Size and stochasticity in irrigated socio-hydrological systems

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Here we present a systematic study of the relation between the size of socio-hydrological systems and stochastic forcing. In particular, through a stylized theoretical model, we focus on how stochasticity in water availability and taxation interacts with the stochastic behavior of the population within irrigated socio-hydrological systems. Our results indicate the existence of two key population levels for the sustainability of such systems: (i) the critical population size required to keep the system operative--with a smaller population size, the system may self-organize toward a collapse; and (ii) the population threshold at which the incentive to work inside the system equals the incentive to work elsewhere—the system will self-organize toward this level, despite sub-optimal per capita payoff to its population. When subjected to strong stochasticity in water availability or taxation, the system may suffer sharp population drops and irreversibly disintegrate into a system collapse, via a mechanism we dub ‘collapse trap.’ Our theoretical study establishes the basis for further work aiming at understanding the dynamics between size and stochasticity in irrigated systems, which is key for devising mitigation and adaptation measures to ensure their sustainability in the face of increasing and inevitable uncertainty.

Keywords: Coupled natural-human systems, Stochasticity, Agriculture, Regime shift

