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A Historical Glimpse of Irrigation and Water System in the Oases Of Egypt from a Sustainable Perspective

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Securing the Sustainability
of Oasis Societies Associated
with Water and Land Use
in the Western Desert
Science and Technology
Research Partnership
for Sustainable Development (SATREPS)
Scarce-Water Research Center at Sophia University

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Introduction

The Western Desert of Egypt witnessed deep geological transformations and the related human adaptation until the land cover became stable in the five oases as life spots in a dead desert. The remains of ancient human settlements are spread within the depressions of the Dakhla and Kharga Oases, between the Acheulean and Neolithic, about 10,000 years ago. Fossils refer to the human efforts to manage water supplies the life activities in the settlements. (Roger S. 2019)

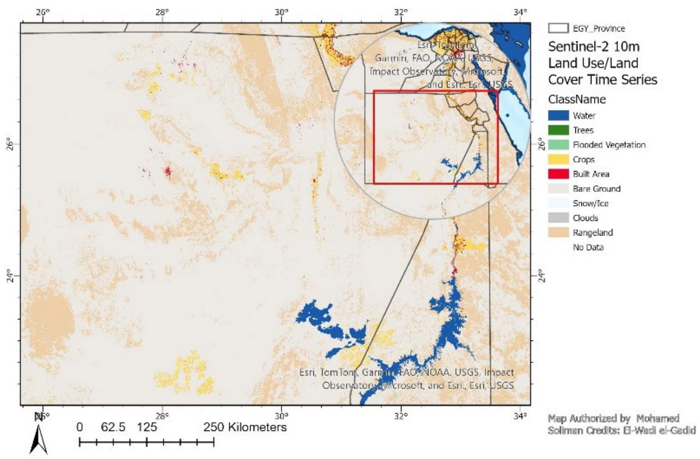
Archaeological remains and the life memory of the Oases communities reflects the water heritage techniques and management based on agricultural land classification. Consequently, extracting artesian water in the oases and the distribution process for irrigation and daily use generated various patterns of water facilities. Water facilities in the Oases of Egypt include Qanāt, Ayen, and artesian well.

The Oases water heritage needs more investigation, compelling the sustainable use and to learn lessons of how to sustain water counting with community vital participation.

Looking at the Oases water heritage from a sustainable perspective would maximize the outcomes of SATREPS. Geodesign could be one of integrated solutions that create a sustainable change model to the water heritage and the various surrounding domains.

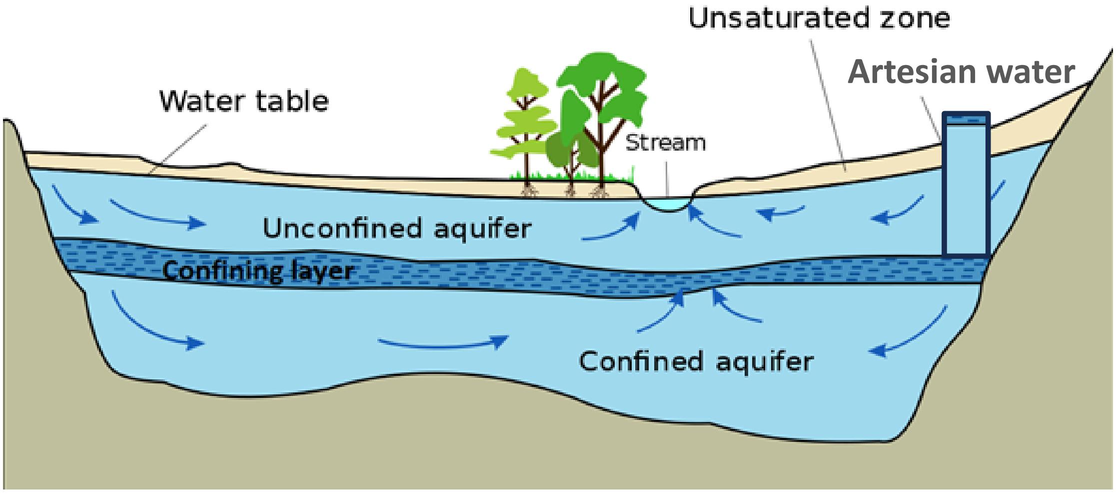
Suitability of water system pattern to topography:

