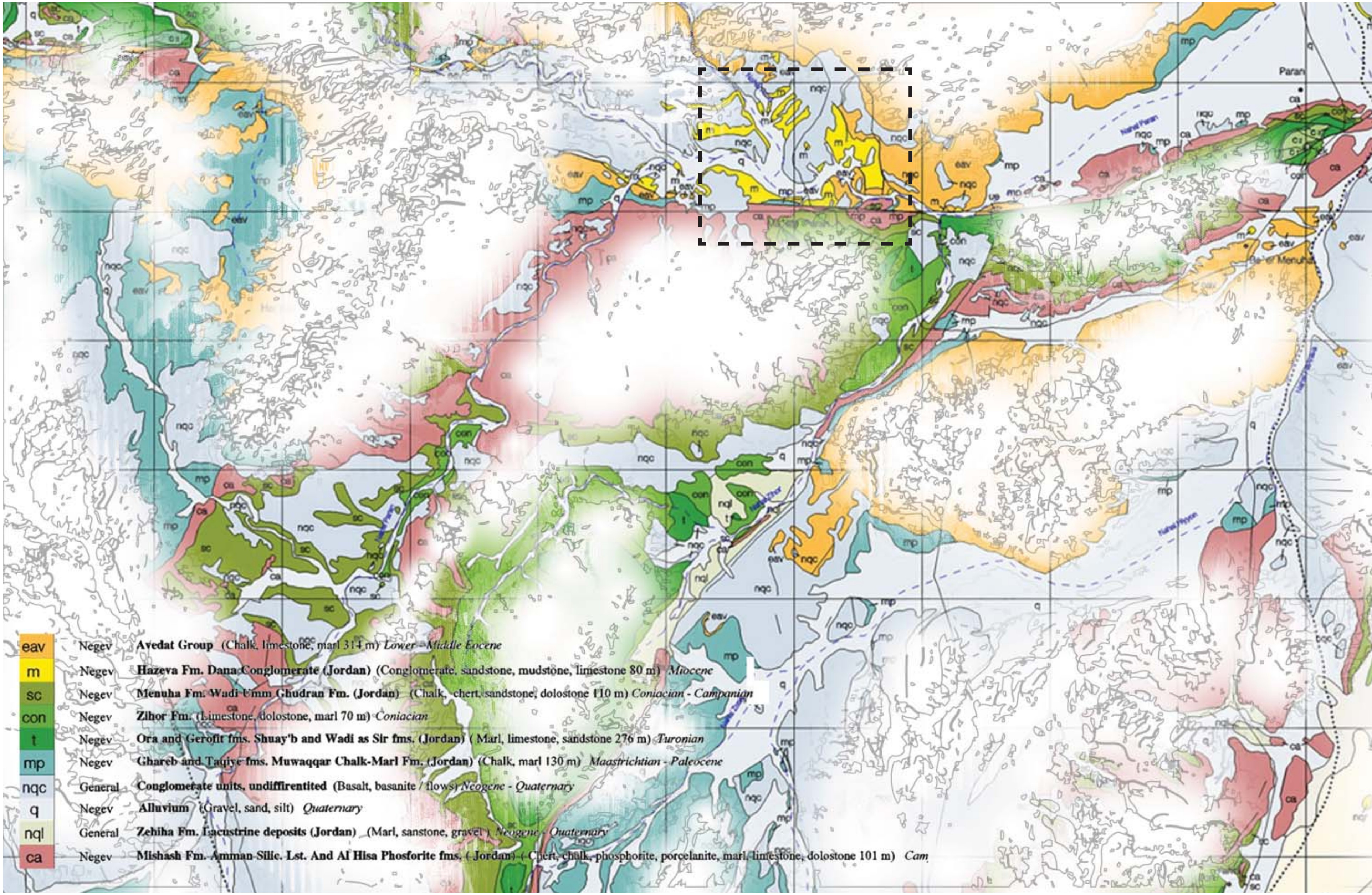

eav Negev Avedat Group (Chalk, limestone, marl 314 m) Lower - Middle Eocene
m Negev Hazeva Fm. Dana Conglomerate (Jordan) (Conglomerate, sandstone, mudstone, limestone 80 m) Miocene
sc Negev Menuha Fm. Wadi Umm Ghudran Fm. (Jordan) (Chalk, chert, sandstone, dolostone 110 m) Coniacian - Campanian
con Negev Zihor Fm. (Limestone, dolostone, marl 70 m) Coniacian
t Negev Ora and Gerofit fms. Shuay'b and Wadi as Sir fms. (Jordan) (Marl, limestone, sandstone 276 m) Turonian
mp Negev Ghareb and Taqiye fms. Muwaqqar Chalk-Marl Fm. (Jordan) (Chalk, marl 130 m) Maastrichtian - Paleocene
nqc General Conglomerate units, undiffirentited (Basalt, basanite / flows) Neogene - Quaternary
q Negev Alluvium (Gravel, sand, silt) Quaternary
nql General Zehiha Fm. Lacustrine deposits (Jordan) (Marl, sanstone, gravel) Neogene - Quaternary
ca Negev Mishash Fm. Amman Silic. Lst. And Al Hisa Phosforite fms. (Jordan) (Chert, chalk, phosphorite, porcelanite, marl, limestone, dolostone 101 m) Cam
Paran
Nahal Paran
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fig. 4.3 Wadi Pharan geology

Geology

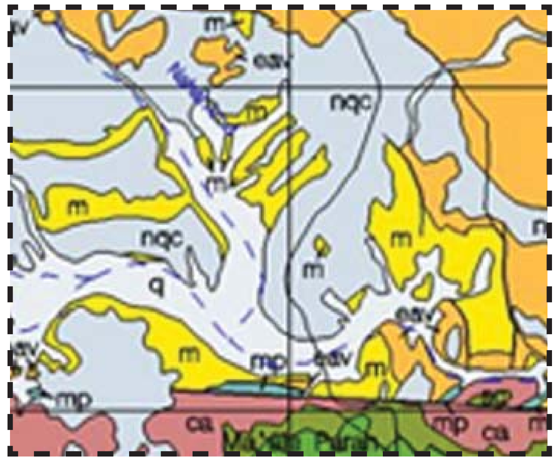


fig. 4.4 Site geology

The wadi bed can be distinguished from its surrounding by its rock and soil composition. It is characterized by alluvium fill which is gravel at its coarsest form and sand and silt where it is finer, usually downstream. Alluvium is created by rock erosion where water flow is present, in lower depression areas through which flash floods are drained.

Alluvium deposits are water permeable, making wadi beds favorable for direct aquifer recharge and subsequently for groundwater reservoirs.[1]

Wadi floodplains are often composed of conglomerate units (see fig. 4.3). Surrounding the selected site there is a strong presence of Dana conglomerate containing sandstone, mudstone and limestone.

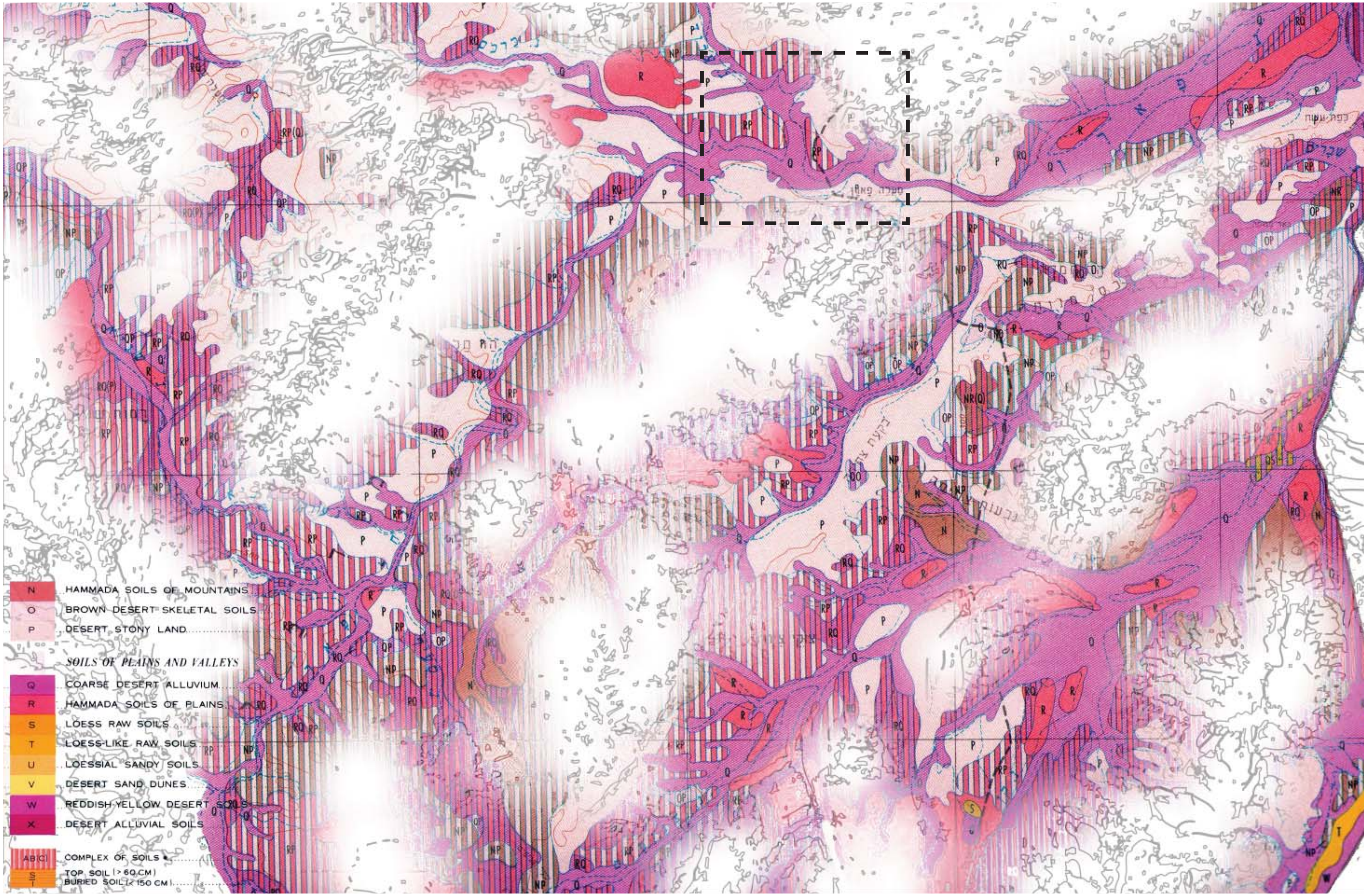

N HAMMADA SOILS OF MOUNTAINS
O BROWN DESERT SKELETAL SOILS
P DESERT STONY LAND
SOILS OF PLAINS AND VALLEYS
Q COARSE DESERT ALLUVIUM
R HAMMADA SOILS OF PLAINS
S LOESS RAW SOILS
T LOESS-LIKE RAW SOILS
U LOESSIAL SANDY SOILS
V DESERT SAND DUNES
W REDDISH-YELLOW DESERT SOILS
X DESERT ALLUVIAL SOILS
AB(C) COMPLEX OF SOILS
TOP SOIL (> 60 CM)
BURIED SOIL (< 150 CM)

fig. 4.5 Wadi Pharan soils

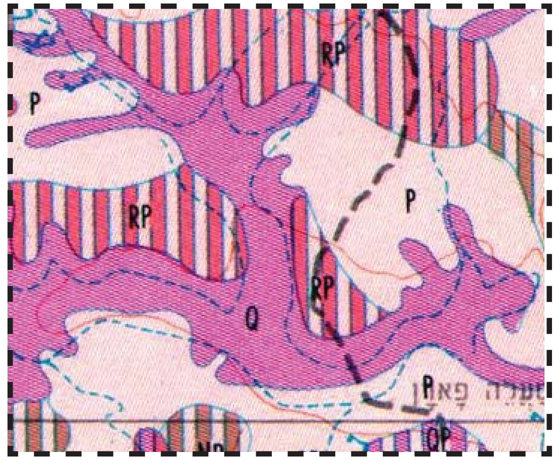
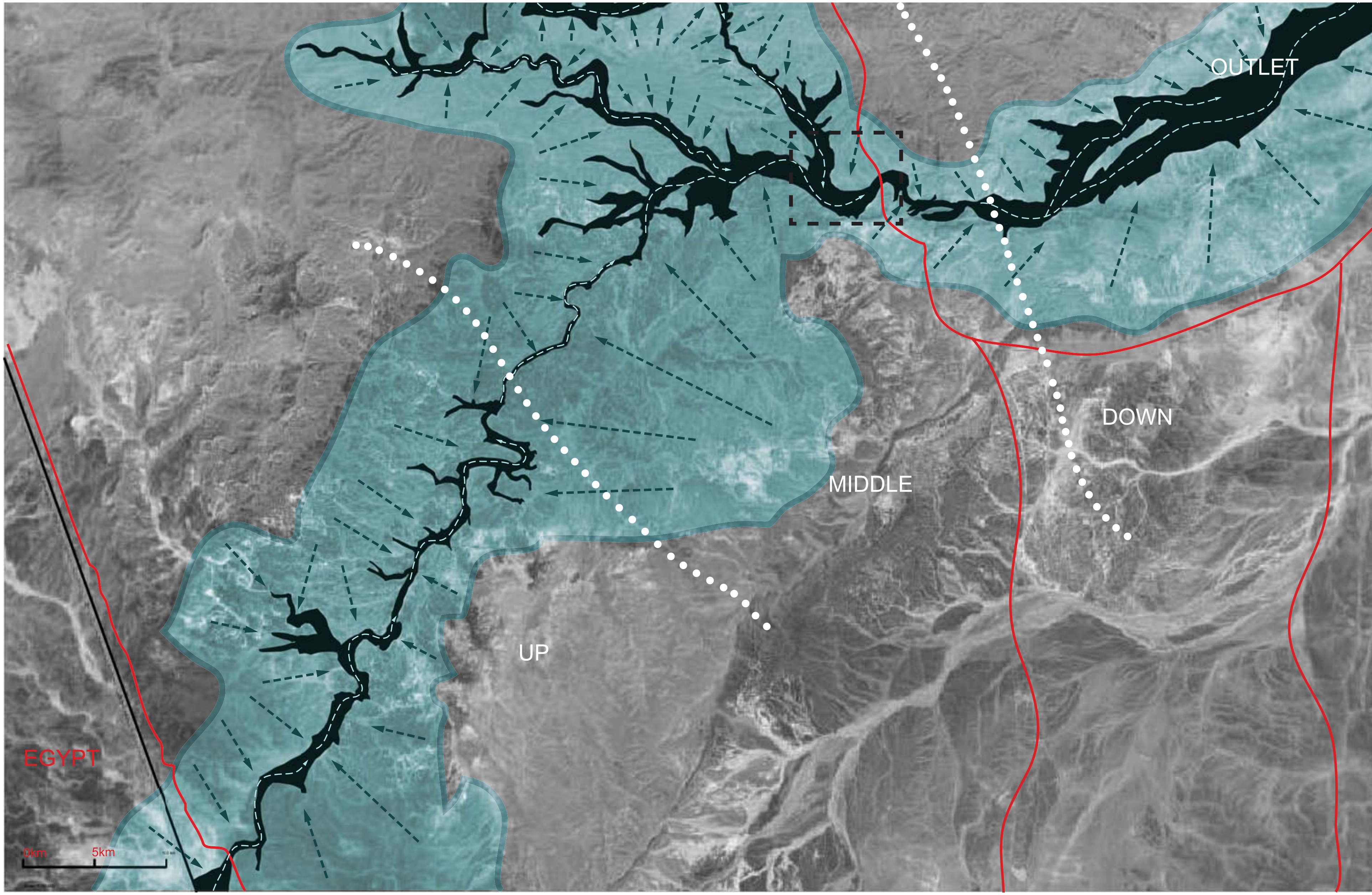


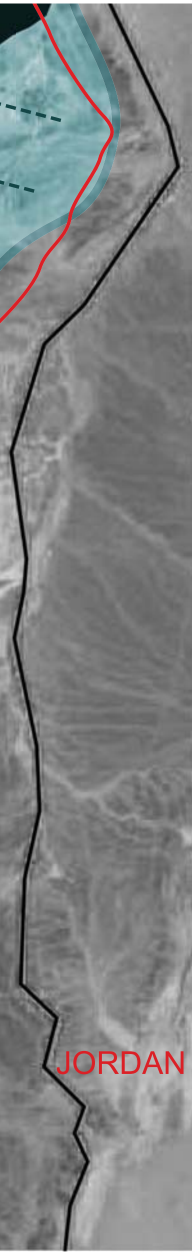
fig. 4.6 Site soils

Moderate slopes and rocky grounds are generally preferable for building, while wadi beds, drainage basins and swelling soils should be avoided, to prevent possible damage to building foundations.[2]

The selected site is composed of desert stony land on its north-eastern side and a composite of desert stony land and hammada soils of plains on its south-western side.

Hammada soils are created through the weathering process of *deflation*[3] whereby fine soil material is removed from the upper layer by the wind, exposing the inner layers of stone and bedrock. These soils, although not always readily arable, are preferable for construction, since they are not vulnerable to swelling and water absorption, and are generally more stable than finer soils.


