Mediterranean semi-arid systems – sensitivity and adaptation

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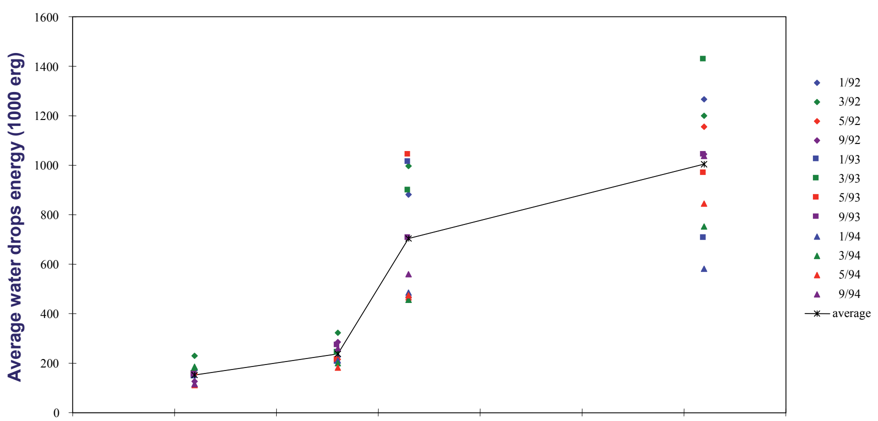
The Semi-arid areas of the Mediterranean are sensitive to climate change as they are located, in many cases, between two different systems, the arid system and the Mediterranean sub-humid system.
A number of "quick response" ecogeomorphological variables were monitored along a climatic transect in Israel, running from west to east, covering an annual rainfall range of 700 – 100mm. The relationships of climatic conditions – available water– soil properties – overland flow – erosion, were investigated. Soil samples were taken from open areas between shrubs and overland flow was monitored in plots of 7, 14 and 21m in length (3m width).
It was found that: (1) high correlation exists between climatic conditions and eco-geomorphic variables (such as organic matter content, aggregate stability and soil moisture) and processes (such as infiltration and overland flow), and (2) the rate of change of these variables along the climatic transect is non-linear; an example, for aggregate stability, is given in figure 1.

Figure 1
Aggregate stability (at 0-2 cm depth)

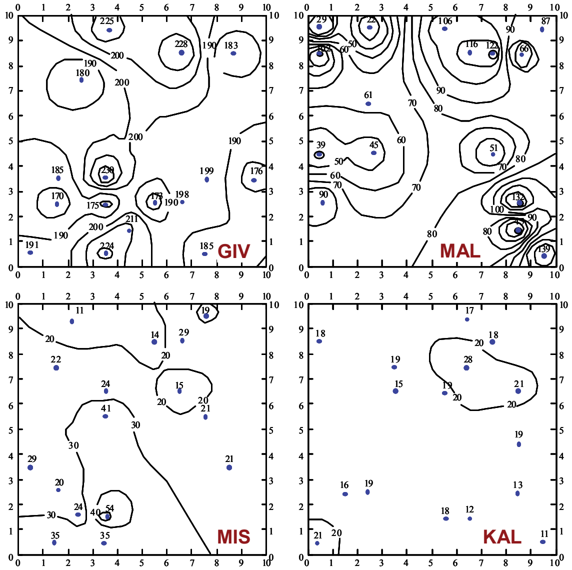


A step-like threshold exists at the semi-arid area, which sharply separates the arid ecogeomorphic system, controlled by abiotic factors, such as soluble salts content and mechanical crust formation, from the Mediterranean sub-humid system, controlled by biotic processes such as microbial activity and organic matter production and decomposition.
This means that even a relatively small climate change is enough to shift the borderline between these two systems. Therefore, many Mediterranean semi-arid areas are sensitive to climate change and are threatened by desertification.
At the same time, a unique spatial distribution of soil properties that was developed in the semi-arid area, as will be described below, enables adaptation of the system to climate variability and change.
It was found that:

(1) Different spatial patterns of soil properties are typical to the different climatic areas along the transect. Figure 2 presents, for example, the typical spatial patterns of aggregate stability at different climatic zones. In the arid zone, sites KAL and MIS, the values (average number of drops needed to destroy an aggregate) are low and uniform all over the area. In the sub-humid Mediterranean zone, site GIV, the values are high and, again, relatively uniform over the area. A patchy pattern is typical to the semi-arid area, site MAL, where patches of high values and patches of low values are located adjacent to each other.

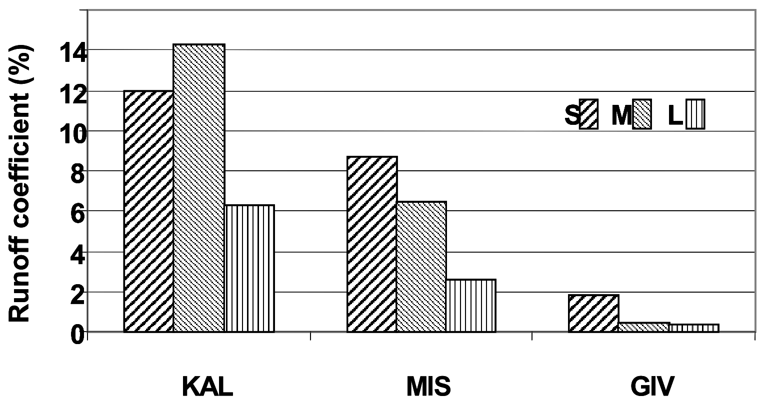
Figure 2

Aggregate stability



(2) The runoff coefficient decreases with increasing hillslope length. This can be seen in figure 3. At the regional scale, runoff coefficient increases with increasing aridity, and at the hillslope scale, runoff coefficient decreases with increasing hillslope length, which means that there were runoff losses along the hillslopes.

