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Sustainability assessment of agriculture water use under water scarcity limitation and climate change adaptation

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Irrigation accounts for about 70% of the global freshwater withdrawals and 90% of consumptive water uses. With 40% of irrigation water consumption occurring in water scarce areas, there is a need to understand to what extent freshwater can be sustainably used in agriculture without compromising environmental flows or depleting groundwater stocks. To date, methods that can be used to evaluate the vulnerability of the water system to climate change and the sustainability of water use for irrigation often fail to provide an integrated analysis of the biophysical and economic dimensions of water use. Here we develop a new approach to evaluate the sustainability of water use in agriculture in conditions of water scarcity. We propose a framework that accounts for both socio-economic and environmental aspects of water sustainability based on three criteria expressing the reliability, resilience, and vulnerability of irrigation. Reliability is calculated as the probability that the system is able to meet irrigation need (i.e. irrigation water demand does not exceed water availability). Resilience expresses the system's ability to adapt to a changing condition and recover from a shock (i.e. a drought or conditions of water stress). Vulnerability is the magnitude (or 'severity') of the water deficit (i.e. insufficient irrigation water availability) the system is exposed to. Similar metrics are used to characterize the economic sustainability of irrigation. The evaluation of performance is based on the frequency of a deficit situation on each dimension of sustainability. The criteria of performance are aggregated into sub-indicators for each dimension of sustainability. The application of this framework to the case of Australian agriculture for the 2002-2016 period shows that Australia suffers from a high level of water scarcity, especially during the growing season. The analysis of the framework highlights the sustainability and unsustainability of the Australian water use system both in space and time. This analysis informs new criteria for managing a sustainable use of water resources, which is becoming challenging for stakeholders. Farmers need to adopt water management approaches that allow for a sustainable water use for irrigation and overcome water scarcity constraints.