OUTLET
DOWN
MIDDLE
UP
EGYPT
0km
5km



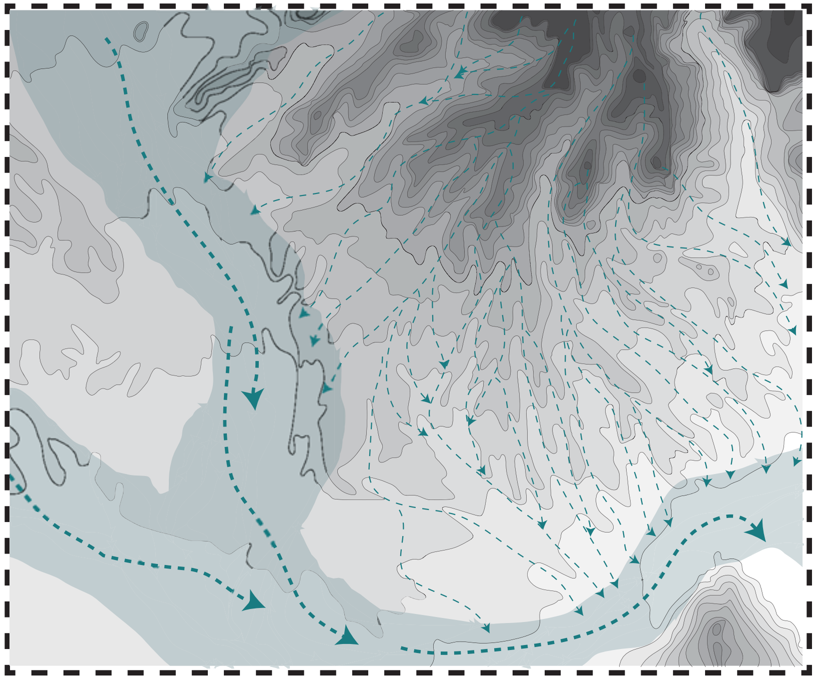
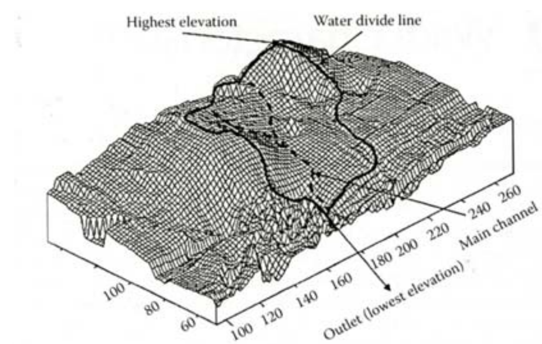


fig. 4.8 Site runoff and flow directions

Wadis are characterized by a water divide line at the highest elevations and a main channel through which water flows towards the wadi outlet at the lowest elevation. Different conditions exist in parts of the wadi: while the upstream has the greatest slope and higher rainfall, the downstream is characterized by shallower topography and lesser rainfall. Surface and ground water are of lower quality downstream since the ground becomes saline due to high evaporation.[4]



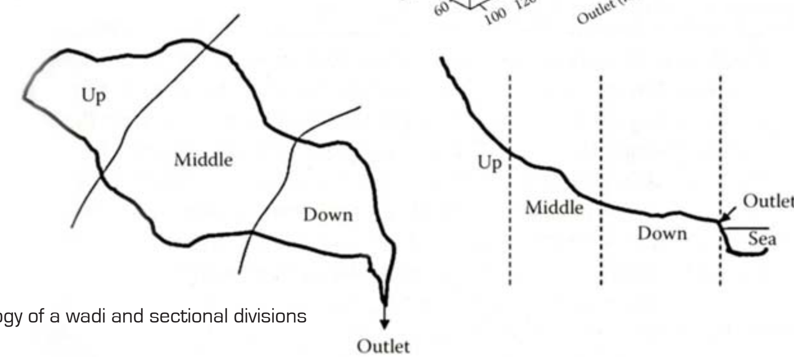


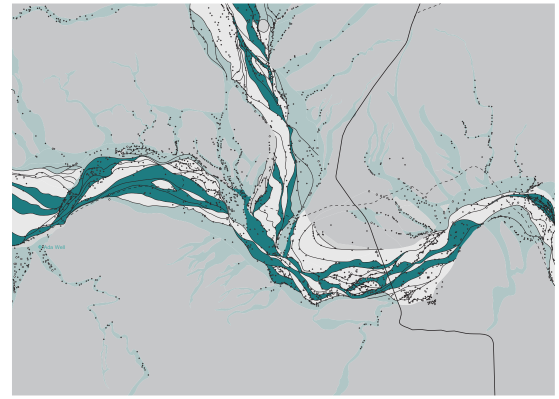
fig. 4.7 Wadi Pharan water divides, catchment areas, runoff and flow directions.

fig. 4.9 Geomorphology of a wadi and sectional divisions

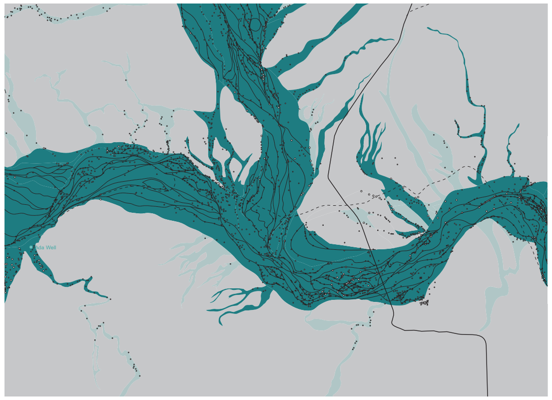
Runoff and flooding patterns

fig. 4.10 Site seasonal runoff and flooding

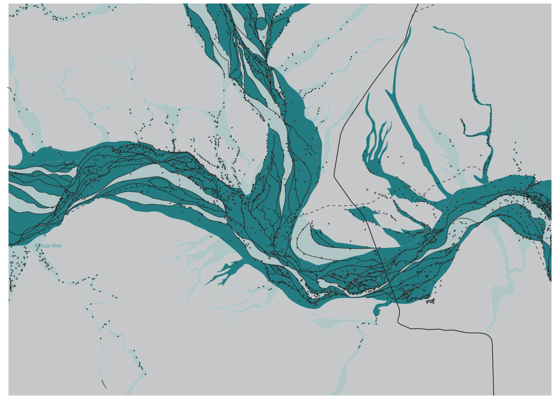
The site is characterized by an average rainfall of 55mm annually. During the wet season the wadi channel is fed by its two tributaries joining at this point and additional runoff draining nearby catchment areas in higher elevations. The site's topography slopes downwards to the wadi, hence the flow direction is towards the wadi as well. The risk of the wadi overflowing and flooding the adjacent slope is low even during above average rainfall events.



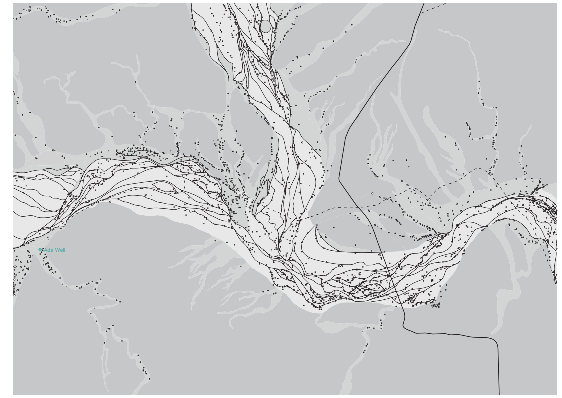
October - November: 7 - 8mm



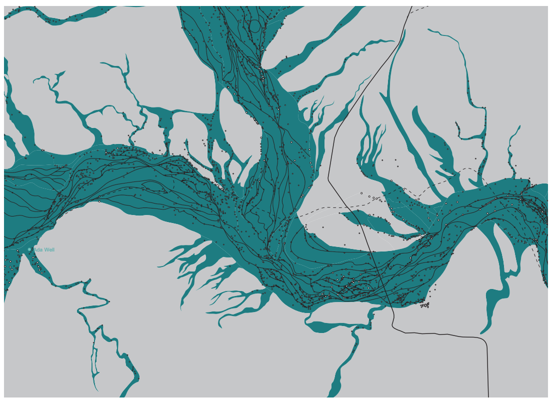
December - February: 31 - 32mm



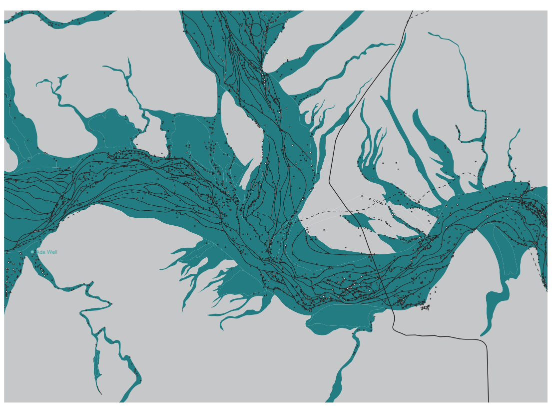
March - May: 12 - 14mm



June - September: 0mm



5 Year Flood ~ 50mm



50 Year Flood ~ 100mm

fig. 4.11 Moshav Paran seasonal runoff and flooding.

Moshav Paran is situated nearby the wadi outlet where the topography is nearly flat. Since the whole wadi drains to this point, high volumes of water have eroded the wadi banks entirely. The wadi channel is very wide at this point and the ground has high levels of salinity and high sediment content. Runoff hardly exists due to the lack of difference in elevation yet flooding occurs frequently and the moshav often suffers loss of agricultural lands.

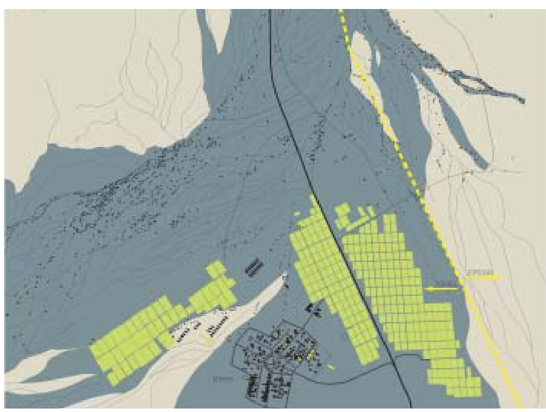
October - November: 5 - 6mm

December - February: 28 - 29mm

March - May: 10 - 12mm

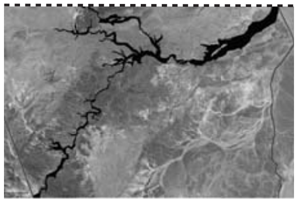
June - September: 0mm

5 Year Flood ~ 35mm



50 Year Flood ~ 80mm

Solar Paths



Latitude - 30.2 N

Longitude - 34.6 E

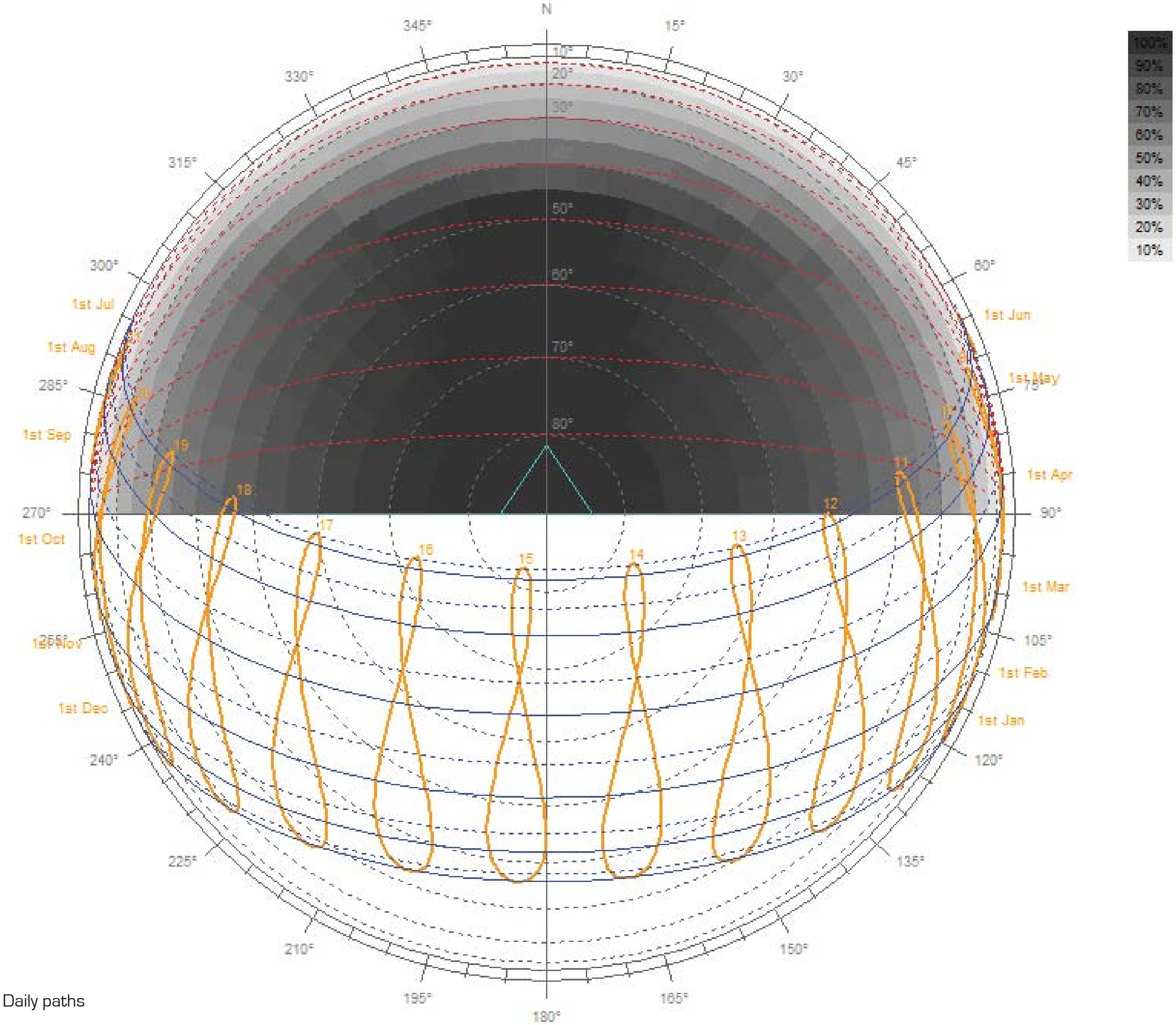
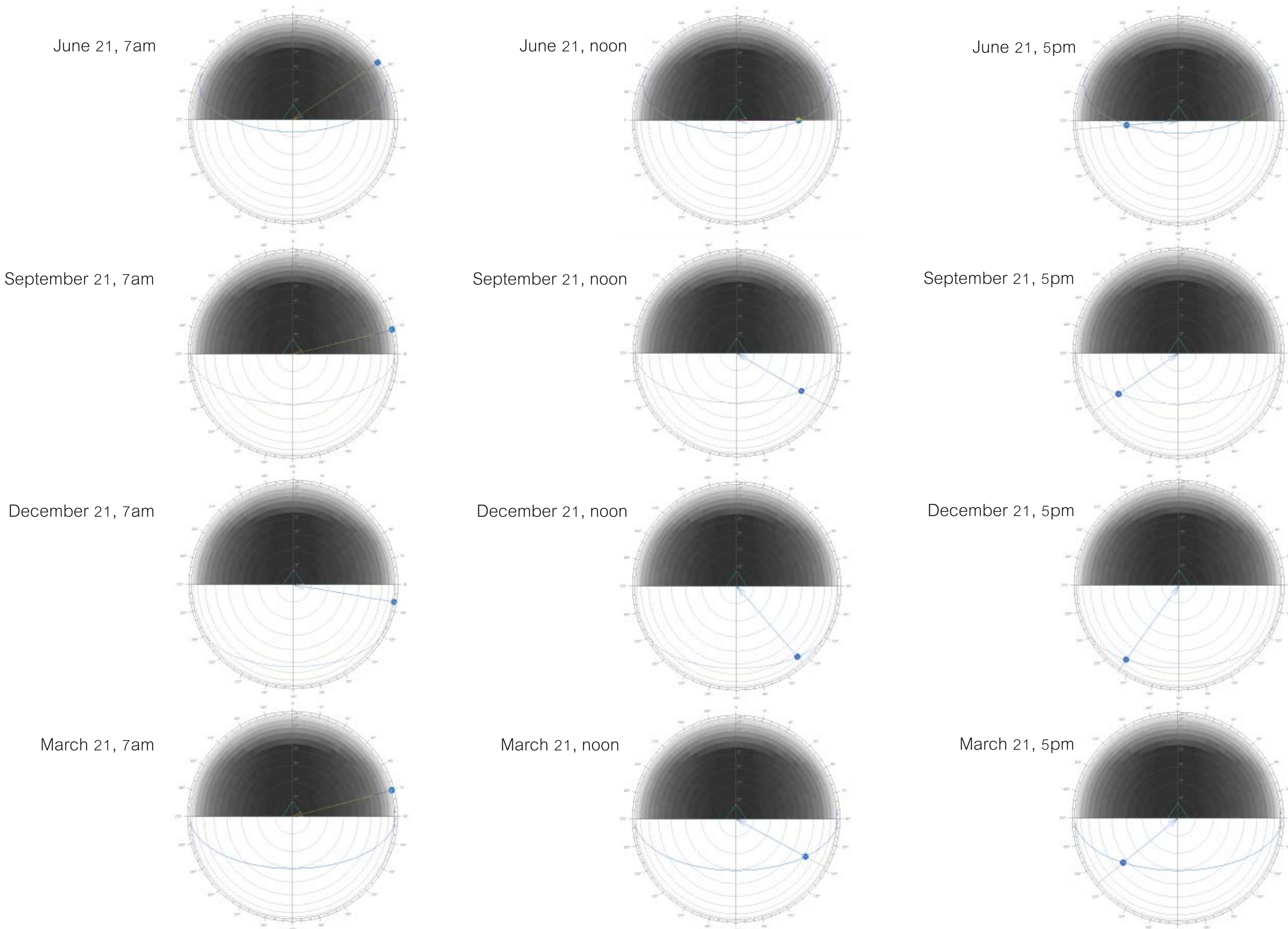


fig. 4.12 Solar paths for Wadi Pharan. Daily paths shown in orange and annual paths shown in blue.