Figure 3



A study on the spatial distribution of soil properties and overland flow at the patch (micro-environment) scale was conducted along another climatic transect in Israel, running from north to south, covering a rainfall range of 800 – 90mm.
Soil samples were taken and overland flow was monitored at several micro-environments, including "under shrub" (US) and "open area between shrubs" (BS). Organic matter content, microbial activity and aggregate size (figure 4) at the US were higher than in the BS, leading to higher infiltration rates. Runoff coefficients at the BS were always higher than at the US (Figure 5). The main conclusion is that the US patches function as water accepting areas (sinks), so that at least part of the overland flow from the BS patches that function as water contributing areas (sources) infiltrate under the shrubs. This explains the runoff losses along the hillslopes.

Figure 4

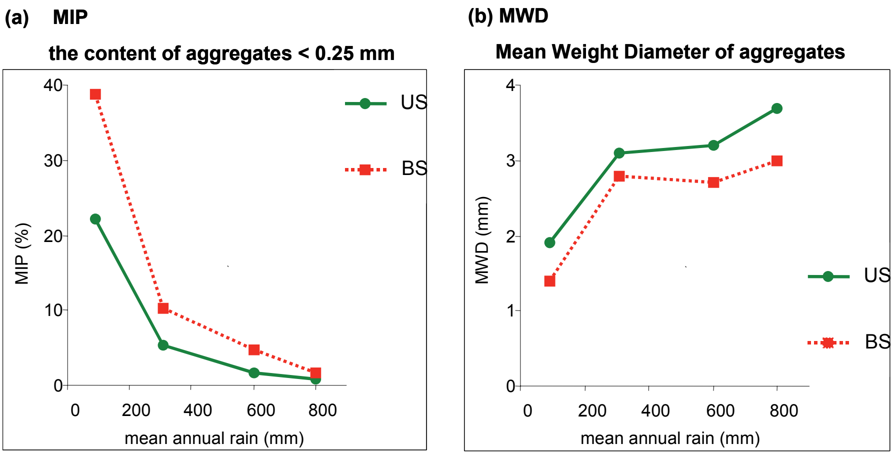
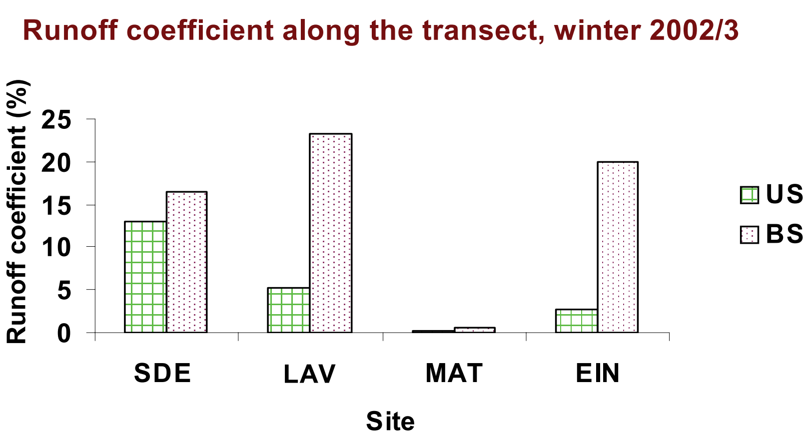
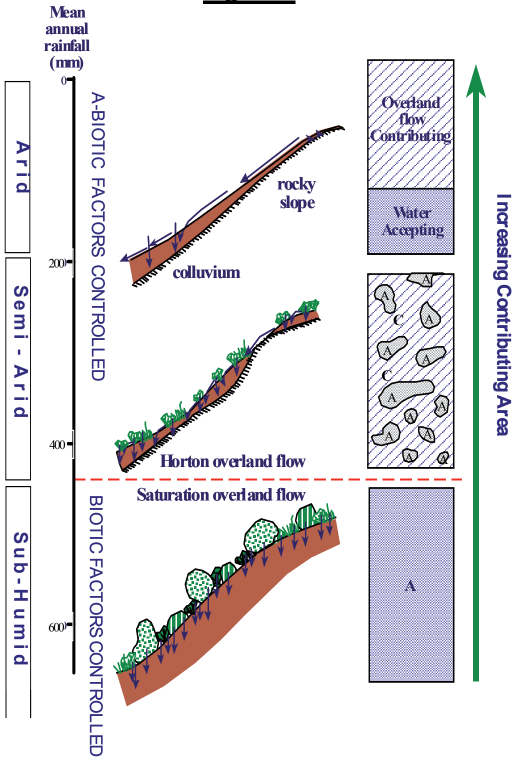


Figure 5



To sum up (figure 6), in the Mediterranean sub-humid area vegetation cover can reach 100 percent, most of the hillslope functions as a sink, infiltration is the dominant process all over the hillslope and saturated overland flow might develop from time to time. In the arid area vegetation cover is very low; most of the hillslope functions as a source and Hortonian overland flow predominate. In contrast to the relatively uniform distribution of processes in these two zones, a mosaic-like pattern, consisting of locally "humid" sink patches (shrubs) and "arid" source patches (bare soil), is typical of the transitional semi-arid area.

Figure 6



The adaptation of the semi-arid system to the high variability of annual rainfall is expressed by the mosaic pattern of soil properties that enables most rainfall to be retained within the hillslope. At the same time the existence of "arid" and "humid" nuclei enables the system to easily adapt itself to new conditions, in a case of climate change.