The geological transformation occurred in the western desert of Egypt left oases that allowed the continuity of human settlements. The topography of the oases, as a fertile spot locates in depression, enabled reachability to aquifers. The geological structure and soil density dictate the appropriate system for water extraction. (Figure 1)



(Figure 1) Land use and land cover of el-Wadi el-Gadid 2025

Water system patterns: Utilization of several water system patterns in the Oases were according to suitability to the topography and geological structure. (Figure 2)



(Figure 2) Suitability of the topography and water extraction system

Spring "ʿĀyn": Streams in a natural waterbody that provide a large amount of water generated by nature. Under the hydrological pressure of the aquifer; the saturated area of thin and fine soil allowed water to flow up generating ʿĀyn. (Figure 3)

(Figure 3) ʿĀyn or natural spring

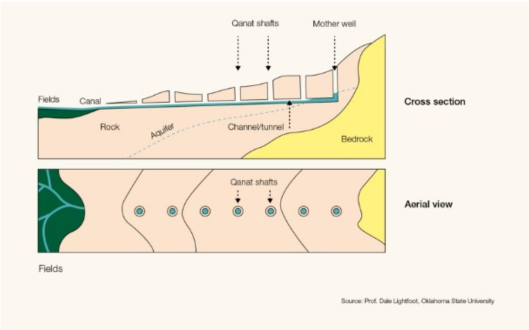
Msqāṫ: Limited human intervention represented in manging water from ʿĀyn to fields. Msqāṫ is the suitable method to convey water. Msqāṫ was a terranean channel inclined from the edge of the ʿĀyn toward fields conveys water by gravity power. (Figure 4) Usually, Msqāṫ should be coated with impermeable plaster to safe water during transportation process.

(Figure 4) Msqāī̈ or water channel

Artesian Well: Unsaturated thick area prevents the aquifer from flowing out. As a result, artesian well is a suitable method for water extraction in the oases. Digging an artesian well requires knowledge of the appropriate area where the aquifer water table is reachable. That reflects how far indigenous people were fully knowledgeable about hydrology. A simple vertical shaft connects the water table to the ground. The shaft was coated with rubble stone to stabilize the soil, preventing collapse. (Figure 5)

(Figure 5) Artesian Well

Qanāt: Qanāt is a complicated water system manage underground water in unsaturated area. The development of qanāt probably began about 2,500 or 3,000 years ago in Persia, and spread eastward to Afghanistan and westward to the Arabian Peninsula, North Africa, and even parts of Europe. Although new qanāt are seldom built today, many old qanāts are still used in Iran and Afghanistan, chiefly for irrigation. Many of these ancient Qanat systems are still in use today, demonstrating their sustainable and effective water management capabilities. Qanats were used for irrigation, drinking water, and other purposes, particularly in arid regions. (Roger S. 2019)



Anthill-like shafts were bored into the earth to reach underground water sources (Credit: Hemis/Alamy)

(Figure 6) Qanāt system design (mānwr / mānwār "s") (Roger S. 2019)

Qanāt system includes digging vertical shafts, which known in the Oases of Egypt with mānwr, connecting them with gently sloping tunnels, and utilizing gravity to draw groundwater to the surface. (Figure 6)