fig. 4.13 Sun location at select times during equinox and solstice



4.2 Wadi potential mapping

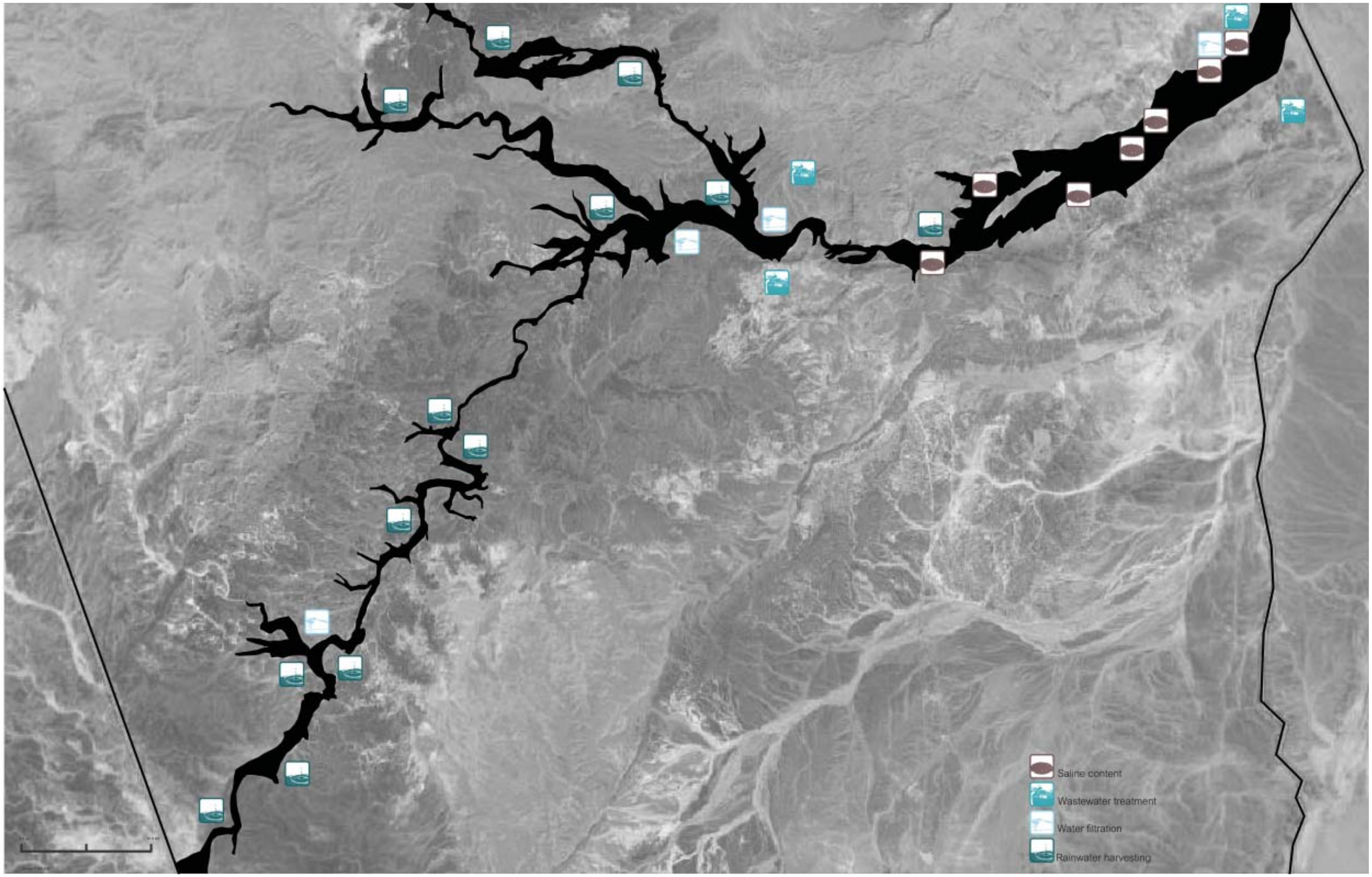


fig. 4.14 Water potential

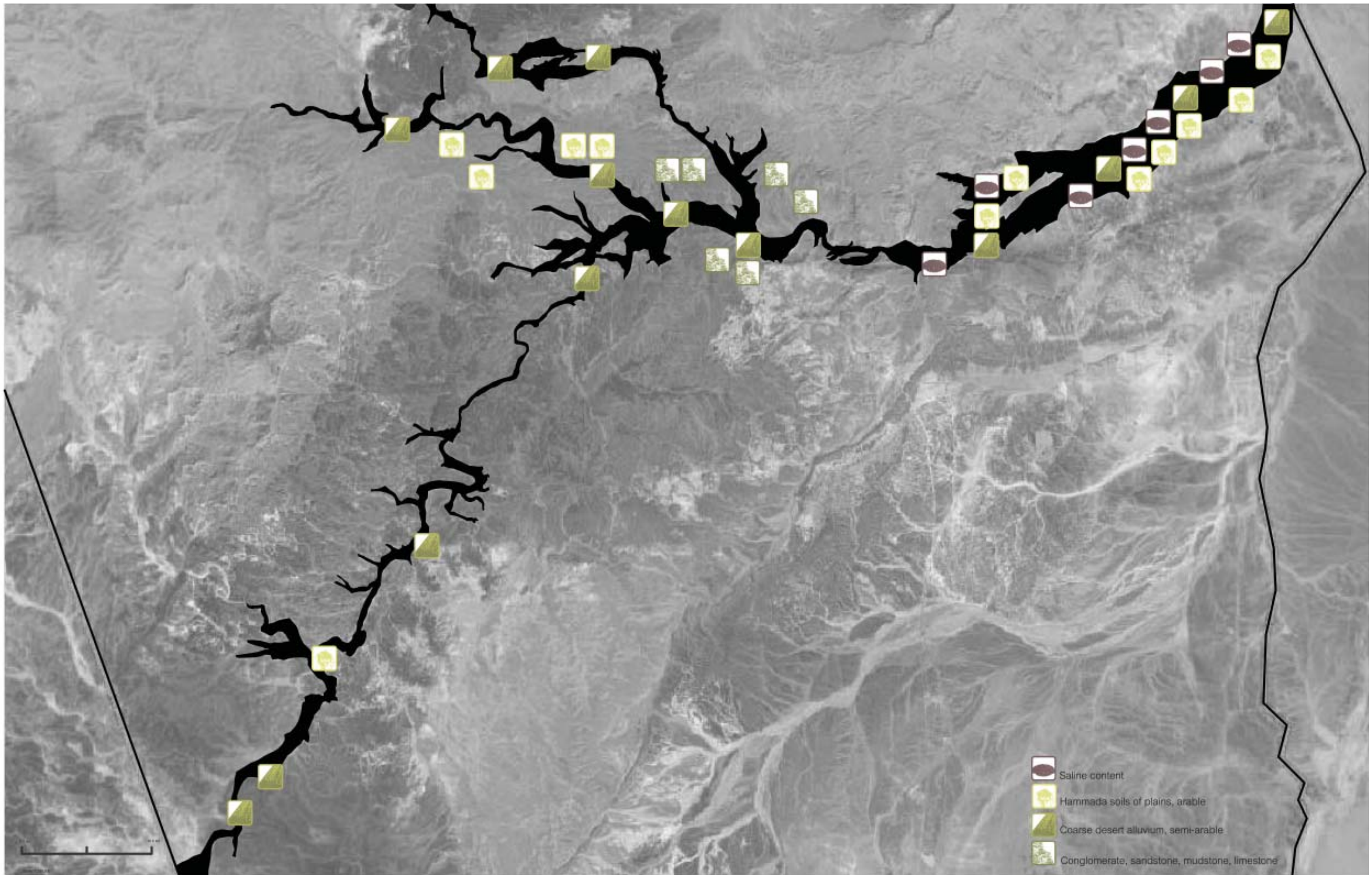


fig. 4.15 Soils potential

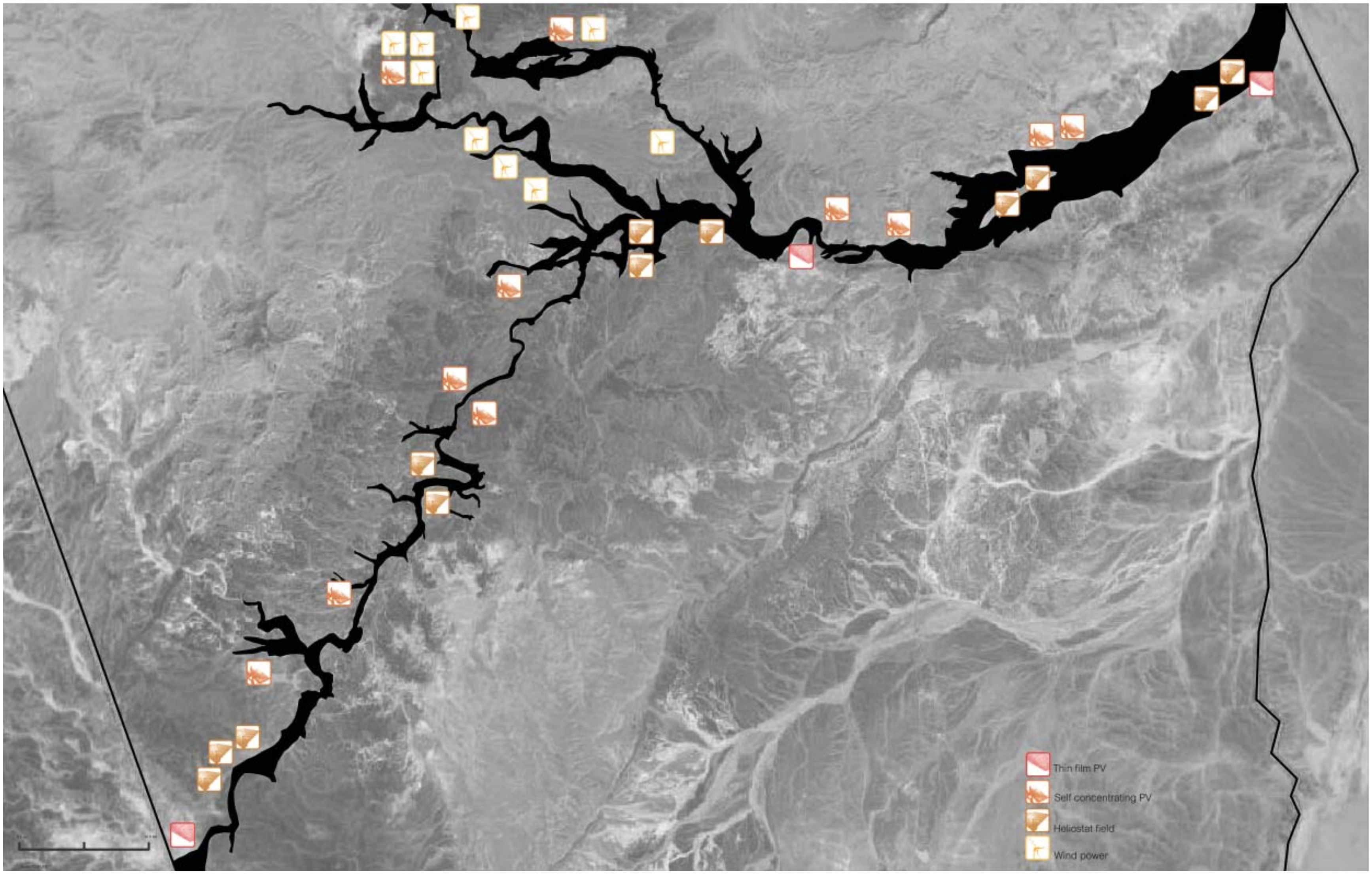


fig. 4.16 Energy potential

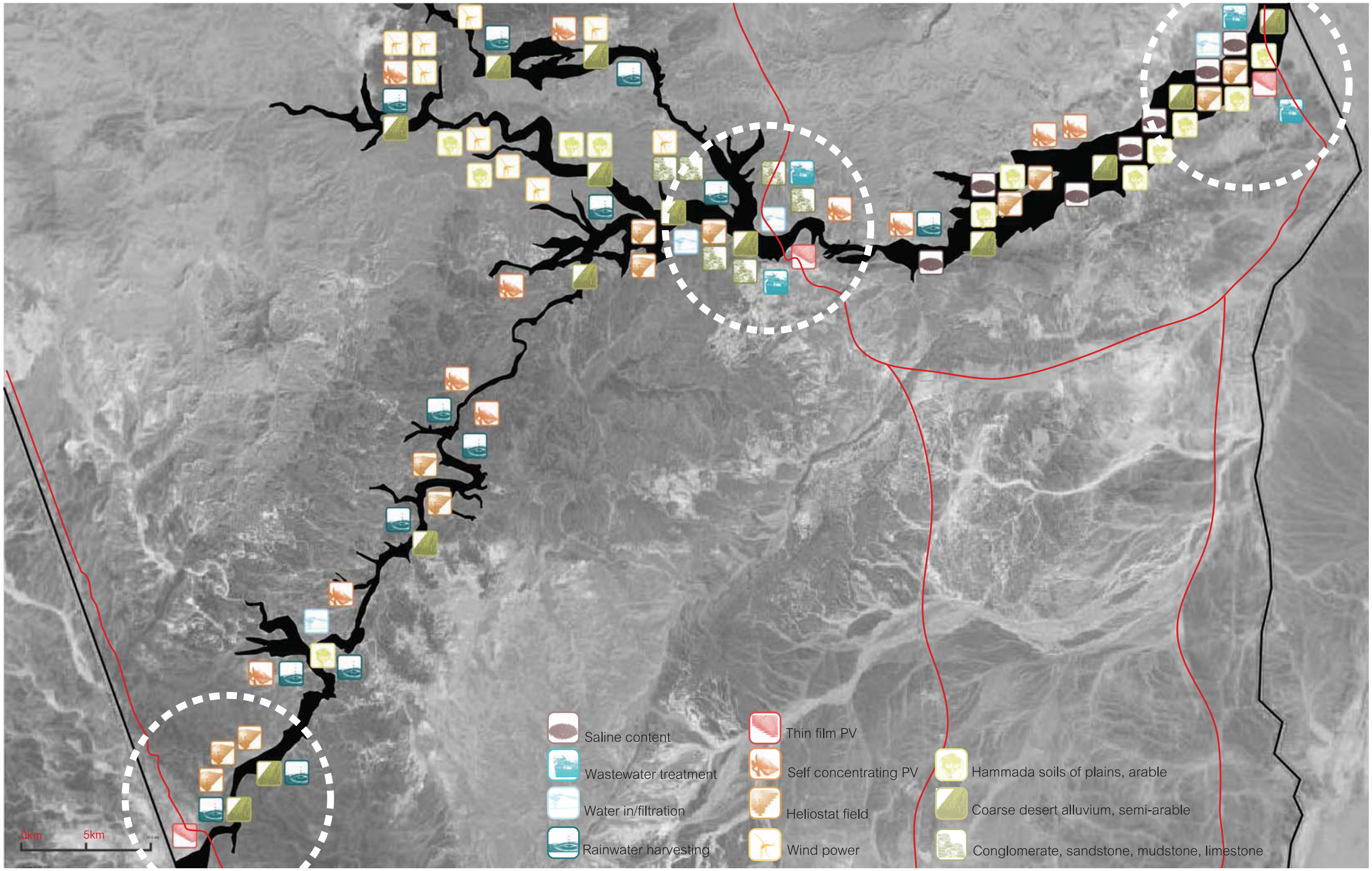
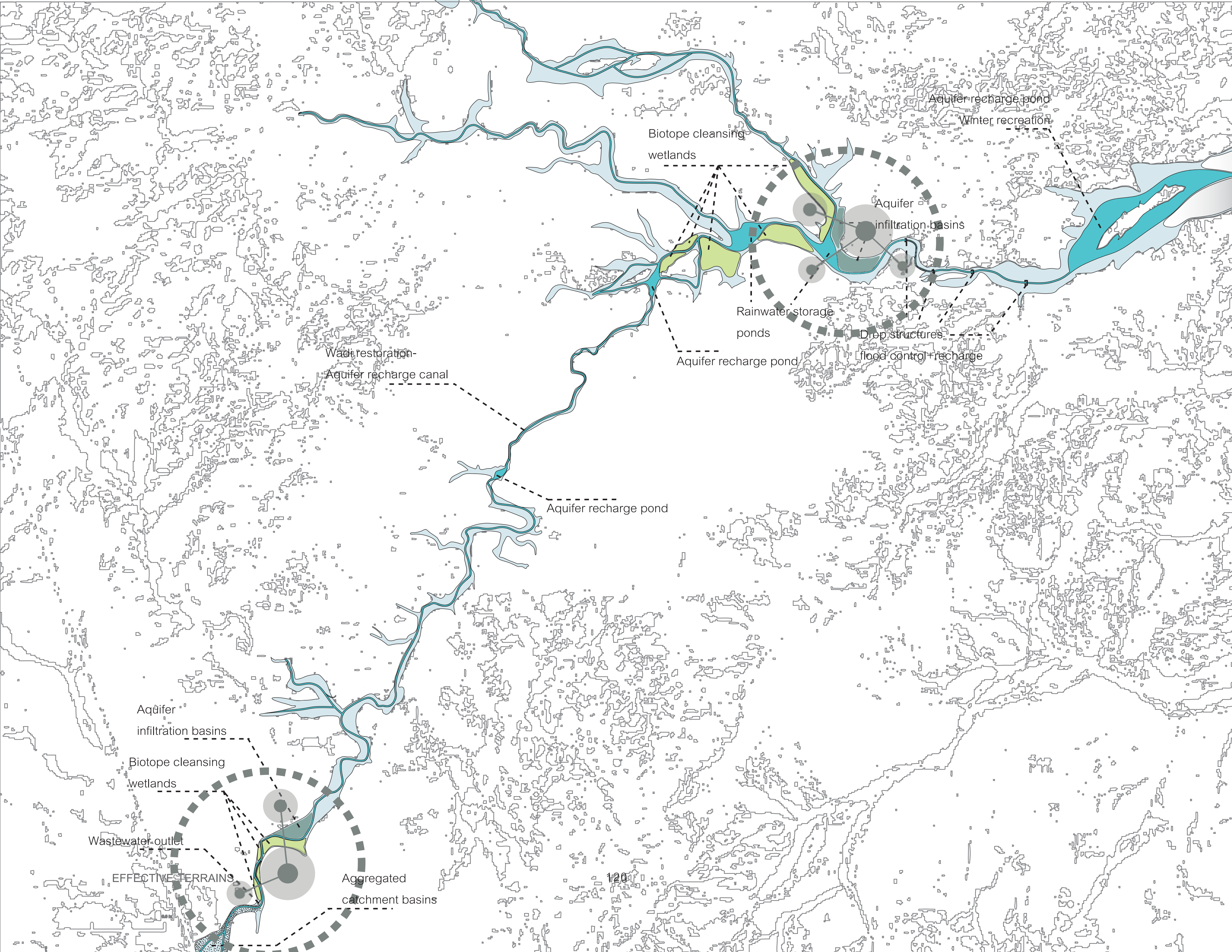


fig. 4.17 Intersecting potentials with sites of interest-
The sites are selected according to their proximity to existing infrastructural networks and their potential for interventions hybridizing water, energy, agriculture and settlement.



Aquifer recharge pond
Winter recreation
Biotope cleansing wetlands
Aquifer infiltration basins
Rainwater storage ponds
Drop structures flood control+recharge
Aquifer recharge pond
Wadi restoration-
Aquifer recharge canal
Aquifer recharge pond
Aquifer infiltration basins
Biotope cleansing wetlands
Wastewater outlet
Aggregated catchment basins

4.3 Regional wadi development

A network of community clusters is envisioned, supported by the wadi while optimizing potential resources as mapped previously. The network operates as a 'closed' watershed management system, employing components gathered from precedents studied in part three. Each community collects rainwater through the wadi in wintertime, by means of aggregated, distributed or centralized wells, sized to supply annual water needs of the community, and directed to agricultural, industrial or residential use. After usage, effluents are treated biologically through constructed wetlands and released back to the wadi (throughout the year). The purified water released to the wadi is either directed to recharging the aquifers (wadi redefinition) or flows through to be used by the next community downstream. This approach projects a gradual restoration of the wadi and its underground aquifer, acceptance by local flora and fauna and the potential to increase water availability year-round.

Water is identified as the limiting factor for the development of Wadi Pharan. The availability of water or lack thereof will determine the system's growth limits. Looking at the wadi's catchment areas, the wadi's maximal water holding capacity is calculated: for an assumed average annual rainfall of 55mm (see Chapter 2: Rainfall Patterns), the wadi capacity is 76.35 million Cu.m. If all water was captured, the wadi could sustain water needs of 100,000 households. If all communities were agriculture based, a much heavier water consumption volume needs to be accounted for. The maximal number is then reduced to 3,680 households.

