

Managing invasive species in a complex social-ecological systems: A system dynamics based insight-building tool for the Banni grasslands, India

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In complex social-ecological systems, ecological changes caused by invasive species can also have unexpected socioeconomic and cultural consequences. Decisions on management of the invasive species must, therefore, take into account its varied impacts and the way in which it is perceived by the multiple stakeholders involved. The Banni, once India's largest sub-tropical grassland, is such a social-ecological system. Banni, in western India, lies adjacent to the Rann of Kutch, a large salt desert. It has historically been home to traditional pastoralist communities, the *Maldharis*. In the 1960s, *Prosopis juliflora* (hereafter, *Prosopis*), a species native to the Americas, was introduced to Banni, ostensibly to check the ingress of the salt desert. *Prosopis* has now spread across more than half the Banni, replacing grasslands, reducing fodder availability, and harming the milk economy for Banni's pastoralists. In response, Banni's resident communities have developed a parallel wood-charcoal economy based on *Prosopis*. The growth of the charcoal economy has led to unforeseen consequences, including—and paradoxically—the intensification of milk production.

We have developed a system dynamics model of the Banni, which brings together the inter-linked biophysical and socioeconomic components of the system (e.g., *Prosopis* and grassland area, livestock, biomass for charcoal, livelihoods, and rainfall). The model was developed through a participatory process. Workshops were conducted to elicit information, trends, stories, model structures, and mental models from the *Maldharis* of Banni as well as from researchers. The model is intended to serve as a learning tool that can help people gain insights (rather than forecasts) regarding alternative future scenarios for Banni. The model simulates the overall behaviour of the system, from 2018-2030. We used this model as the basis for a user-friendly 'insight-builder' tool. This tool—an Android App with pictures and interactive graphics—provides a way for stakeholders to explore the implications of potential management scenarios under different 'What-if' conditions, such as different management regimes of *Prosopis*, and climate extremes (like recurrent droughts). It gives the user the option to choose scenario parameters to simulate outcomes. The App could have greater outreach as compared to the system dynamics model. Through the App we aim to engage with stakeholders to envision possible future scenarios for Banni and build consensus on the decisions that could lead to management that is consistent with the priorities of Banni's communities as well as official land managers.

The Android App, **Banni in a Time of Change**, can be accessed on Google Play Store at the following link: <https://play.google.com/store/apps/details?id=org.atree.banni> (or by doing a search on "Banni in a time of change" on Google Play).