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Runoff pathways, disconnected contributing areas and adapted ancient watershed management in the semi-arid Northern Marmarica (NW-Egypt)

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Marmarica was a province of the Roman Empire covering the Northwestern part of modern Egypt up to the Mediterranean coast. Mainly from November to January, the coastal zone in average receives rainfalls of app. 140 mm (station Marsa Matruh). Rainfall totals are becoming less towards South roughly at a rate of 15 mm/10 km. Soils are loamy, stony, calcareous, and shallow except in favourable relief positions where colluvium may accumulate. The land is generally sloping North and rises in a sequence of steps and plains up to a maximum elevation of 230 m asl app. 30 km inland.

A major step separates coastal plains from inland tablelands. Their Northern parts are dissected and drained by wadis that discharge to the sea or to coastal plains. Further South, the linear drainage pattern ceases. Nevertheless, potential catchment areas of the coastal wadis reach app. 20 km inland and may include large parts of undissected tableland. Relief is an important hydrological control factor for agricultural suitability since it redistributes overland flow creating natural runoff (slope $>$ 3 %) and runin areas (coastal and other basins, valleys floors, silt fans, plains). Agriculturally suitable areas only account to a small percentage of the region. A coastal fringe of some 20 km width is inhabited by bedouins mainly breeding sheep and goat, growing barley, figs and olives. Mean population density is less than 10 cap*sqkm-1.

Abandoned ancient rainwater harvesting and watershed management structures (bunds, check dams, terra-ces, conduits) spread all over the region and forming systematic schemes incorporate the experience of former inhabitants with specific hydrologic dynamics. Abundant remains of settlements with pottery from Roman and Byzantinic times give evidence of the fact that the region prospered some 2 millenia

ago. Today, the ancient water management schemes are generally not maintained. Cultivated area was possibly double as large in the past on the modest basis of few percents of cultivated area in total. It is yet unclear when the adapted way of water management was abandoned but an ongoing archeological-geographical project is aiming to answer the question (www.nomadsed.de/projects/en_a7.html).

Probably one of the most outstanding features of the ancient system was a flood protection system for valleys. The remote catchment parts contribute to wadi runoff only in case of intensive and/or long rainfall events which is in accordance with the partial area contributing concept by Ward (1975). Once the tableland overland flow has descended from the plains and has concentrated to channel runoff, the resulting floods can hardly, if at all, be controlled by technical means. In this case heavy wadi floods are generated by the combined effect of large effectively contributing areas, high runoff coefficients and high rainfall totals. Low bunds on the tableland diverted shallow overland flows from the valleys. In many cases terraced fields or gardens (Ďkharms“) on the tableland were irrigated systematically with diverted runoff although soil depths there rarely exceed 40 cm. Thus the remote source catchment areas on the tableland were disconnected preventing the wadis from low frequeny high magnitude runoff events which does not yield much runoff in terms of seasonal runoff coefficients ($<$ 3.3% at three gauged wadis).

In cases of heavy rainfalls, the remaining connected parts of the catchment area (mainly valley slopes) generate sufficient local runoff for the wadis terraces and fields. In case of medium magnitude rainfalls runoff from local source areas still are runoff productive (high frequency, low magnitude), while the remote areas are not or are generating runoff that is redistributed there. Local runoff source areas are in any case more efficient and reliable. Runoff runin area evaluations showed that catchment cropping area ratios from 5 to app. 10 are sufficient to increase local water harvests to sufficient levels under the given rainfall and pedological frame conditions. Terraces grew simultaneously by intended or unintended soil harvesting which was an important process to increase soil depth that is to say available soil water storage capacity.

The above described rationale was as well realized in the valleys where side terraces can be found that were implemented above the wadi bottom level and that could not be irrigated with wadi but only with lateral runoff. The ancient schemes must have evolved over decades or even centuries, as many dry stone structures show that are completely incorporated into well sorted colluvium.

The implementation of the system was realized with minimum intervention and maximum effect. Its interpretation gives substantial indications for the hydrological frame conditions of the region and for an adapted watershed management concept.