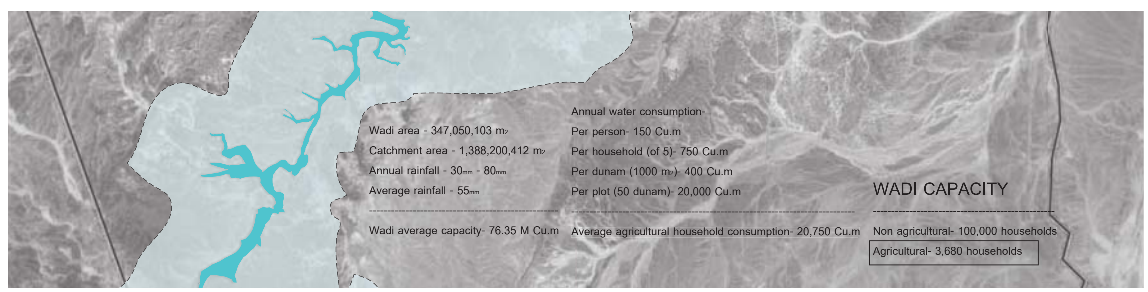


fig. 4.19 Wadi capacity

fig. 4.18 Regional wadi development plan

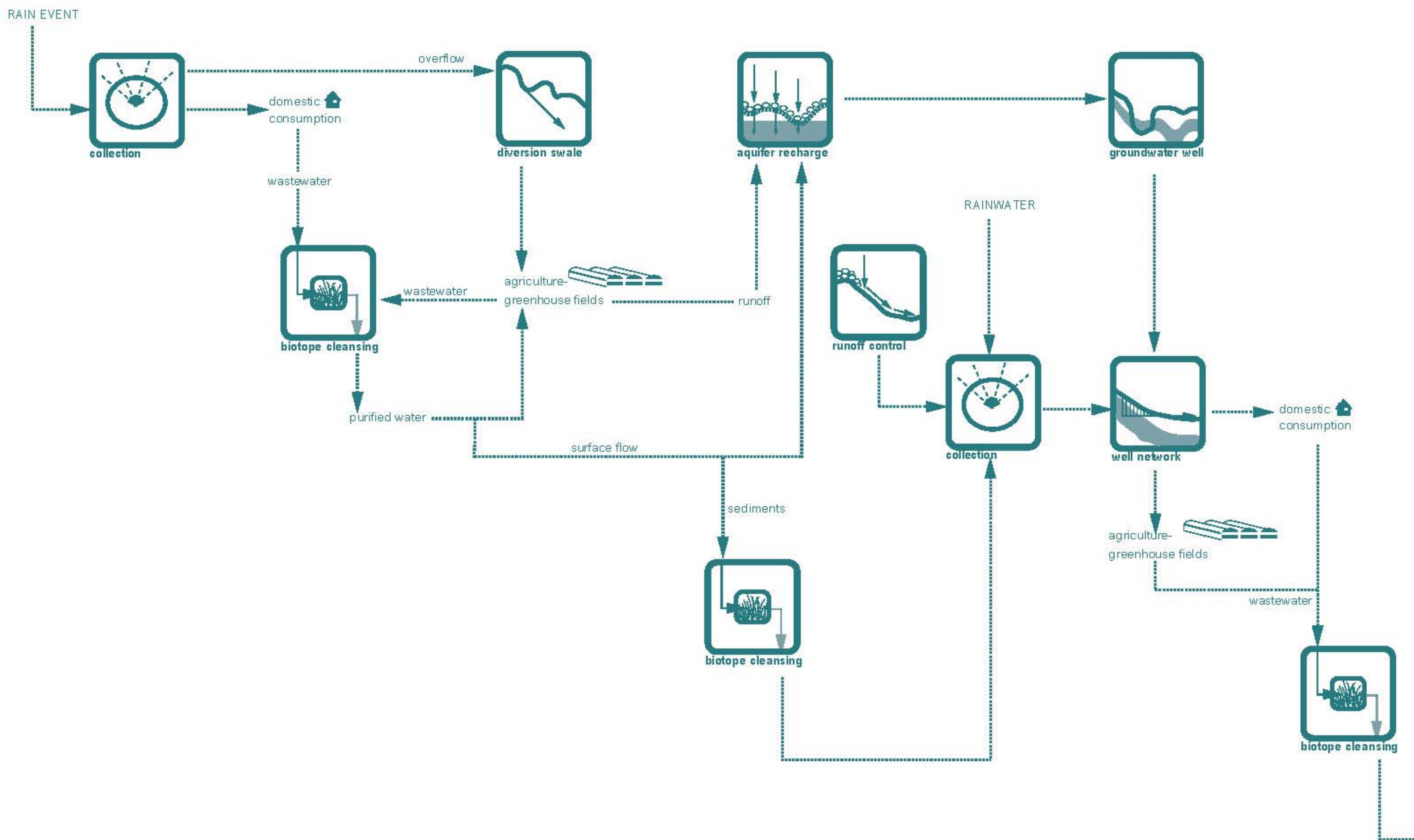
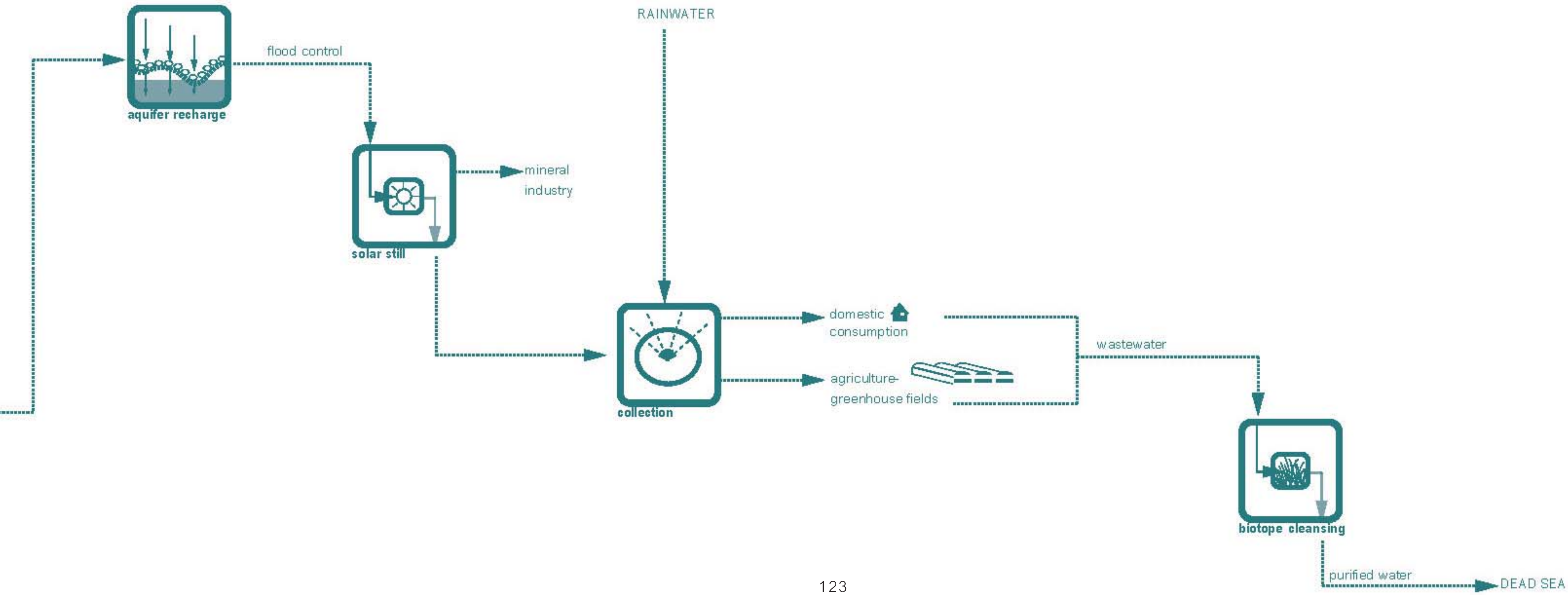


fig. 4.20 Wadi water management diagram



flood control
aquifer recharge
RAINWATER
mineral
industry
solar still
domestic
consumption
agriculture-
greenhouse fields
wastewater
collection
biotope cleansing
purified water
DEAD SEA

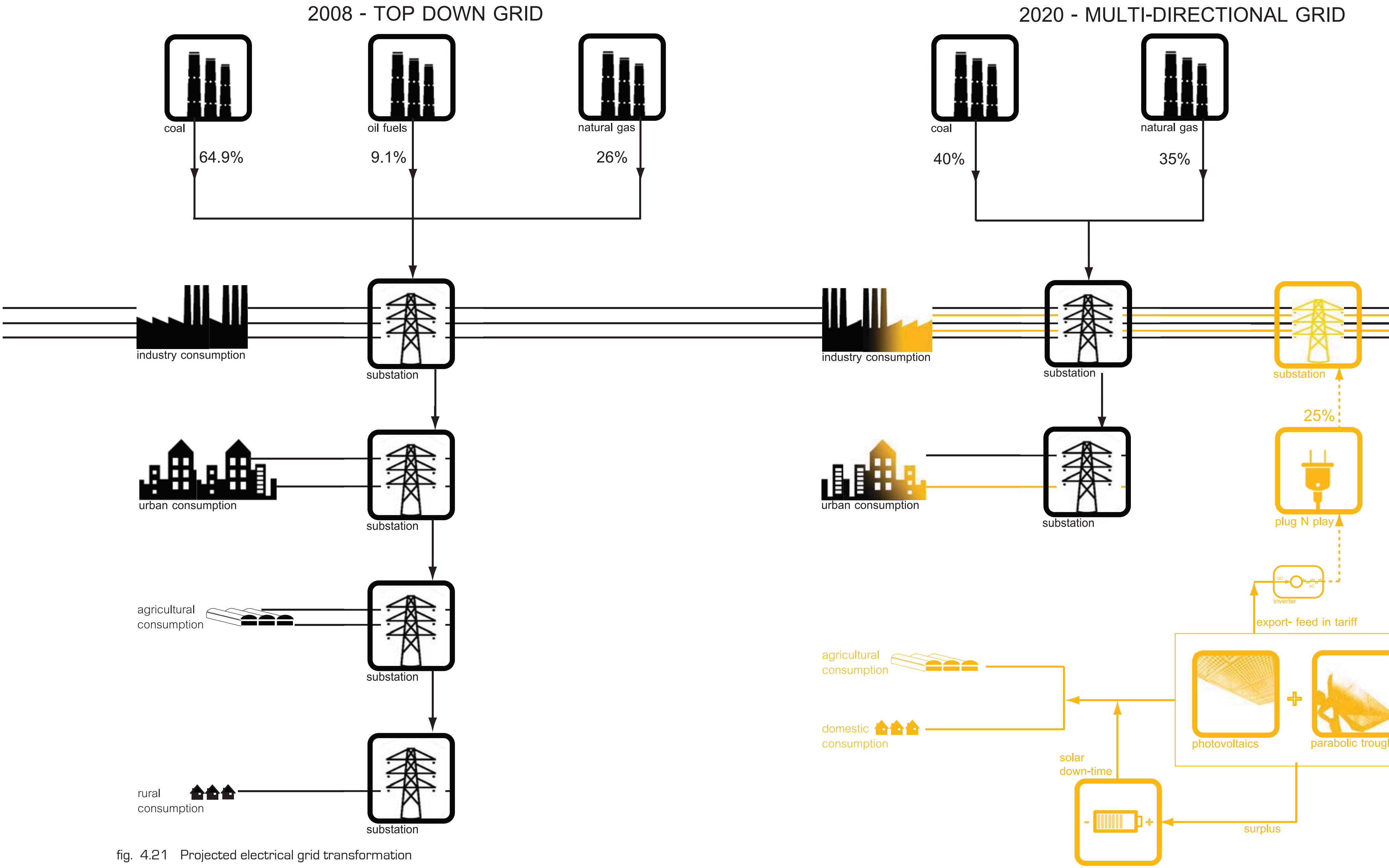
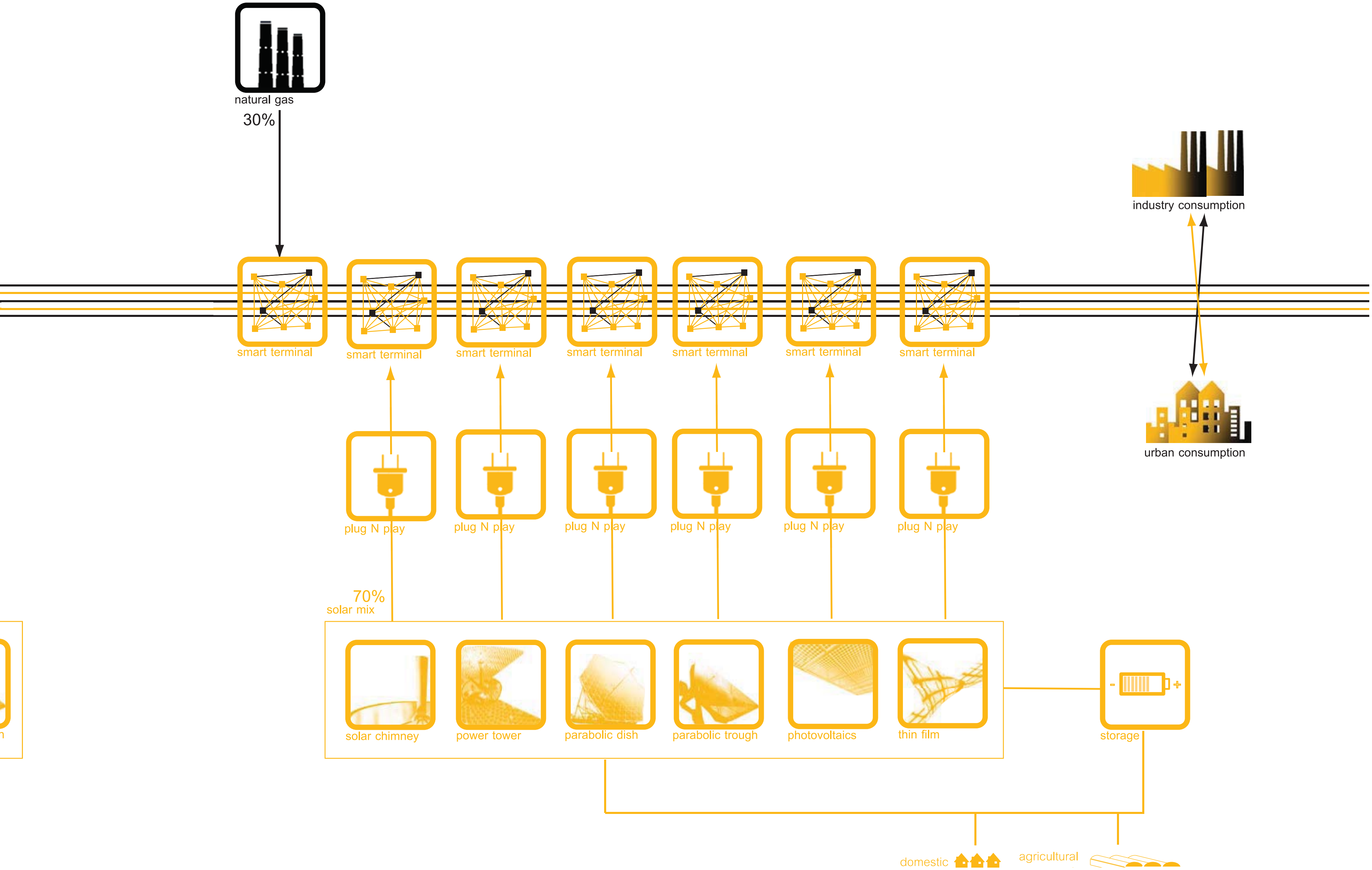
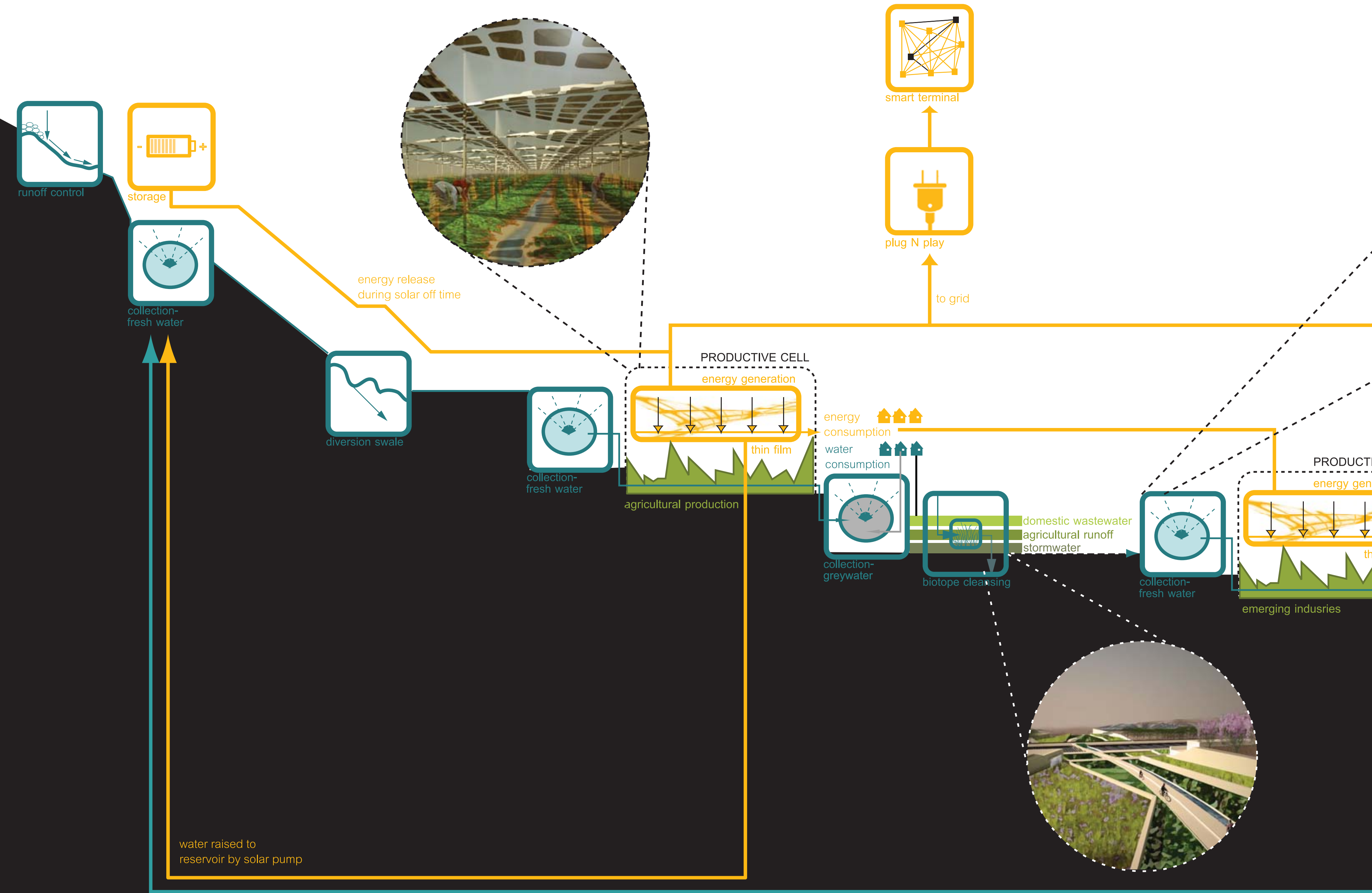


