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Dynamic optimization for sustainable management of salt lake basin´s water-food-energy-carbon nexus.

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The mitigation of the consequences of extreme environmental events, such as floods and droughts, has been addressed as an optimal control problem of an agroecological system [1]. The rational use of water resources in a productive agriculture and livestock system located in a semi-arid region and the preservation of a valuable fish species in a salt lake have been considered [2]. In the present work, an extension of the optimization model is proposed for the sustainable management of ecohydrological processes, agriculture and livestock of a salt lake and its basin. Five objectives are set out: a) to prevent flooding of a nearby village and its touristic areas during a wet period by diverting part of the flow from a Chasicó Lake tributary into an artificial reservoir (the diversion flowrate is a control variable); b) to optimize management of the artificial reservoir to keep the salinity in the lake within desired levels for silverside fish during drought periods; c) to include restoration strategies for native species that comprise a xerophilic woodland currently existing in the salt lake basin, combining new plantations of *Prosopis flexuosa* and *P. caldenia* with drought resistant crops (*Chenopodium quinoa*) and pasture (*Eragrostis curvula*), irrigated with freshwater taken from the proposed artificial reservoir and d) to provide drinking water and shade to cattle. The outlet fresh water flowrate of the artificial reservoir is a control variable for the latter three objectives. A last objective has been added: e) to minimize possible impact of greenhouse gases (GHG) emissions by adding balance equations of carbon equivalents for sustainable production of food and raw materials for the agribusiness. Numerical results show that if water is accumulated in an artificial reservoir during wet periods (six-year period, with average annual precipitations of 650 mm), a subsequent ten-year drought period (average annual precipitations 250 mm) can be overcome, while maintaining the salinity level of Chasicó Lake required for the conservation of silverside fishing. In this way, during the dry period, quinoa and pasture can be sown and *Prosopis species* can provide shade and fodder for cattle, and long-term ecosystem benefits. The proposed agroecological system can produce 22.5 $tn.yr^{-1}$ of meat, 2.5 $tn.yr^{-1}.ha^{-1}$ of quinoa, which would represent a profit of U$S150,000 and U$S 2,000,000 yr^{-1}, respectively. Regarding carbon sequestration by pastures (*E. curvula*) and wood of *Prosopis species* (Caldén and Algarrobo), it can be noted that *E.curvula* carbon capture is two orders of magnitude lower, as it is pasture for cattle. The resulting agroecological system would support 100 cows emitting methane for 32 months on 300 ha, offsetting the production of GHG with planted crops, pastures and trees. The model has proven to be an efficient tool for the sustainable management of the water-food-energy-carbon nexus of the Chasico Lake and its basin. It can be demonstrated that the consequences of droughts can be effectively mitigated while improving economic incomes in a semi-arid region, preserving the valuable fish population, allowing high value-added farming (quinoa), pastures and even raising livestock in dry periods, with the addition of conservation and long-term production of high commercial value timber (such as, Caldén and Algarrobo).

References

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