

## **Rocks, climate and the survival of human societies in hyper-arid and arid environments – Are the human civilization in deserts at a permanent risk of collapse?**

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The great challenges of living in the arid and hyper arid regions worldwide are the shortage of water, limited resources and the permanent uncertainty of the desert climate. These challenges are known as the main weaknesses of desert societies that are prone, according to the existing paradigm, to a permanent risk of collapse. However, in the Middle East deserts, human societies are known since prehistoric times and during the entire hyper-dry Holocene. This hints that the simple paradigm of desert societies' high vulnerability to harsh desert environments needs to be better examined.

In this context we examine three case studies:

1. The Southern Sinai region in Egypt: In this region, the annual precipitation fluctuates between 20-50 mm/y. However, in this highly mountainous area, desert agriculture plots including orchards were constructed, located mainly around the byzantine monastery of Santa Katerina. During the last 1500 years, much of the water supply needed for humans and agriculture was generated from runoff developed on exposed granite rocks.
2. The southern Jordan region south of Petra: Much of this wide area connecting the deserts of the Arabian Peninsula and southern Jordan receive only 20-30 mm/y. However, the main caravan route established by the Arabian tribes during the first millennia BC managed to cross this land, supplying the water needs of many camels. Most of this water was stored in large cisterns dug into the sandstone rock formations exposed along the route, especially within the Disi Formation.
3. The Negev Highlands of southern Israel: This region is divided between the hyper arid region to the south, receiving 70-80 mm/y, and the arid region to the north receiving 90-130 mm/y. During the last two millennia, the hyper arid area was used for camel grazing and goats herds, while the northern sector was used for the construction of agriculture plots, agriculture farms and even desert towns. All these activities were sustained by runoff harvesting techniques. Water was stored in hundreds of cisterns dug into the soft rock formations.

These three examples hint on:

1. The ability of desert societies to utilize the geodiversity for water supply, even under the harsh hyper-arid regions of the Middle East.
2. Given that the rock-climate relations and the environmental conditions were almost unchanged during the Holocene, the ability of desert societies to access drinking water even in the driest regions depended on their will to learn the conditions and invest human energy.
3. When conditions became extreme, the survival strategy of desert societies was to take advantage of their high mobilization and to move to better locations within the desert environment instead of investing large and costly efforts of constructing more water storage systems at a specific location. That was done only if a permanent enterprise was constructed, like caravan route, monastery or an urban center.

These evidences hint on a very robust structure of desert societies compared to the present common paradigm, provided they are willing to learn and adapt their behavior to changes in the conditions.