fig. 4.21 Projected electrical grid transformation

2030 - MULTI-DIRECTIONAL SMART GRID

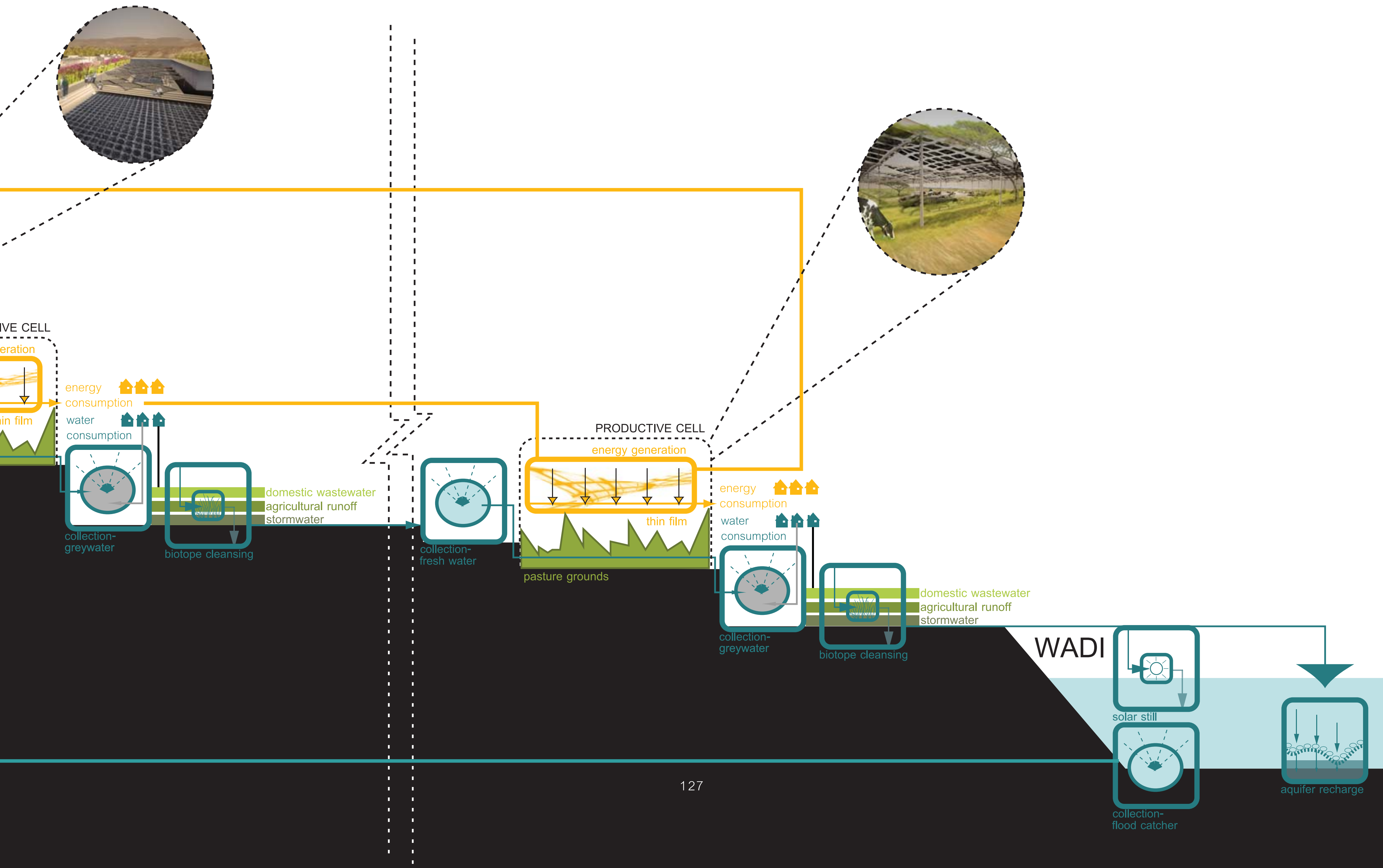




runoff control
storage
energy release
during solar off time
collection-
fresh water
diversion swale
collection-
fresh water
smart terminal
plug N play
to grid
PRODUCTIVE CELL
energy generation
thin film
agricultural production
energy
consumption
water
consumption
collection-
greywater
domestic wastewater
agricultural runoff
stormwater
biotope cleansing
collection-
fresh water
emerging indusries
water raised to
reservoir by solar pump

4.4 Local implementation

fig. 4.22 Communicating Vessels - Integrated systems diagram



01 solar greenhouses

02 microcatchment orchard

03 retaining walls + housing

04 domestic wastewater treatment wetlands

05 fresh water reservoir

06 cell logistics shed

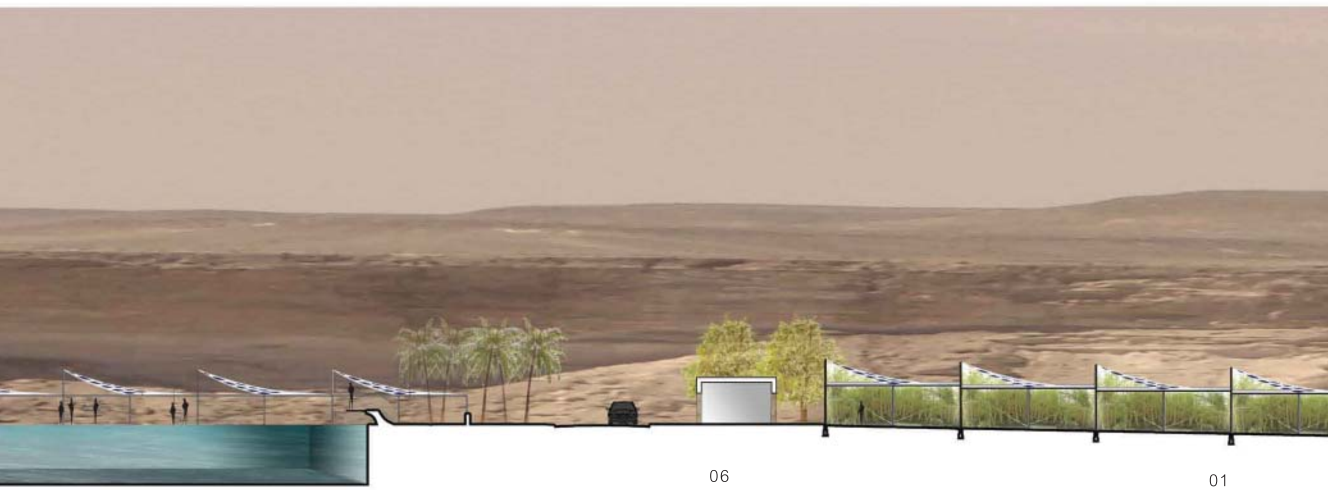
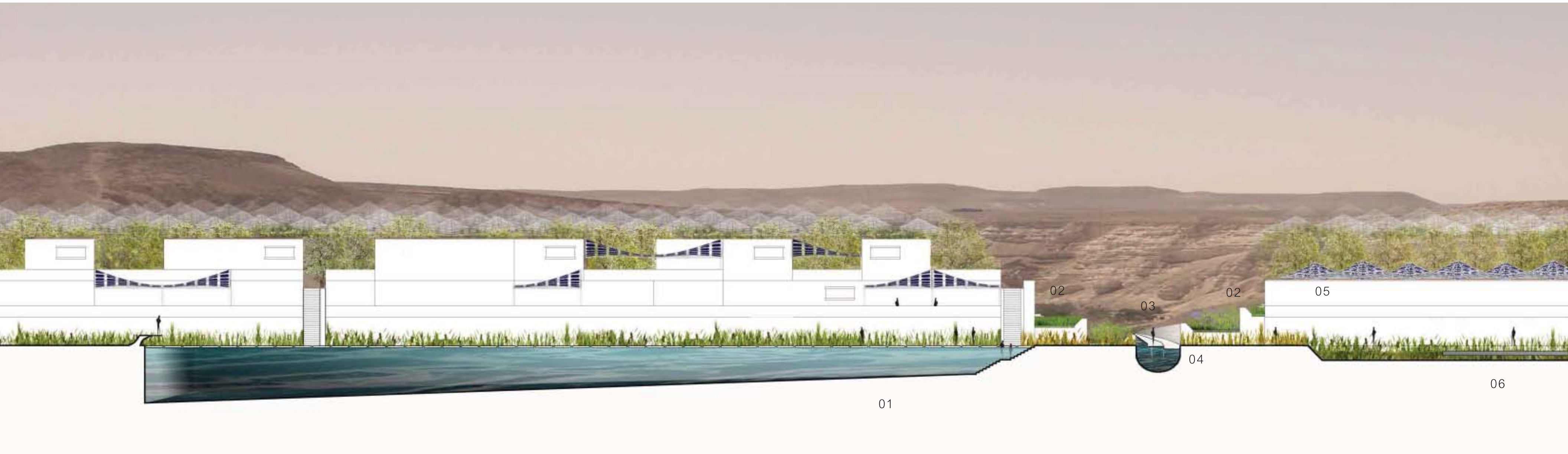


fig. 4.23 Typical longitudinal section through productive cells

The forming of the site into a framework of productive cells starts predominantly with earthwork, which includes definition of terraces, creation of microcatchments for planting, and digging depressions into the ground for cisterns, reservoirs and conduits. The structural retaining walls of the terraces are built out of soil-cement, a mix of the existing soil material in the site with Portland cement for reinforcement and a sealant material in places where water erosion needs to be managed.

Residential complexes will use the retaining walls as their foundations and will be built of a similar soil-cement mix, beneficial for its high thermal mass values. They will be painted white or in light desert shades to reflect the sun's rays and avoid overheating.

01 fresh water reservoir
02 irrigation and stormwater management wetlands
03 foot and bike path
04 water conduit
05 greywater basin behind
06 domestic wastewater treatment wetlands



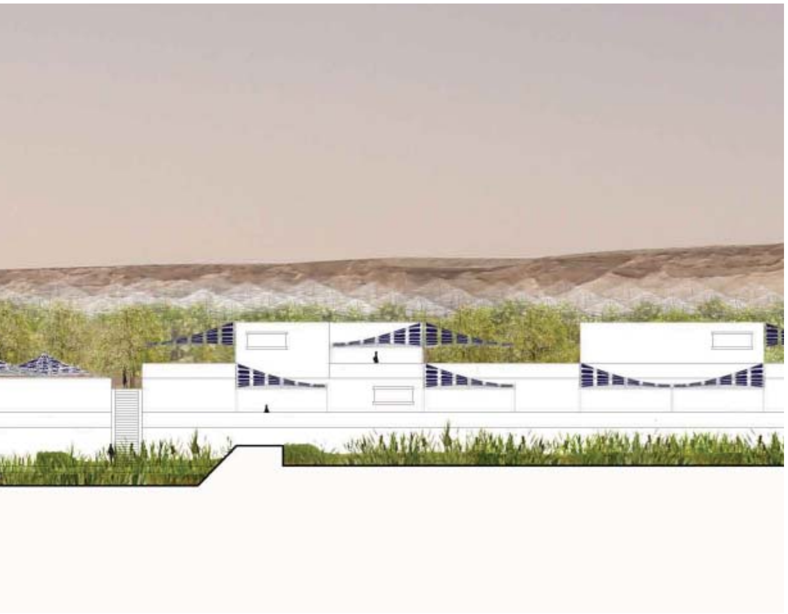


fig. 4.24 Typical transverse section through ravine path

A variety of reeds, rushes and Irises is selected for the domestic wastewater treatment, irrigation runoff and stormwater wetlands. For the shallow domestic plots within the residential streets lower reeds are used, to maintain continuity of vistas between residential blocks and the public space. Along the ravines a variety of depths and plant heights is applied to moderate varying water flow through rainfall events and to create lush landscape corridors which offer relief from the dry heat.

In the background and amidst the residential blocks more ephemeral and transient structures offer shade and improved growing conditions under a PV canopy. These structures are modular and made of light steel members, with tensile thin film fabric stretched between them.

SITE TRANSFORMATION-

EXISTING CONDITIONS

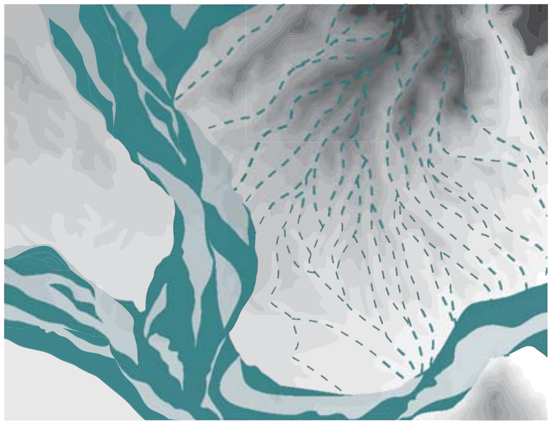


fig. 4.25 Existing- water

Existing runoff patterns convey water from the hilltops (the water divide line) to the wadi. Runoff collected from all the surrounding hills floods the wadi during and shortly after rainfall.

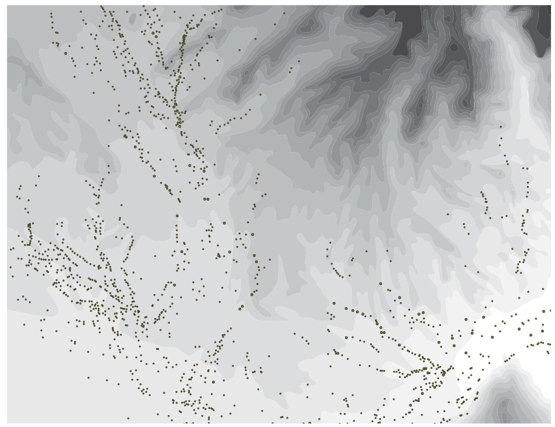


fig. 4.26 Existing- flora

Acacia trees fill the wadi bed and reveal the courses most favored by water as well as a higher underground water table. The Acacia's canopy provides protective habitat for other forms of desert life.

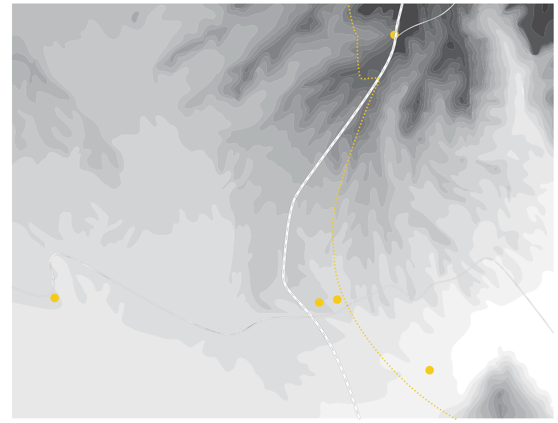


fig. 4.27 Existing- circulation + built form

Highway 40 crosses through the site on a north-south axis. Israel's National Hiking Trail also passes through the site (marked in orange) and two desert dirt roads intersect it.

01	deserted bedouin wells
02	travelers' night parking
03	'Mekorot' drill station (pharan confined aquifer)
04	'Ada Wells' access point
05	'Har Kipa' access point
06	Highway 40

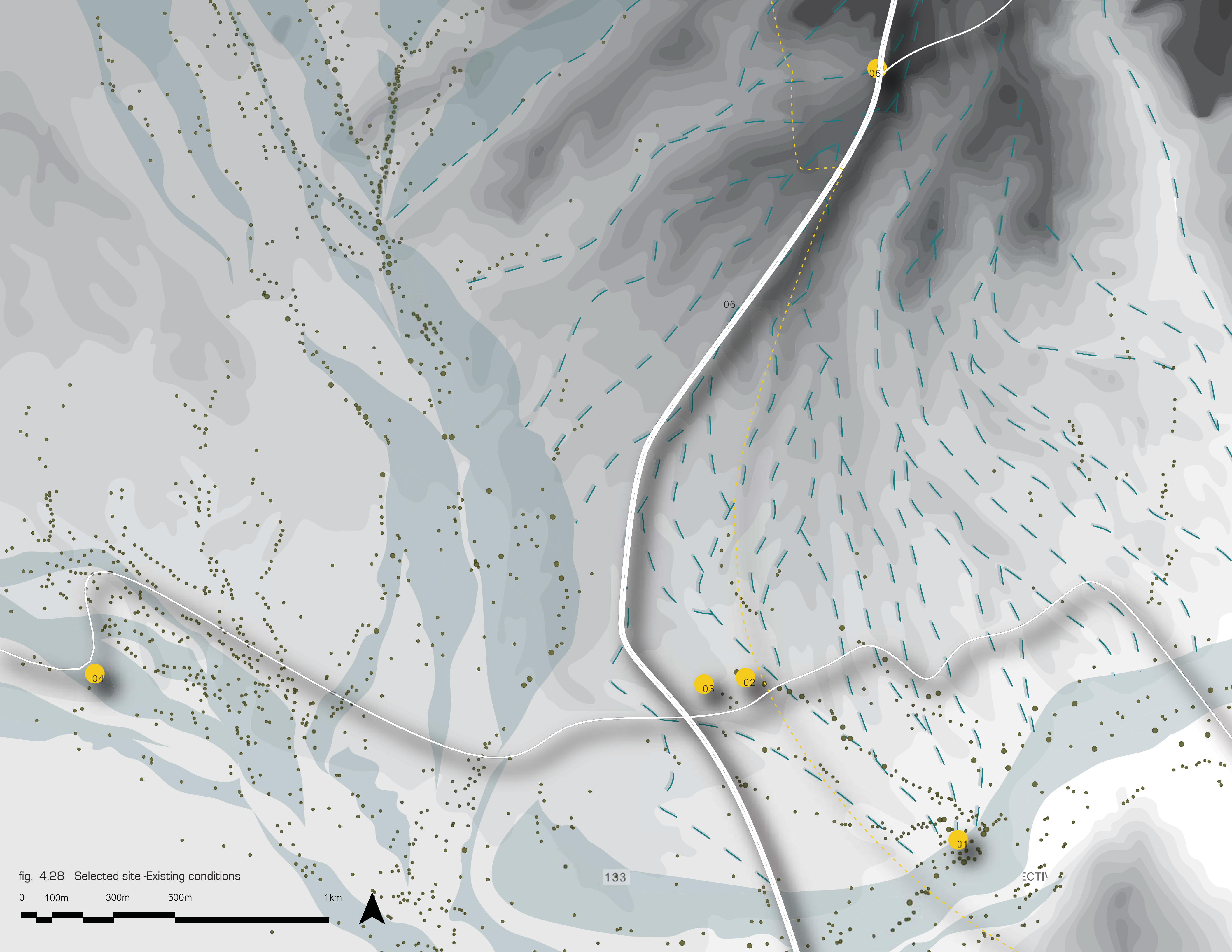


fig. 4.28 Selected site -Existing conditions

SITE TRANSFORMATION-

PHASE I

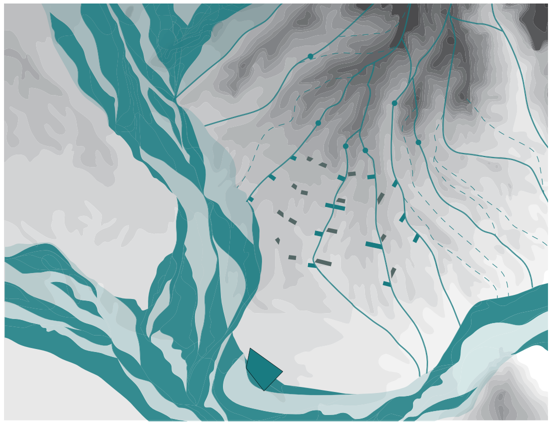


fig. 4.29 Phase I- water

The first flood catcher is put in place, runoff paths are reclaimed as conduits, greywater basins and fresh water reservoirs are aggregated starting at the community core and projecting outwards, preceding settlement.

