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# Water Scarcity and Droughts in Mediterranean Mountains: Regional Examples from a Global Change Perspective

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In Mediterranean mountains, areas with high frequency and intensity of precipitation can be found side by side withislands oflow precipitation and dry valleys experiencing water scarcity and occasional droughts. Climate change and increasing human pressures are expected to cause an increase in the dryness of these dry islandsin parallel with an increase in the wetness of wet islands. Under these conditions, the spatial expansion of dry islands can also be expected. Thus it is important to be able to identify and evaluate drought and water scarcity variables and tendencies. Water scarcity problems in mountain regions are not unknown. For example, in inner alpine valleys such as the Rhone valley, there was a culture of intense irrigation of alpine pastures until the middle of the last century. The impacts of summer droughts and over- fertilization over the last decades have caused a decline in the quality of pastures and associated hay for milk production, so that agriculture may have to return to irrigation in the future again. The existence of water scarcity and droughts has always remained an important problem in mountain ranges,however there has been little scientific focus on them. With rapid expansion of human settlement and tourism in mountain areas, local water scarcity is emerging in both summer as well as winter tourism hotspots. This is related both to irrigation of golf ranges, artificial snow production over ski runs, and high rates of daily water consumption for spas and hotels, sometimes 6 times higher than the local water consumption. More and more vertical and horizontal interbasinwater transfers are being developed in mountain valleys, both as a reaction to but paradoxically also as an accelerator of water scarcity.

Monitoring and Early Warning Systems for droughts are not well developed. Existing systems work at the national scale, but they are often not of a high enough resolution for local scale or sub-basin issues and totally lacking at higher altitudes. Although laws and regulations exist in the majority of countries for maximum water abstraction from streams and river courses, these oftencannot be controlled due to lack of monitoring. In terms of modeling water scarcity and droughts, the location, characteristics and functions of different units, such as streams, scree surfaces, the presence and absence of snow and differences in evapotranspiration and sublimation have to be determined. More importantly, modeling approaches for including human water use are often lacking.For forecasting water scarcity and droughts in mountains, a multi-disciplinary approach is necessary including hydrology, meteorology, biology, soils and human water usesuch as water storage for hydropower, with reaction times over highly varying time scales. In the frame of Alp-Water-Scarce, an alpine space project on the development of strategies against water scarcity in the Alps, stakeholder questionnaires were carried out to evaluate the perception of water problems. Nearly 70% of the stakeholders mentioned having experienced water scarcity in the past or present, often in combination with natural scarcity of water resources, climate change, or water overconsumption, mostly linked to lacking water management. Where measured data are lacking, conceptual models have to be developed based on stakeholder knowledge. The project was thereforecited by the DG Regional Policy as a good practice example for integration of ICT for sustainable development of natural resources. An increase in summer and winter droughts and water scarcity is to be expected in Mediterranean mountains with relation to global change. Adaptation and mitigation strategies will be required, in particular those focused towards water economy and changes in human behavior geared at the long-term.