

## Appendix A: Sensitivity Analysis

I conducted a local sensitivity analysis to determine the effect of small changes in ten parameters (P) on system-level outcomes in the model (Railsback and Grimm 2012). I varied each of these 10 parameters by  $\pm 5\%$  (dP), then examined how those variations impacted the values of 8 system-level currencies (C) at the end of each model run<sup>1</sup>. Each model run was initialized in 1978 and then incremented yearly before ending in 2015, for a total of 37 time-steps per run. For example, I ran 50 simulations for each of the following income tax rates: 9.5% (P – dP), 10.0% (P), and 10.5% (P + dP), recorded the final values for system-currencies at the end of each simulation, and then averaged those currencies over the 50 runs. I then calculated the Sensitivity (S-, S+) for each parameter using the following formulas:

$$S- = \frac{(C)/(C-)}{(dP)/(P)} \quad \text{and} \quad S+ = \frac{(C+)/(C)}{(dP)/(P)}$$

**Equation A1:** Calculating the sensitivity of a parameter

In the equation above, the variable C+ describes the value of a system-level currency from a model run with a parameter (P + dP), while the variable C- describes value of a system-level currency from a model run with a parameter (P – dP). Differences in Sensitivity (S-, S+) for the nine parameters were relatively small in most cases, suggesting that the model's system-level outcomes are not much more sensitive to one parameter than to another. The one parameter with a relatively strong impact on system-level outcomes was annual maintenance costs: when annual maintenance costs were decreased by 5% per year (S-), the average wealth of households increased dramatically. This suggests that the wealth of households in the model is sensitive to small changes in annual cost-of-living expenses. The full sensitivity results are shown in Table A1, below.

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<sup>1</sup> These currencies included the following: total number of households in the study area, total number of canals, total number of rice fields, mean wealth per household, mean number of wives per household, mean number of family members per household, mean household head age, and mean expected income in the upcoming year.

**Table A1:** Local Sensitivity Analysis

Parameters	Reference Values		Quality of Knowledge	Source of Knowledge	Averaged Sensitivity of 8 System Currencies	
	P	dP			S-	S+
1. Marriage cost	600,000	30,000	4	Field surveys	19.57	19.52
2. Income tax rate	0.10	0.005	5	Acreman et al 2004: 65; Field surveys	21.90	19.17
3. Field cost	300,000	15,000	4	Field surveys	19.97	20.16
4. Canal cost	510,000	25,500	4	Field surveys	19.94	20.05
5. Canal ownership threshold	2,000,000	100,000	3	Drijver et al 1995: 38	19.94	20.12
6. Average fishing payoff	461,000	23,050	4	Field surveys	19.96	19.43
7. Average canal payoff	571,780	28,589	4	Field surveys	19.78	19.93
8. Average field payoff	153,516	7,676	4	Field surveys	19.61	19.40
9. Annual maintenance costs per person	140,000*	7,000*	5	Moritz 2003: 85; Field surveys	27.16	21.67
10. Wife annual childbearing probability	0.256	0.013	4	Field surveys	22.30	21.24

\* The numbers listed are annual maintenance costs for adults aged 12-59. Children, infants, and the elderly have lower annual maintenance costs which also changed by  $\pm 5\%$  for sensitivity testing.

## References

- Acreman, M., Ali, M., Bauer, H., Braund, R., Evans, S. Y., Emerton, L., ... Scholte, P. (2004). *The return of the water: restoring the Waza Logone floodplain in Cameroon*. (P. Loth, Ed.) (1st ed.). Gland, Switzerland and Cambridge, UK: IUCN: The World Conservation Union.
- Drijver, C. A., van Wetten, J. C. J., & de Groot, W. T. (1995). Working with Nature: Local Fishery Management on the Logone Floodplain in Chad and Cameroon. In *Local Resource Management in Africa* (pp. 29–46). Chirchester, NY: John Wiley & Sons.
- Moritz, M. (2003). *Commoditization and the Pursuit of Piety: The Transformation of an African Pastoral System* (Doctoral dissertation). University of California, Los Angeles. Retrieved from <http://www.mandaras.info/PublicationsForDownloading.html>.
- Railsback, S. F., & Grimm, V. (2015). Sensitivity, Uncertainty, and Robustness Analysis. In *Agent-Based and Individual-Based Modeling: A Practical Introduction* (pp. 291–307). Princeton, NJ: Princeton University Press.