Land and water management in dry climates, an unresolved dilemma
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Water redistribution at diverse scales
In dry regions, vegetation frequently shows self-organised spatial patterns of patches or bands that optimise water harvesting and plant water use; densely vegetated patches are fed by runoff coming from upslope bare areas, resulting in overall ecosystem productivity higher than the one that could be reached without patterning¹. Traditional farming schemes apply either natural or man-made rain water harvesting settings at the hillslope scale; rocky outcrops or vegetation-cleared upslope sectors provide excess runoff water to small fields or even single fruit trees². Where the spatial scale is wider, however, water use conflicts emerge³. Land and water management in the wet headwaters endanger the availability of water and optimal stream flow levels that are required to maintain aquatic life, irrigation and water supply downstream. The encroachment of irrigated areas for food, fodder or fibre (e.g. rice, alfalfa and cotton, respectively) may cause the deterioration of river deltas (e.g. Ebro) or the desiccation of lakes or inland seas (e.g. Aral Sea⁴). Even ‘soft’ strategies such as local water harvesting schemes may have severe consequences, reducing importantly river flow.

Under a global change perspective, things are even more intricate. In the next decades, rainfall, river flow and water resources are expected to decrease in many (already) dry regions, concurrently tree and scrub species in these areas will adversely face drier climate conditions with increasing mortalities and forest fires.

Catchment management wavering
Densely vegetated or forested mountains have been perceived as their optimal environmental condition by the mankind since ancient times. “Watershed management” has been conceived during many decades following this premise and advocating dense forest cover as the best provider of hydrological ecosystem services, particularly water quantity and quality. However, scientific evidence on the high evapotranspiration rates from forest and scrub cover compared with lighter (e.g. pasture) vegetation cover was acquired mostly during the second half of the 20th century. At present, it is well established that the many environmental advantages of a forest cover in a catchment have the drawback of decreased water yield due to increased evapotranspiration⁵. Indeed, increased evapotranspiration may imply increased precipitation, but this recovery is typically performed at the wide, regional scale, as demonstrated in the Amazonia⁶. As it happens with most scientific paradigm changes, the acceptation, teaching and application of these evidences is still far from satisfactory⁷. Some conservationists argue that the diffusion of this paradigm may incentive generalised deforestation by felling or burning woodlands.

Fortunately, some management advances emerged with the onset of the 21st century. Classical catchment water management was based on the extraction, storage and transfer of water volumes from surface and subsurface origin, whereas the large amounts of water evaporated by terrestrial ecosystems, even if they provided us with goods such as timber or fodder, were called ‘losses’. Since the last century, an innovation in terminology was introduced in order to allow the Integrated Land and Water Resource Management (ILWRM): all the water precipitated in the catchment may be subject to management; the water evaporated by terrestrial ecosystems, pastures and dry crops is named ‘green water’, whereas the water that can be stored and transferred in liquid form is called ‘blue water’⁸. If more blue
water is needed in the catchment, the consumption of green water may be reduced expanding pastures at the expense of woodlands. Yet, the amount of water necessary to obtain diverse goods (timber, fibre, food, fodder, manufactured objects) is called ‘virtual water’, which can be stored, traded and accounted in the catchment water balance. The concept of ‘water footprint’ is also used as synonymous of virtual water to raise citizen’s awareness on the need to avoid misusing water resources.

The integrated catchment management dilemma

The dilemma may be condensed in a short expression: “Integrated watershed management in arid climates has to aim at a certain balance in degradation. Some degradation is necessary to feed aquifers, while too much degradation leads to harmful downstream impacts”9. As it happens when optimizing simulation models with several criteria, the improvement of one of the sought objectives implies the deterioration of someone other. The diverse objectives of the catchment management cause the emergence of conflicts: “Tensions between the many different users – agriculture, forestry, industries, power and mines; urban and rural consumers; amenity, ecology and environmental users – exist in many parts of the world”10. These conflicts must be managed with sound science, equity and public participation.

But in some cases, management activities may have concurring instead of conflicting effects on some ecosystem services. This is the case of woodland masses overgrown on abandoned pasture or agricultural lands in mountain Mediterranean areas where thinning may decrease excessive competition for water between trees, decrease the wild fire hazard and improve aquifer recharge11. This opens up the possibility that these management practices are financed through the payment for ecosystem services (PES).

Nevertheless, our knowledge on key driving hydrological processes is insufficient at the temporal and spatial scales adequate for management. The plethora of models that simulate many of the ecohydrological processes needs a parallel development of field-based hydrological research at diverse scales and environmental conditions, but taking into account that they will provide inevitably uncertain predictions12.

References