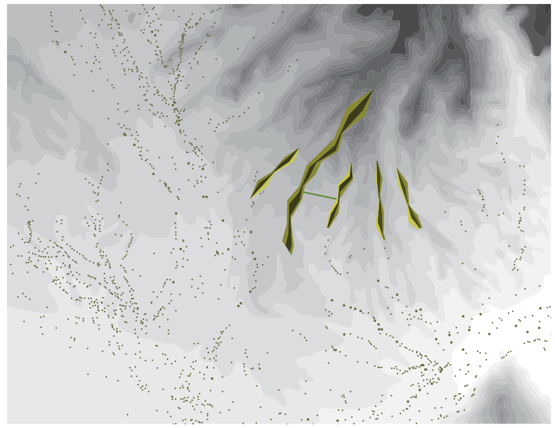


fig. 4.30 Phase I- flora

Orchards are seeded along planned residential streets. Domestic wastewater treatment wetlands are constructed on the first inhabitable street. Stormwater and irrigation management wetlands take place along established conduits.

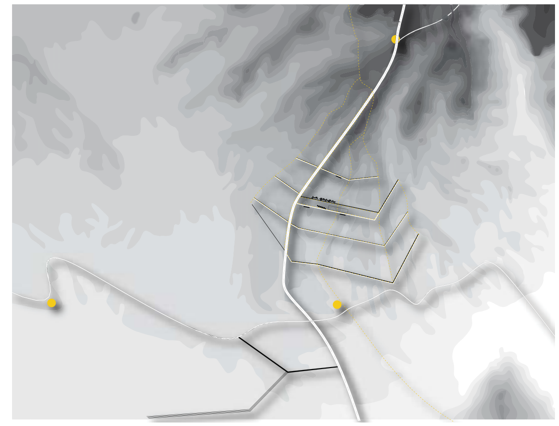


fig. 4.31 Phase I- circulation + built form

Drop structure within the wadi helps to control and direct flooding into the flood catcher. Terracing retaining walls are constructed following contour lines. Vehicular traffic accesses each productive cell through east-west routes. First street is established at the core to service the first founders.

01	drop structure and flood catcher
02	aquifer recharge infiltration basins
03	founders' street
04	farmers market
05	productive cells
06	underground hilltop cistern

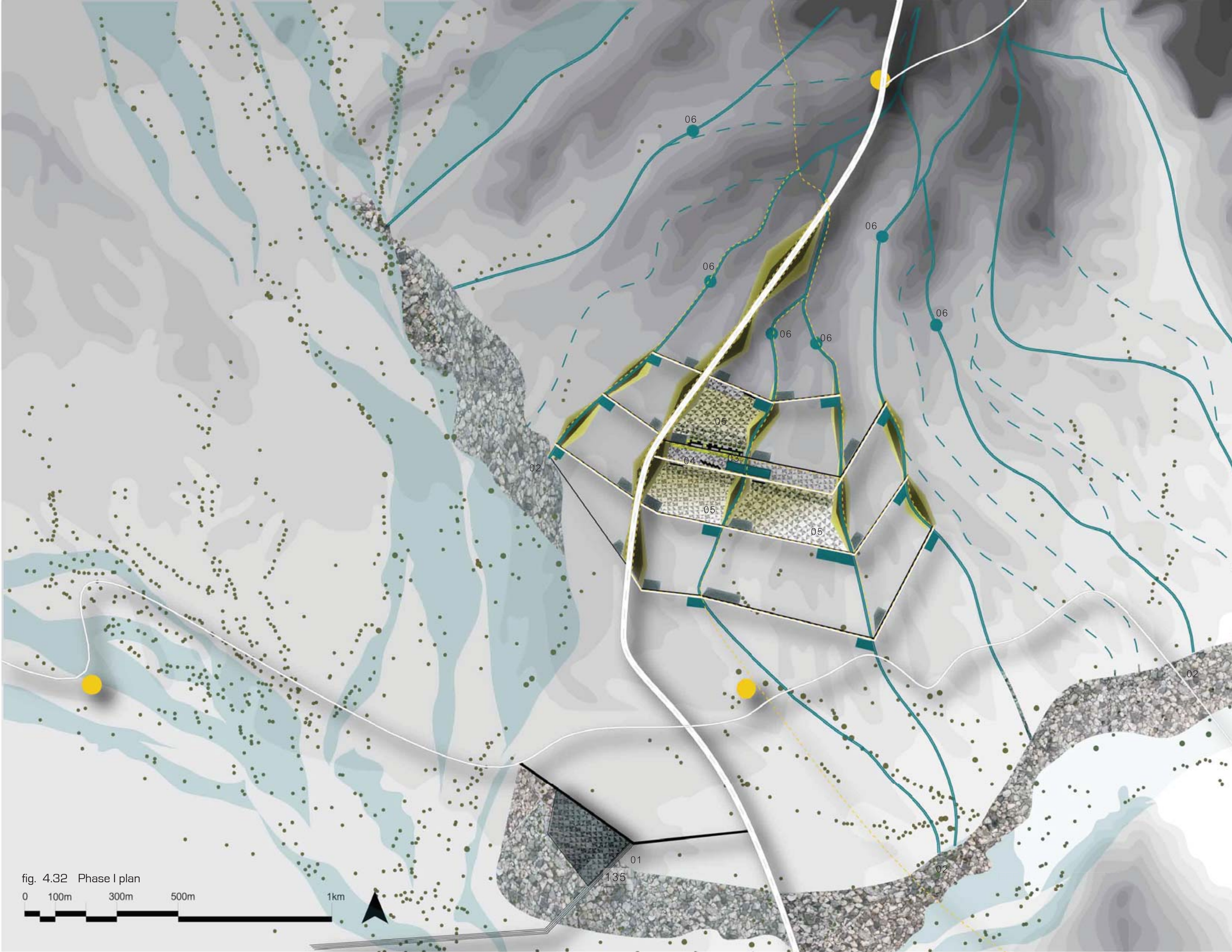


fig. 4.32 Phase I plan

0 100m 300m 500m 1km

SITE TRANSFORMATION-

PHASE II

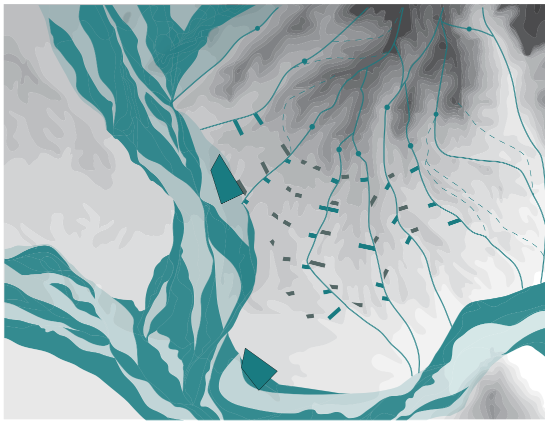


fig. 4.33 Phase II- water

The second flood catcher is put in place. Flood catchers are connected to hill top cisterns, which start filling with solar distilled water. Conduits, basins and reservoirs continue to deploy.

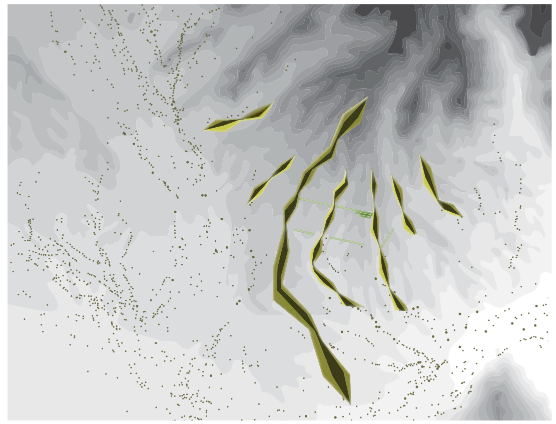


fig. 4.34 Phase II- flora

Orchard seeding and wetland establishment proceeds, following the water framework. Acacia trees are preserved on site to form part of the wetland ecosystem.

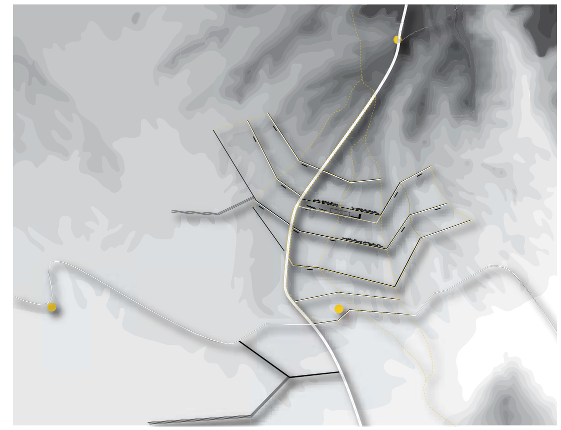


fig. 4.35 Phase II- circulation + built form

The community grows to approximately 60 households. The farmers market is expanded to serve visiting travelers. A community center is built in the civic center and defines the public square. Additional productive cells are prepared.

01 drop structure and flood catchers
02 residential streets
03 civic center
04 farmers market
05 productive cells

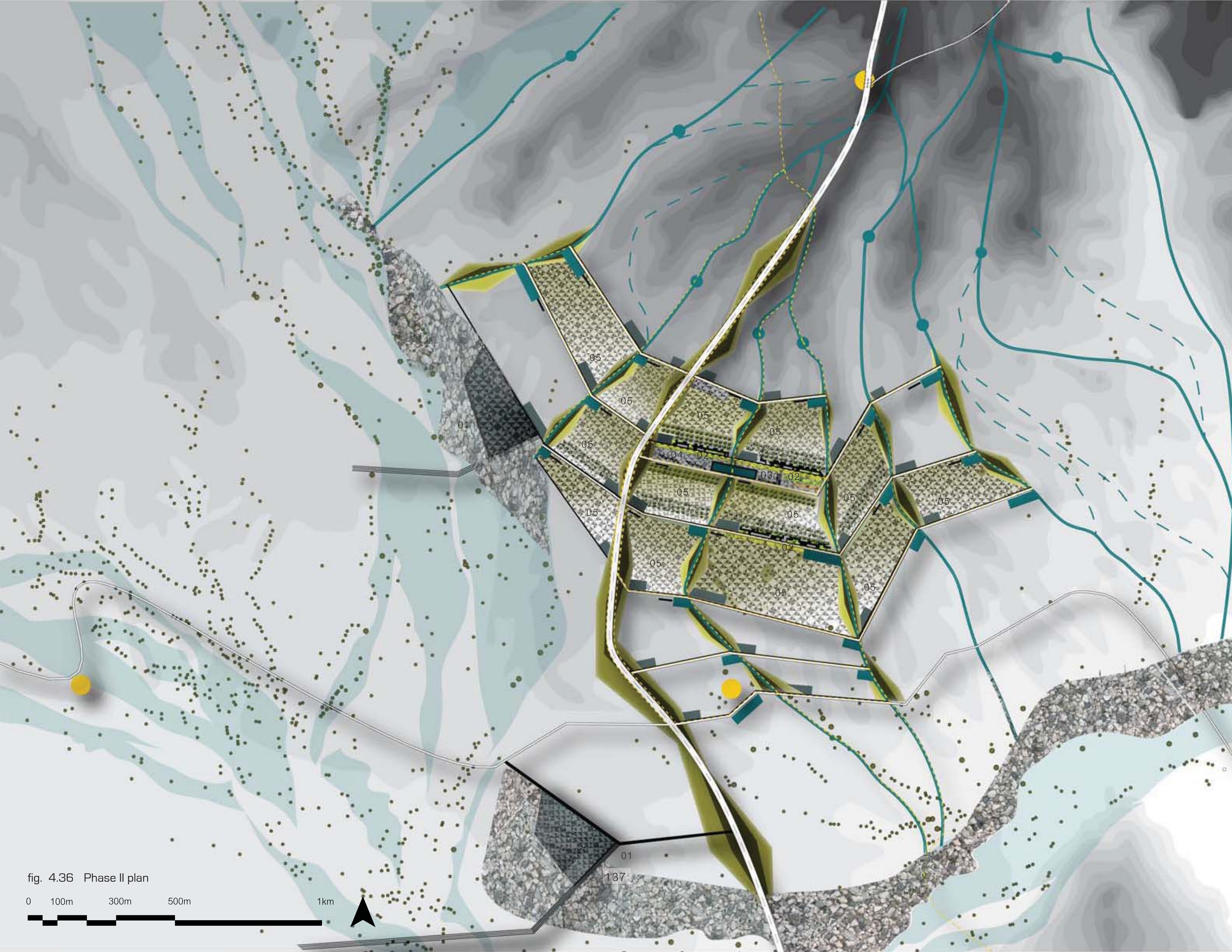


fig. 4.36 Phase II plan

SITE TRANSFORMATION-

PHASE III

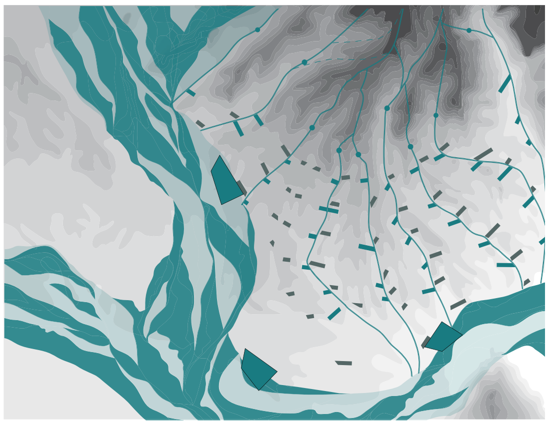


fig. 4.37 Phase III- water

A third flood catcher is connected to the system. The water network is functional in its full capacity, capturing flood and runoff rainwater during rainfall, storing it through the dry season, distributing it to the various reservoirs, recycling and reusing the water and finally releasing it purified back to the wadi. The network of reservoirs can store enough water for the community needs for 8 months, while the flood catchers and hilltop cisterns store emergency reserves for an additional 12 months.

fig. 4.38 Phase III- flora

Orchard seeding and wetland establishment proceeds, to complete the community's green infrastructure network. A buffer zone defines the wadi edge to mitigate and moderate the community's outputs. The buffer zone is a diverse mix of recharge basins, intentional seeding and emergent species.

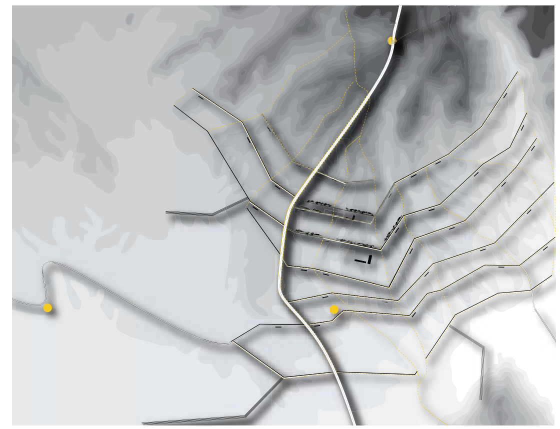


fig. 4.39 Phase III- circulation + built form

The community reaches a size of approximately 100 households. A school and recreation center are built to form a secondary service node. The productive cells are fully established containing: greenhouse agriculture, pasture grounds, camping sites and other emerging industries.