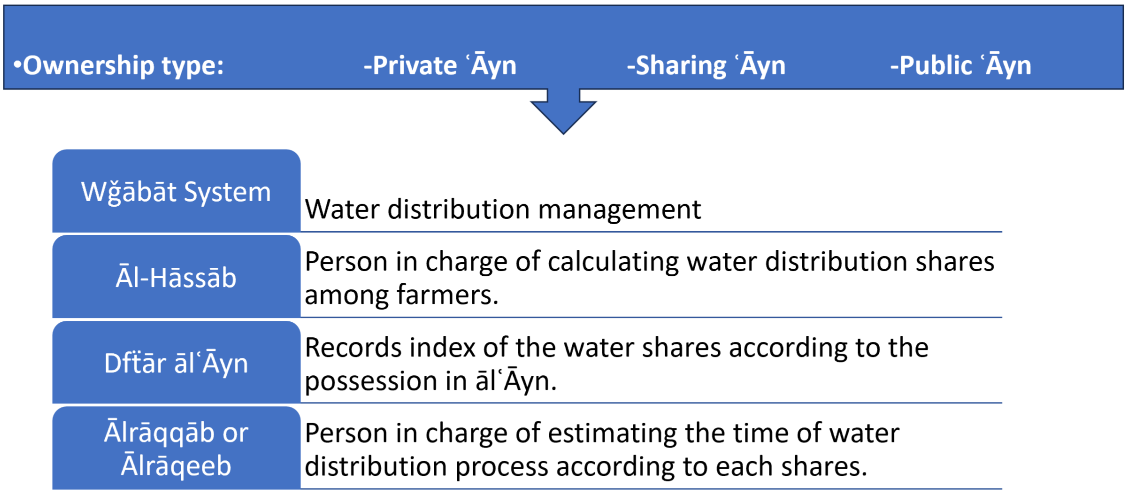
Local water management and regulation:

Indigenous people innovated a collaborative management system to share water. That conception of that management system founded on the ownership type of water facility.

The ʿĀyn has a special system of ownership divided into three types: (1) Private ʿĀyn: owned by their owners and often located within their farms, and no one else has the right to benefit from its water, (2) Jointly owned ʿĀyn: the partners dispose of its water according to the needs of their crops, and managed by av and Ālrāqqāb, (3) Public ʿĀyn: which locates in public land are considered public benefits. (Refaei, 1932) (Figure 6)

The ʿĀyn water was distributed according to a share system (Wğābāt System). Āl-Hāssāb's profession was responsible for calculating water distribution shares among farmers according to their rights and water quantity in the ʿĀyn. Āl-Hāssāb records the water shares in an authorized index called Dfẗār ālʿĀyn (Index of spring record). Āl-Hāssāb records in Dfẗār ālʿĀyn every amendment or deletion in the water distribution system whenever land ownership is transferred from one farmer to another. (Refaei, 1932)

Technically, releasing water during this process Ālrāqqāb or Ālrāqeeb (observer) estimating the time of water distribution process according to each share, which runs from sunrise to sunset and from sunset to sunrise. (Refaei, 1932)



(Figure 7) Indigenous water management system

Geodesign: Creating a sustainable change model:

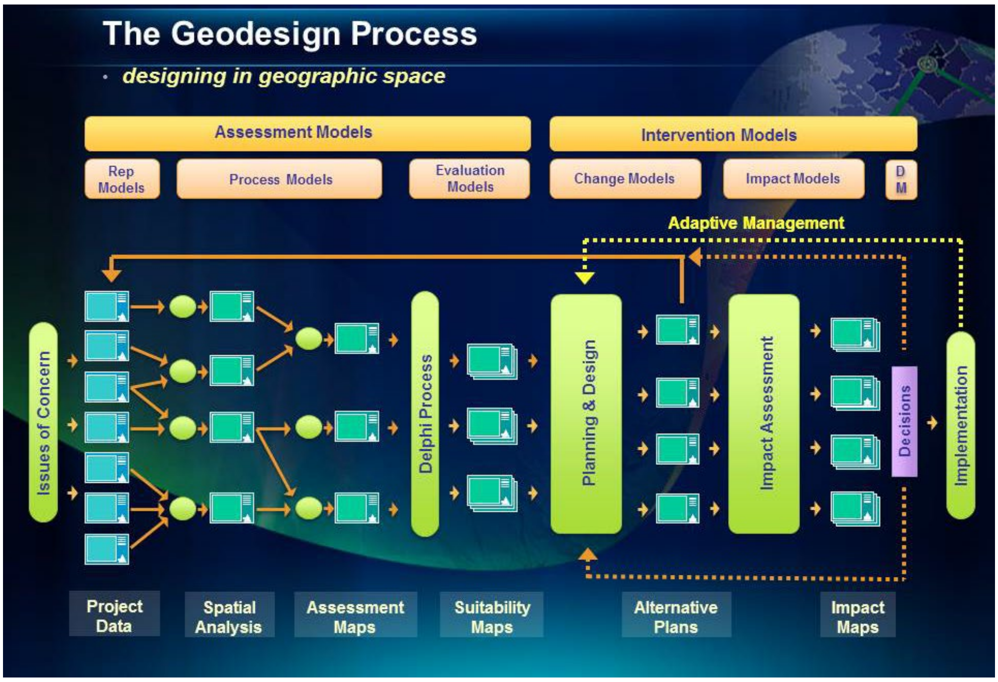
Lack of communication and potential conflict between stakeholders undermines efforts in the Oases. Geodesign presents merits of applying minimal relevant data and natural language when seeking a strategic solution to a complex and relatively unpredictable problem.

Integrating SATREPS to sustainability:

SATREPS endeavours strive to achieve the SDGs to the Oases of the Western Desert Egypt, basically in Dakhla Oasis and Kharga Oasis. Underground water management is essential to farmer community and related agriculture practices. Consequently, endeavors in the Oases aligned specifically to goals 6, 7, 11, 12, 13, and 15. These six SDGs require aligning the efforts and objectives of the stakeholders. (Figure 8)

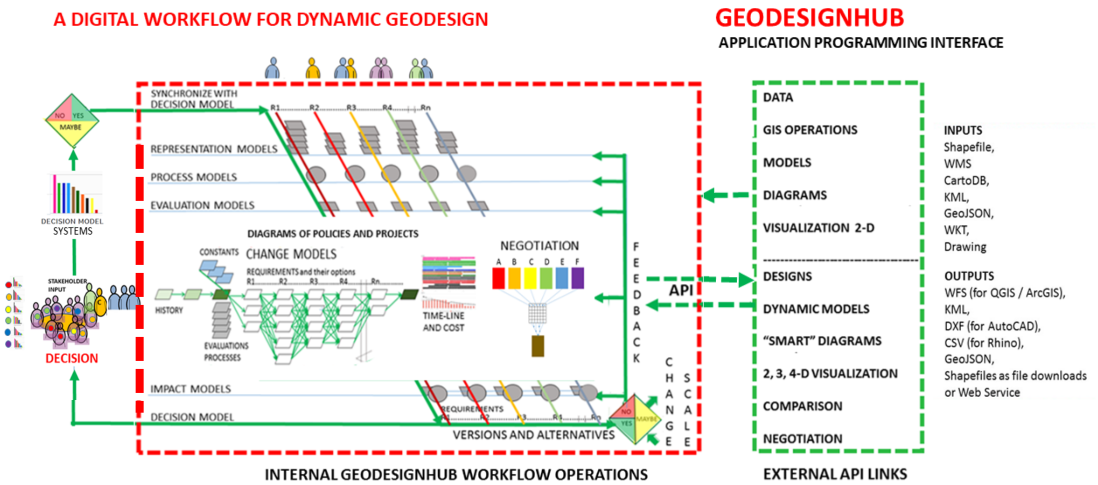
(Figure 8) Relevant Major UN SDGs to the Oases of Egypt

Geodesign conception and workflow: Geodesign is the development and application of designing intended to change the geographical study areas in which they are applied and realized (Steinitz 2012). Geodesign introduces a dynamic framework that enable stakeholders to represent their goals based on negotiation. (Figure 9)



(Figure 9) Geodesign conception and framework (Steinitz 2012)

The framework for Geodesign consists of six questions that are asked (explicitly or implicitly) that have sub-questions that are modified as needed by the Geodesign team. (Figure 10) The answers to those questions are models, and their content and levels of abstraction are particular to the individual case study. Some modelling approaches can be general, but data and model parameters are local to the people, place, and time of the study (Steinitz 2014).