01	drop structure and flood catchers
02	residential streets
03	civic center
04	farmers market
05	education + recreation node
06	camping site
07	pasture grounds

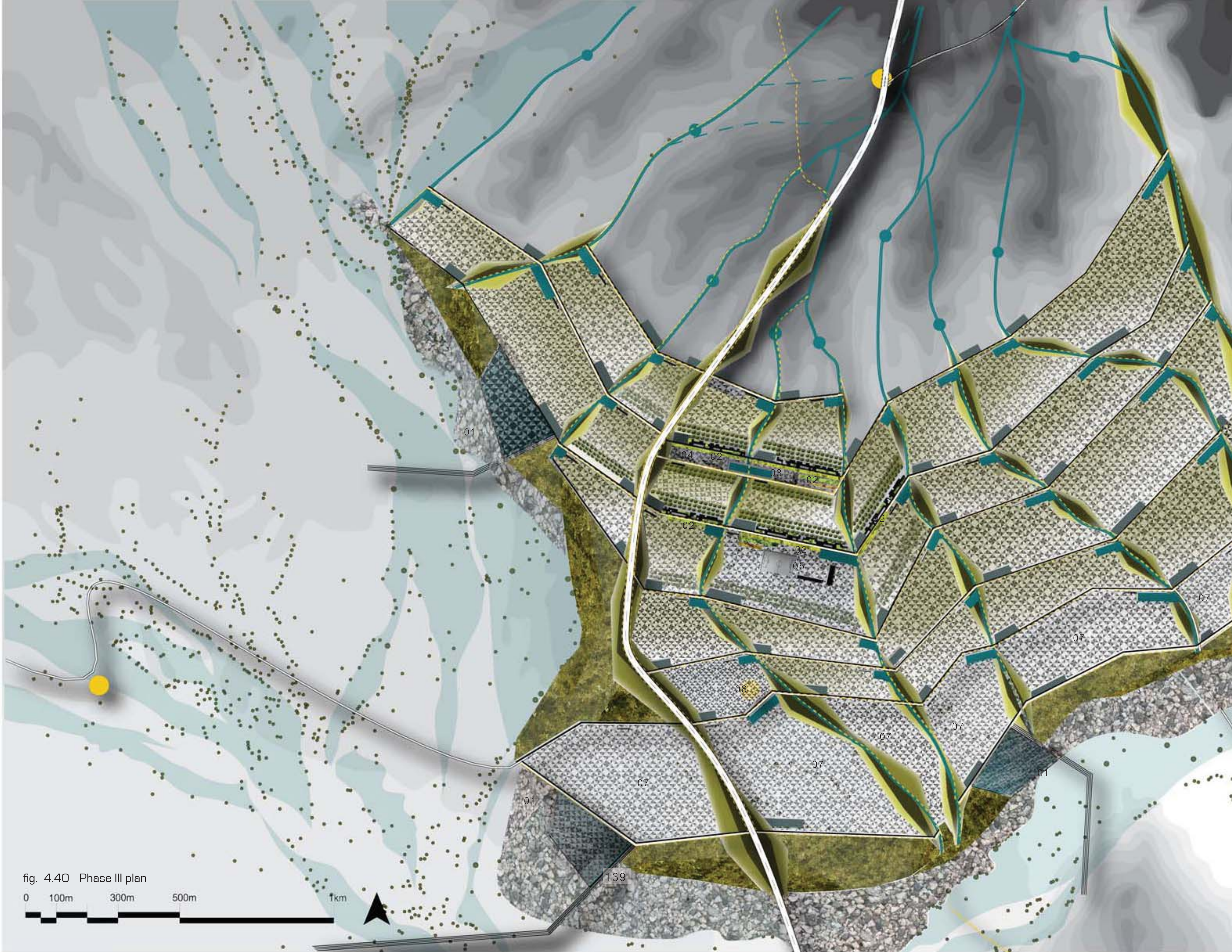


fig. 4.40 Phase III plan

fig. 4.41 Community built form

Community housing is organized along the terracing retaining walls, forming habitable edges to the productive cells. These edges are the urban streets of the community. The distribution of unit types along the street is mixed, to encourage the integration of multiple household types into a vibrant community. Unit types can be joined together or separated to fit the needs of non conventional households.

Public buildings and service nodes are located at major intersections of the infrastructural system, in order to be best served by it, but also to take advantage of the augmented opportunities embedded in overlapping cultural functions with infrastructural landscapes.

Housing is dense in order to preserve open areas for agriculture and public activity, and to maintain a sense of familiarity and neighbourly relationships within the community. Public functions are given larger areas across from residential streets in order to encourage community life, while maintaining a distinction between the private and the public.

Bachelor unit

2 Bedroom unit

3 Bedroom unit

Public building

Domestic wastewater wetlands

Orchard

01 community center
02 farmers' market
03 community garden plots
04 school + recreation center
05 sports fields
06 cell logistics shed

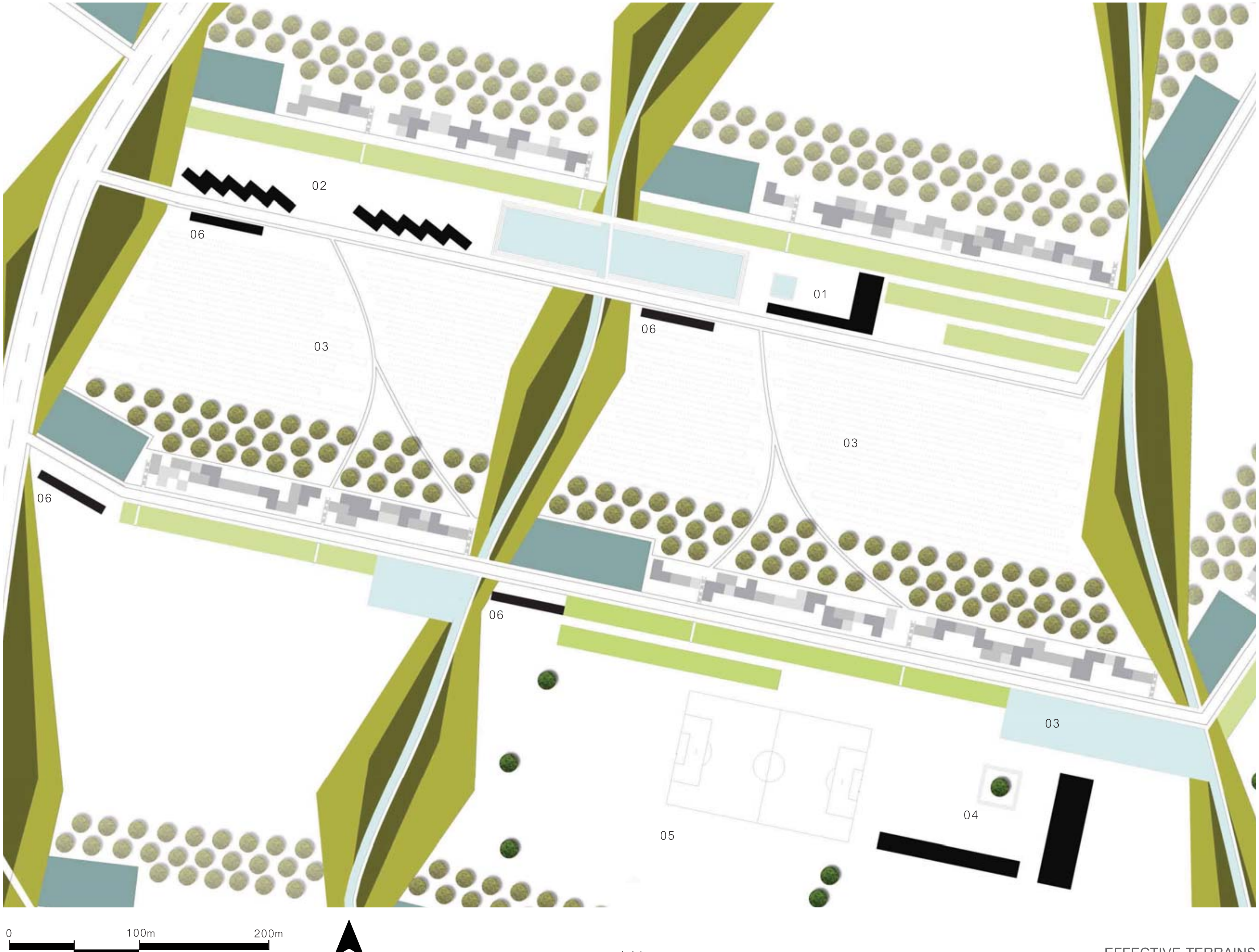

02
06
01
06
03
03
06
06
03
04
05
0
100m
200m

fig. 4.42 Solar Greenhouses

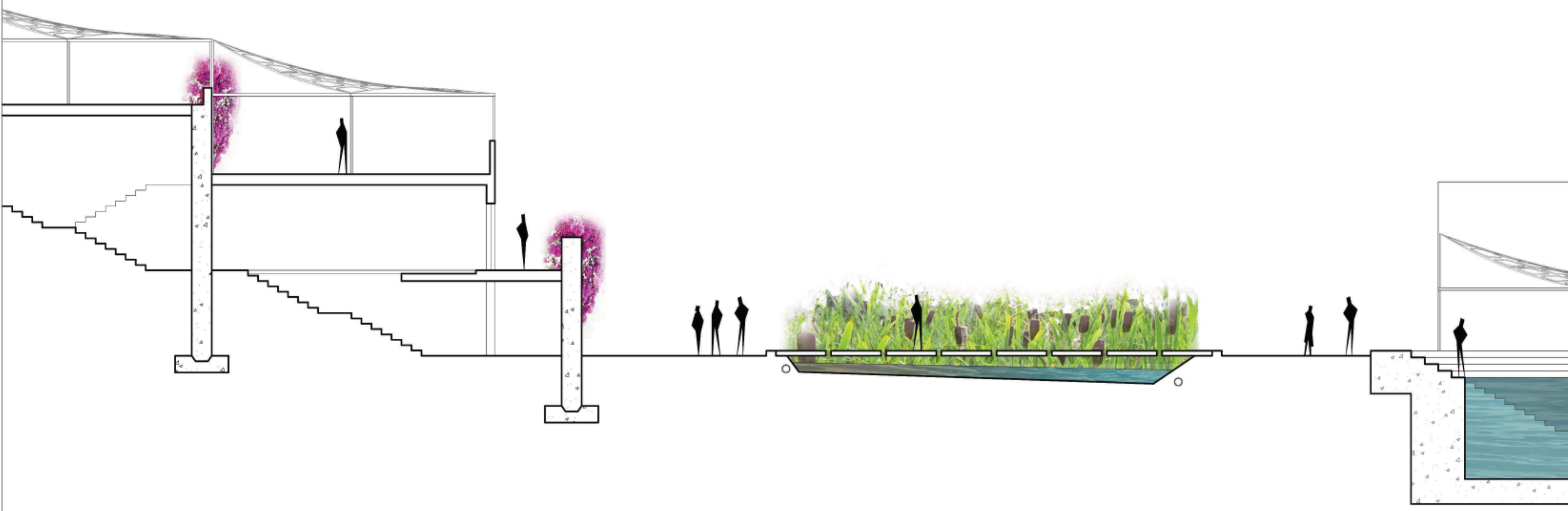
The solar greenhouses are the community's main economic base and integrate agricultural production with solar energy production. Irrigation runoff is conveyed by a drainage swale to the cell's greywater collection basin. During rainfall, the solar roof's gutter system directs the accumulated water into the stormwater wetlands adjacent to the productive cell.

fig. 4.43 Solar Pasture

Pasture grounds are provided for the raising of live-stock. The roof structure is similar to that of the green-houses: tensile thin film PV membrane stretched over a modular steel structure shelters and shades the grazing herds. The Solar Pasture is less enclosed or subdivided than the greenhouse units providing freer movement and ventilation. Drought resistant pasture plants are cultivated and irrigated with ‘recycled’ water.

fig. 4.44 Solar Camping

A camping site takes the place of the travelers' night parking lot. The site remains a convenient place for the National Trail travelers and visitors to Ada Wells to stop for the night, while providing additional amenities including: shade canopy, electricity connection, running water and access to the community center where commercial services are available.



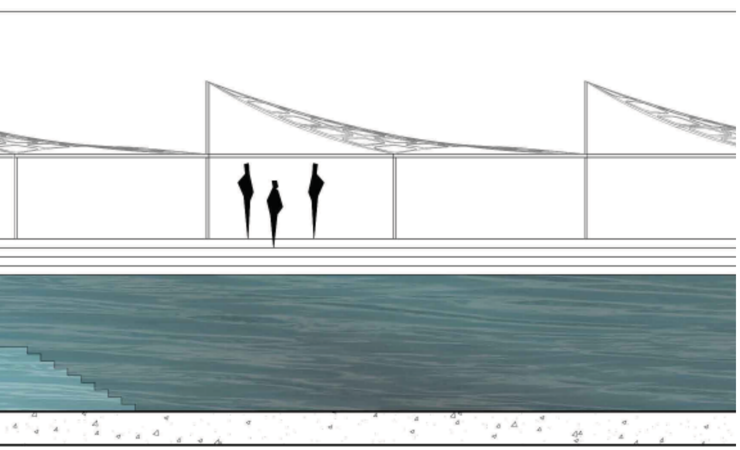


fig. 4.45 Civic Street Section

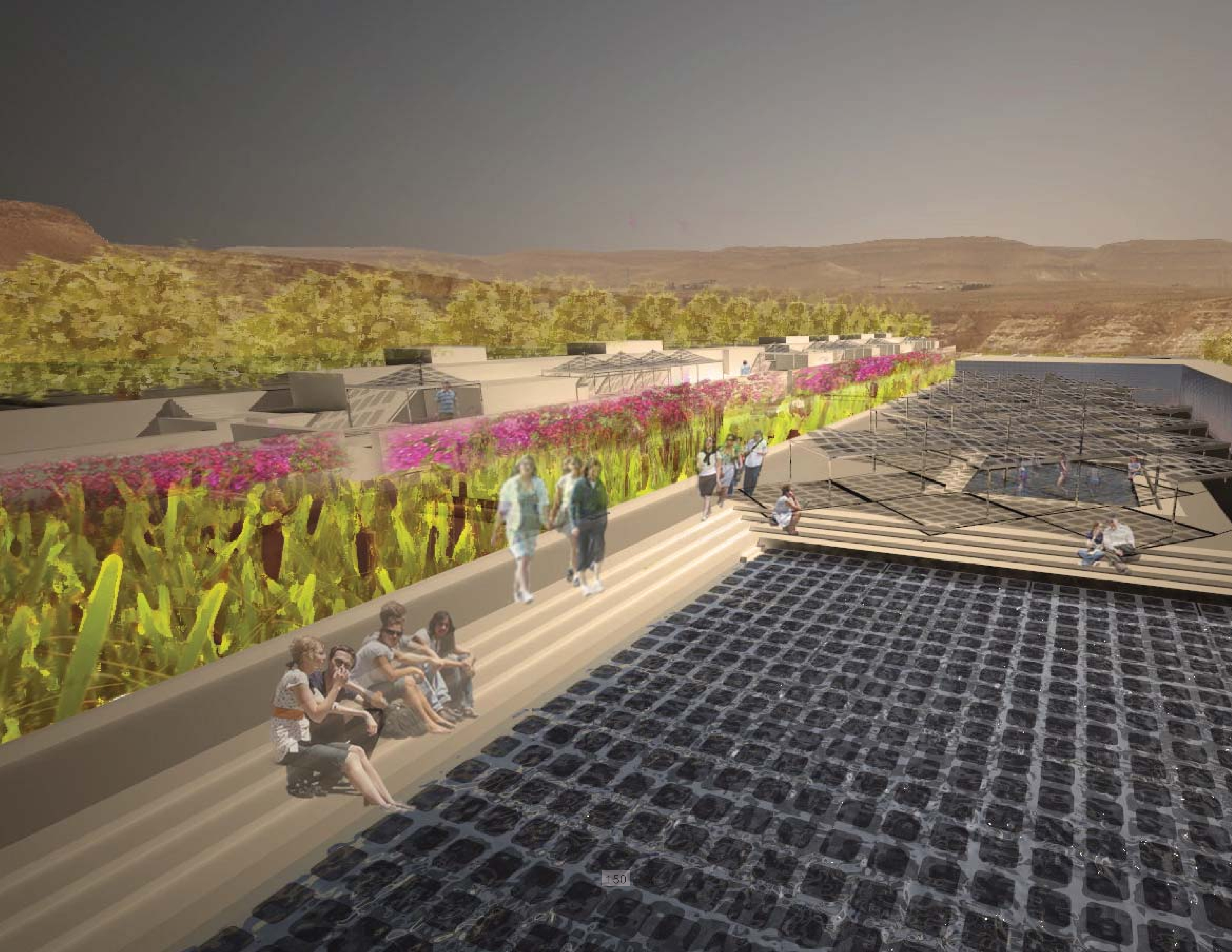


fig. 4.46 Civic Center

The central fresh water reservoir acts as the community locus and a public gathering place. The main reservoir is covered with a solar membrane while not in use to prevent evaporation. A small wading pool encourages children's play in the main square. In a desert community, the constant presence of fresh water helps to create a refreshing sense of ease and comfort. The centrality of water availability in the desert symbolically and practically shapes this community's identity.

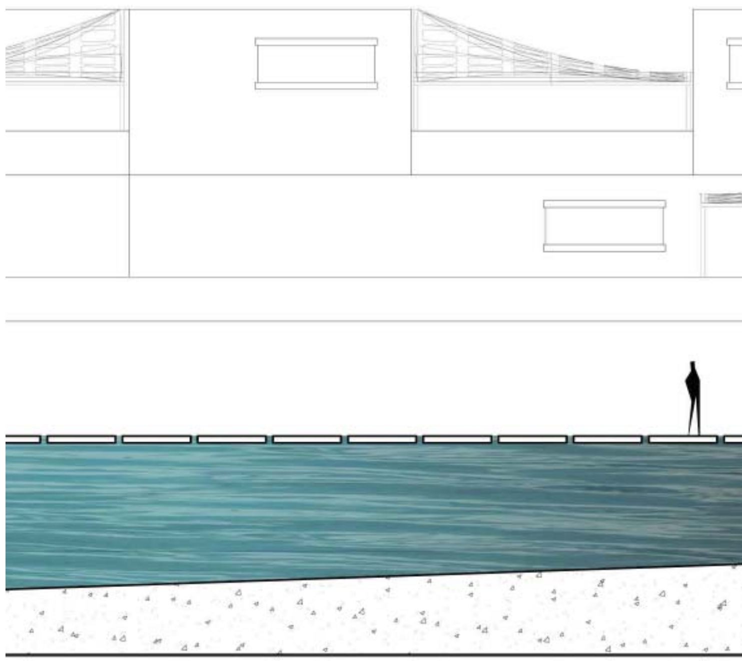


fig. 4.47 Ravine Path and Canal Section

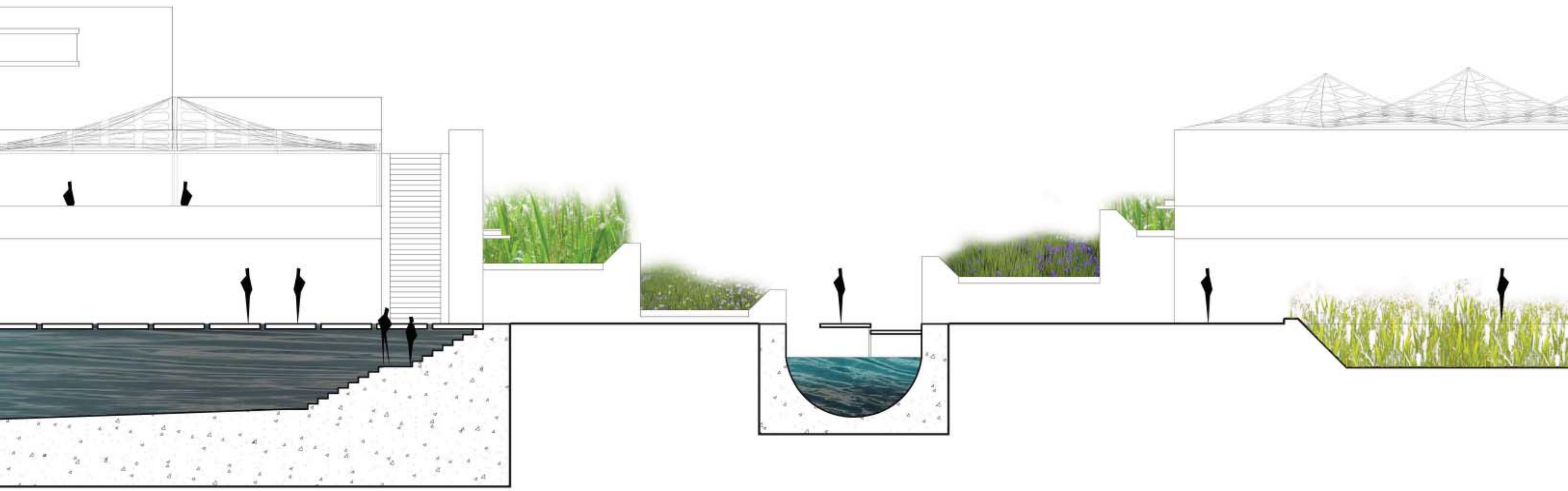


fig. 4.48 Ravine Network

A ravine network transverses the productive cellular terraces. The ravine paths are determined by existing runoff patterns to preserve the natural flow of water through the site. The network doubles as a community park system and as an infrastrcutural conduit; distributing water from the hilltop cistern to the reservoirs within the cells. A layered system of constructed wetlands purifies agricultural runoff, manages stormwater during erratic rain events and provides wildlife habitat.

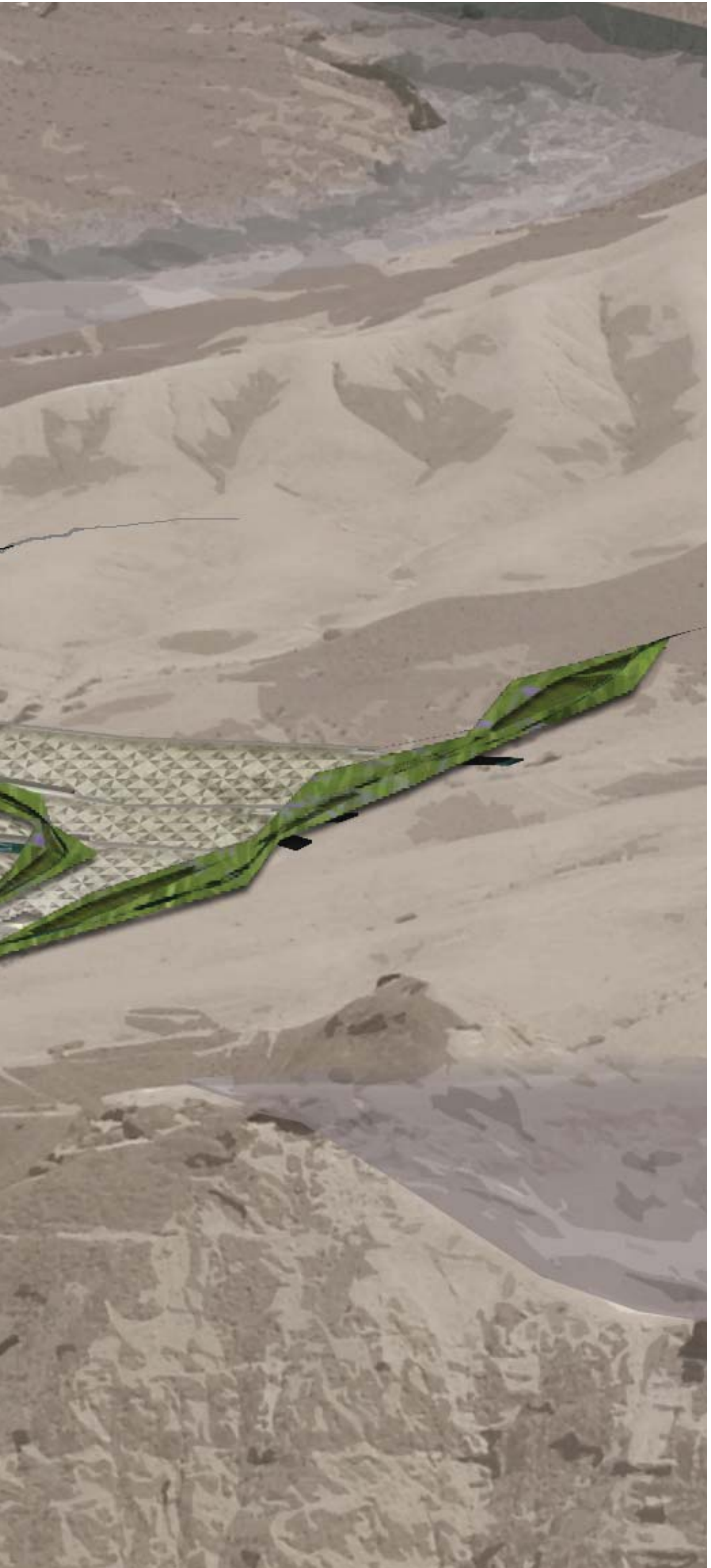


fig. 4.49 Terrain aerial view

The community settlement is planned as a network of open ended cells of activity, which are sustained by an infrastructural framework. The settlement is captured here at a single moment in time, where the framework of productive cells has reached maximum growth, yet residential and communal uses are concentrated mainly along the central cells and can still grow outwards. The process of such growth is open-ended, yet ruled by considerations of sustainable input and output equilibrium. Such considerations will be informed by a mechanism of continuous information flows, helping to deepen the community's knowledge regarding resource availability and demand, changes to the physical environment of Wadi Pharan and evolving cultural needs.

ENDNOTES

1 Zekai Sen, *Wadi Hydrology* (Istanbul Technical University,Turkey: CRC Press, 2008), 17-24.

2 Isaac Meir, Yair Etzion and David Faiman, *Energy Aspects of Design in Arid Zones* (Jerusalem: Center for Desert Architecture and Urban Planning, 1998), 98.

3 Daniel Hillel, Daniel Hillel, Negev: *Land, Water, and Life in a Desert Environment* (New York, N.Y.: Praeger, 1982), 29.

4 Zekai Sen, *Wadi Hydrology,* 18-19.

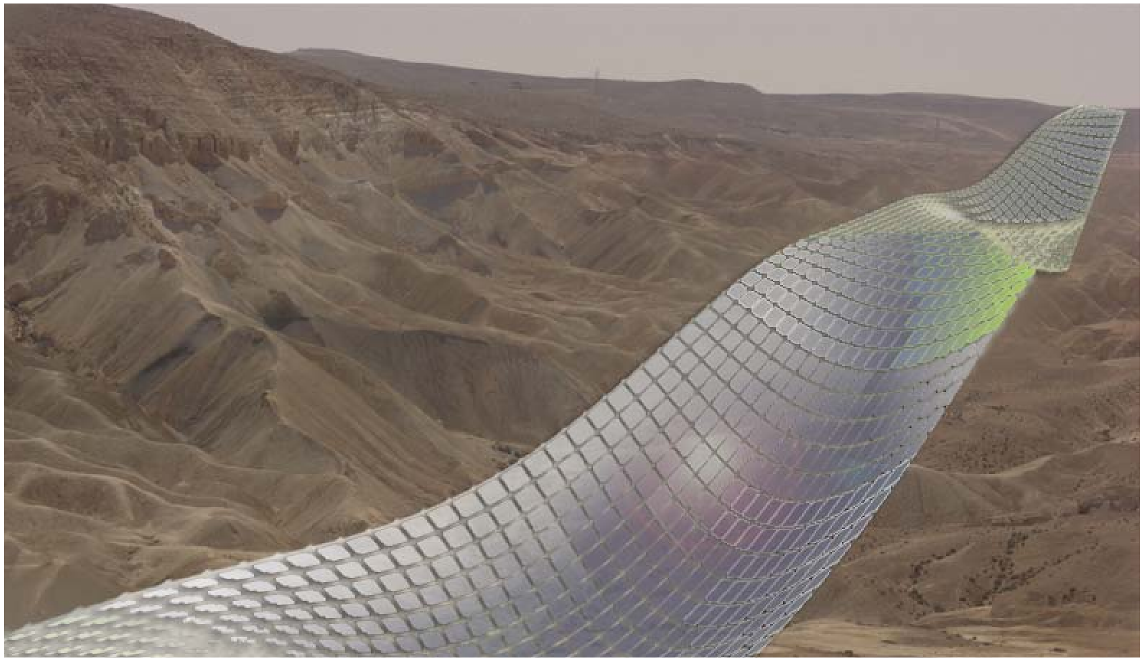


fig. 4.50 Unrolling Desert Infrastructure

4.5 Design Strategies

WATER

1. Use existing site topographic conditions and hydrological processes.
2. Provide basins to capture directed runoff water from expansive catchment areas.
3. Provide auxiliary reservoirs for water needs for a minimum of two rain seasons.
4. Allow interconnectivity between reservoirs to optimize water availability on demand.
5. Take advantage of air born moisture, rain collected from rooftops and reclaimed wastewater.
6. Invest in long term aquifer recharge to combat desertification- enhance water table by releasing year round unused cleansed water back to the wadi.

ENERGY

1. Plan a system compatible with existing electrical grid, ready for incremental deployment.
2. Select energy production technology according to site context, orientation, topography, community size, solar radiation available, climate data etc.
3. Allow for two way transmission- the multi-directional grid.
4. Plan adequate energy storage to synchronize supply and demand.
5. Enable system modularity for future adaptability.
6. Integrate smart grid capabilities: web communication, networking, monitoring and responsive feedback loops.

SYNTHETIC

1. Study the physical and cultural context across all relevant scales.
2. Develop an understanding of the site and define the human system's relationship with it.
3. Plan system imports and exports to be in sustainable equilibrium.
4. Synthesize effective infrastrucutral systems with urban place making.
5. Encourage self organization, diversity and emergence patterns.
6. Envision design as a multi-disciplinary ongoing process of evolution vs. a single fixed intervention.

Conclusion

"There is no such thing as the ideal city, but there are cities which are good, in the widest sense of the word, energy-wise, ecologically and humanely."[1]

REFLECTION Architecture is the physical and metaphysical representation of the cultural values within which it is formed. At its best, it can be a driving force that predicts, forms and leads a cultural reform. Utopian thinking has often been a powerful vehicle in the hands of architects and thinkers alike, to imagine new social orders and bring to the forefront a new set of ideals. Many writers when describing their idea of a perfect society provide a clear physical manifestation and elaborate on fundamental relationships including community organization, orientation and layout. The specific forms in which utopias are designed are a powerful embodiment of the values held by a particular society and how the daily routines of life are managed. As such, the architect's preoccupation with Utopia is a stimulating exercise, rooted in the ambition to improve the human condition.

Utopia is ever linked with crisis. It envisions a new social order, where the previous one failed. Only once the unhealthy condition has collapsed, can Utopia be envisioned. As an ideal and complete model of society it requires a complete obliteration of the past condition. Without crisis, there is no Utopia. It can be said that the crisis is the fuel of counter reaction which is in the essence of Utopia. It is often a source of inspiration for visionary architects while they imagine new paradigms. Therefore, crisis is a vital and dynamic force in the creative process, without which stagnation would persist.

Utopia however, cannot be realized. By definition, it is a "non place," an ideal fixed outside time and space. Its design often follows geometrical forms of cosmological and ideological symbolism not related to a real dynamic site, which is always in flux, changing with time. Hence, the problem with the realization of Utopia is its incompatibility with the inevitable notion of evolutionary change, inherent to reality.

Here lies the paradox between Utopia and change; on one hand Utopia can be interpreted as the re-organization phase in Holling's model of ecosystem dynamics (see fig. 2.3). Under this view, it is a single phase of a cyclically dissipative process of destruction and creation, a process essential to the healthy equilibrium of any ecosystem, human societies included. On the other hand, Utopia, in its construction denies the very existence of change.

VISION The concept of Utopia appears to sit well with the idea of settling the desert. The desert is perceived as a 'Tabula Rasa', a wilderness in a heightened crisis. Survival in such context requires a reliance on communal structures that enable self-sufficiency. These communal structures allow us to imagine a society, different than the one we are familiar with. In a sense, the proposal presented here can be considered a Utopian idea, a diagram, or a prototype, in the way it wishes to reform the relationship between the environment, the community and the individual.

The aim of the thesis, however, is to expand conceptually beyond the realm of Utopia by forming spatial and temporal relations that include evolutionary dynamic processes. The thesis argues, that in envisioning new ways of life, better fitting to our contemporary world, special care should be taken to consider the constant fact of change within our predictions.

The community village envisioned in this project is deliberately small. At the end of phase III it reaches a size of just over a hundred households. Living in the desert is not for the masses. It has always been an endeavour fitting for only the non- normative few, who choose it as a fulfilling way of life and regard it as a mission. The strength of these communities lays not in their numbers, but in their unique knowledge of their environment and in their powerful conviction. This community is based on economical thinking that directs the oscillations of its expansion and contraction. Economy in this context is defined not only in monetary terms but predominantly in terms of water, energy and food. The current model, with only a hundred households, allows for a surplus of all of the above factors, available for storage in the case of water, or for export in the case of energy and crops.

This is in a sense the 'Ideal', best case scenario, which leaves room for oscillations towards other attractors, less favourable economically, but still manageable. One of these scenarios could be a case in which the community grows to 500-600 households. In this case, it will become more urbanized, and much of the agricultural land will be substituted for housing, community services and commercial activities. This scenario will mean the end to agricultural export; the community will still grow crops for its own consumption, but will have only energy as an export industry. Water will still be sufficient to support the community, but this might start to affect how large other communities living off the wadi could be, since the wadi can only support a total of 3680 households.

A different scenario could be in the case of nomadic Bedouin communities, which might not be present in the site year round, but will frequent it seasonally. In this case, the housing and community services will have a much more transient character to them, ready to be assembled and disassembled as need be. The water and energy infrastructures in contrast, will be continuously operational throughout the year. They will supply an oasis station with water and vegetation for the Bedouins to stop at, while the Bedouins could oversee its maintenance and re-seed plots for future pasture grounds. This scenario also predicts self sufficiency in terms of water and food, with a viable energy export industry.

This project proposes a community that is self sufficient, but not disconnected from a larger settlement fabric and natural systems. The successful development of Wadi Pharan and similarly of other wadis in the Negev is dependent on the optimization of water availability through simple and local water infrastructure. Similar methods of harnessing desert waters have been in use by many civilizations in the region for thousands of years, previous to the construction of the national water carrier in 1964. Ironically, when Ben-Gurion settled in the Negev, the massive carrier's pipes from the north took the place of more ancient systems, and the efforts to revive them were abandoned. With this infrastructural novelty, the Negev's residents lost the working knowledge of these ancient techniques.

Water in the desert is not a luxury. It is very likely that the Negev will continue to be a desert, and might become even more arid in the future. Water concerns will continue to dictate how people live in this area probably for many years to come. For this reason, I believe that the proposed water system, built into the ground and shaping this community, is more fixed than any of the other more ephemeral systems.

The community might shrink or grow, industries will emerge, technologies will evolve and different social ideologies will change the cultural needs of the community. With these changing dynamics it is likely that residential and public buildings will be reconfigured with the needs of the time, updated ones will be built, while older ones will be renovated and adjusted periodically. The PV canopy over the productive cells is probably the most ephemeral element of the system, since it is meant to be modular and transient. These structures can be disassembled and re-assembled according to planting needs, land usage demands and energy production strategy. It is also quite likely that solar technology will progress, requiring the gradual transformation of the canopy. Water, however, will remain the limiting factor, and the water infrastructural system could serve the community for many generations, barring minor necessary adjustments to account for annual and seasonal flow variations.

PRAXIS The sun's energy is a resource readily available, abundant almost everywhere within the borders of Israel and especially in the Negev. It takes a shift in thinking to divert infrastructural funding into new technologies, but if decision makers decide to take this step, it could benefit Israel both in terms of water and energy availability. Israel can reinvent itself in both these fields, with the help of communities in the Negev.

In terms of water, the model should be local and renewable. If communities in the Negev can harness enough water locally, communities in the north who enjoy more rainfall could surely do it as well. Similarly with agriculture, Negev communities need to be able to grow their own food, locally and/or regionally. Exporting these products to the rest of the country will only be viable if other agricultural land is lacking and consumers are willing to pay premium prices for desert produce. When it comes to energy, communities in the Negev can operate like small power plants. With initial government investment to subsidise the fields of PV, or other solar technology, these communities could eventually supply the national energy demand.

This solution could be varied; with a high community investment, the community could be the owner of its own power plant, and sell the energy to the grid, producing a profit. Another option could be private or commercial investor who will supply the initial investment, rent the land from the community and make a profit from the energy market. The community could still use the land for agriculture or industry, and would have another side income from renting its roof surfaces. Another solution could be formed with a greater government involvement, which will subsidise the initial investment in partnership with the community, and will then be able to sell energy back to consumers for cheaper rates.

Many creative solutions exist, and could be applied in conjunction to one another. The realization of this idea however, requires a new set of priorities on the legislator's part. First in demilitarizing the lands of the Negev and restoring them from the control of the IDF, and back into the possession of communities who will cultivate them, and second in establishing the support mechanisms to forward solar developments.

A first step in this direction is the feed-in tariff law accepted in summer 2008, requiring the utilities to pay a higher rate for energy coming from independent PV installations. Private developers such as the “Arava Power Company” exist and are ready to negotiate with Kibbutzim in order to rent their lands for solar applications. All that is still lacking is serious government support in the form of legislation which will regulate the formation of these partnerships with the well being of national economy, desert communities and the consumers in mind.

“The recognition of unified spatially wide- reaching contexts for questions of habitability, ecology and economy have brought about this change in thinking, even if little of this can be seen as yet in praxis, which in the case of all planning always lags behind.”[2]

THE MOMENT

The moment when, after many years
of hard work and a long voyage,
you stand in the centre of your room,
house, half-acre, square mile, island, country,
knowing at last how you got there,
and say, I own this,

is the same moment the trees unloose
their soft arms from around you,
the birds take back their language,
the cliffs fissure and collapse,
the air moves back from you like a wave
and you can't breathe.

No, they whisper. You own nothing.
You were a visitor, time after time
Climbing the hill, planting the flag, proclaiming.
We never belonged to you.
You never found us.

It was always the other way round."[3]

1 Otto Frey, *Occupying and connecting: Thoughts on Territories and Spheres of Influence with Particular Reference to Human Settlement* (Stutgart/London: Edition Axel Magnes, 2009), 111.

2 Ibid.

3 Margaet Atwood in an article for Haaretz Newspaper, http://www.haaretz.com/haaretz-authors-edition/the-shadow-over-israel-1.293653 (accessed June 02, 2010).

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