(Figure 10) Geodesign and Geodesign Hub dynamic workflow (Steinitz 2012)

The basic problem of Geodesign can be stated as, "How do we get from the present state if this geographical study area to the best possible future?". In the framework the answer of the question: "How might the study area be altered?" is provided with change models; the ways of designing and achieving the objectives of the Geodesign study

(Steinitz 2012). Every change model goes through four common and hierarchically organized phases, all of which are essential for a successful decision and implementation: vision, strategy, tactics, and actions. Geodesign change models frequently combine “offensive” development-oriented allocation strategies and “defensive” conservation strategies. All change models combine decisions related to allocation, organization, and expression, and all require visualization and communication (Steinitz 2012).

The evaluation system is related to building a reliable change model. Accordingly, the Geodesign evaluation system adopts five categories based on constraints, obligations of stakeholders, and current land use of the study areas, aiming to determine the appropriate intervention. (Soliman 2021) (Figure 11)

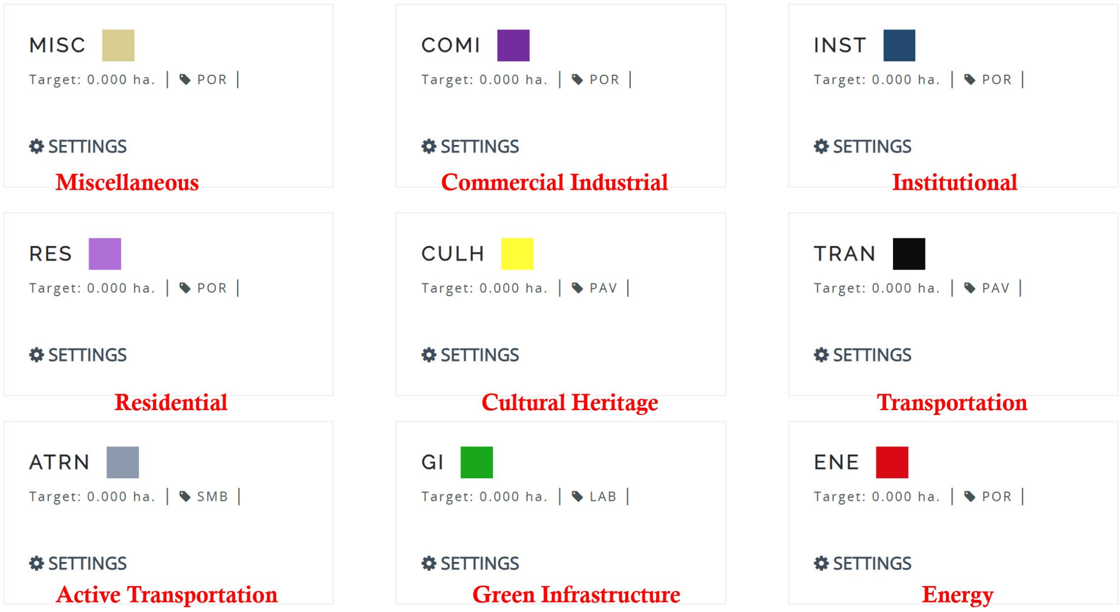
	Existing	Not appropriate	Capable	suitable	Feasible
classification	is where the system is “existing” already and in a healthy state, meaning that it is feasible to remain ….a constraint in terms of information but not a total Constraint.	is lowest priority for change… “not appropriate” or not capable of supporting the system, meaning don’t put it there, e.g. too wet or steep or….unless you provide change to the basic area conditions e.g. fill in the ocean for new land, regrade the mountain, etc.. (all very risky projects). This is also a constraint in terms of information.	is low but higher priority ….”capable”, meaning that you can place it here IF you also provide the technology and market to make it feasible, e.g. water and sewers, access roads for mechanical harvesting, etc., and the market comes…	Is higher priority ….”suitable” , meaning that the area is capable of supporting the project and it already has the Appropriate technologies to support the activity taking place e.g. septic tank soil or sewers, access roads for mechanical harvesting, etc. BUT there may not yet be a market for the change.	is the highest priority for change….“feasible”, meaning that it is suitable AND there is a demand or market to provide the new land use change, e.g. that someone wants to buy the product or new house (and at a profit) OR that the government wants to protect and improve an historical landscape.

(Figure 11) Geodesign evaluation system (Soliman 2021)

Geodesign Hub as a dynamic platform

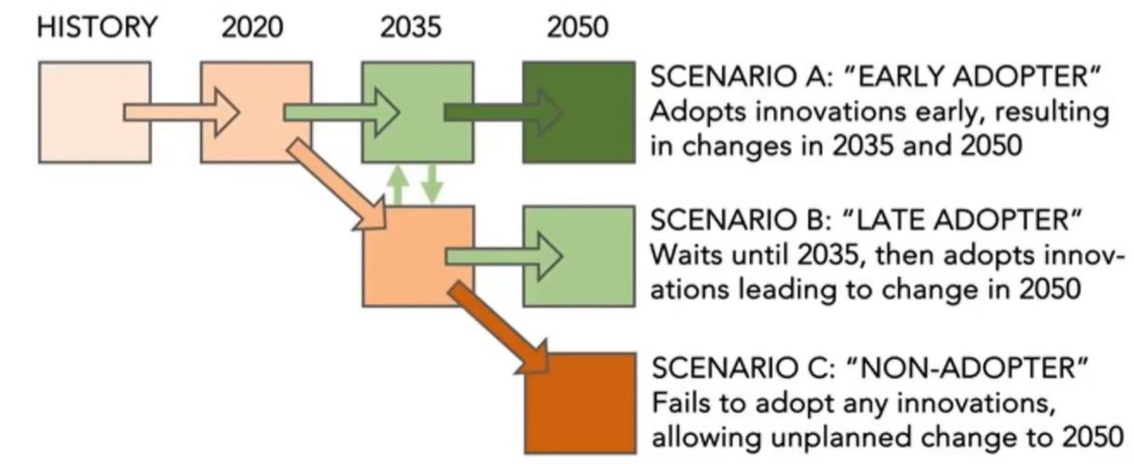
Geodesignhub is a cloud-based, free and open access, open platform software. It is designed to link with other tools and models via APIs rather than to contain complex substantive algorithms itself. Geodesignhub is designed to support collaboration and negotiation towards agreement.

Geodesign organizes targets for change across nine systems, meaning what kind of change anticipated in the coming years needs to be addressed in the design, which are designed according to the typical Geodesign Hub symbology to distinguish targets of the strategy adopted in advance. (Figure 12)



(Figure 12) The GeodesignHub nine domains

Accordingly, these nine systems integrated to generate the final change model of the Oases Geodesign project for achieving the SDGs, while the proposed change model was designed based on concepts of each system to achieve timetabled targets by 2050. (Figure 13)



(Figure 13) Adopted Sustainable strategic scenarios (Steinitz 2012)

Conclusion:

Water management in the Oases of Egypt reflects unique indigenous patterns shaped by local topography and geological structure. Various water system techniques were utilized to optimize resource use, and agricultural assets were classified according to water accessibility. This adaptive approach highlights the importance of further technical investigation into the region’s water heritage and its contextual significance. Learning from these traditional practices can inform sustainable micro-projects tailored to local conditions. Geodesign offers a promising method to integrate and model these insights, including outcomes from SATREPS, into a comprehensive framework for sustainable development and resilient water management in arid environments.

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