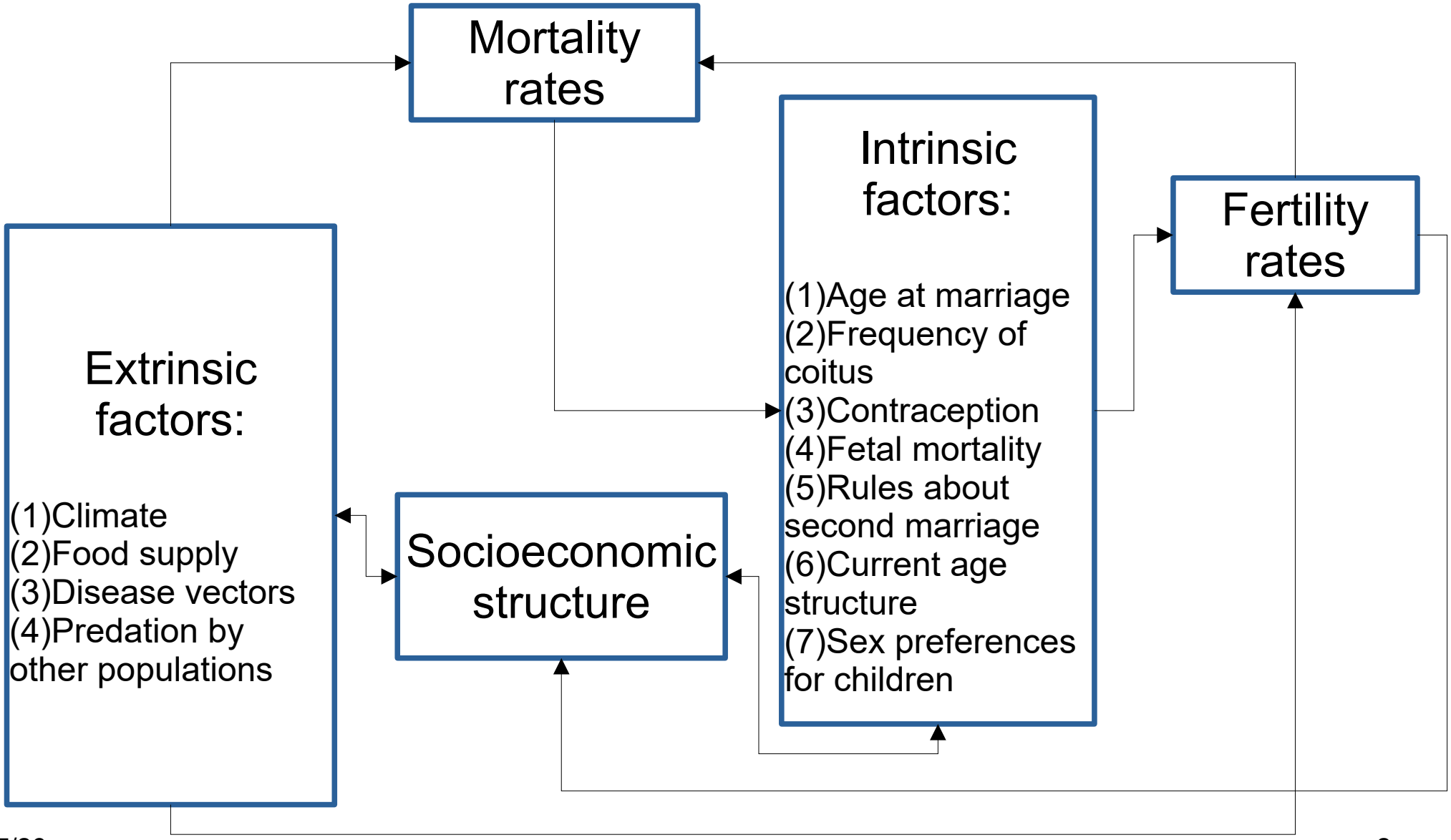
Integrated model of human-environment

- Submodels to consider
  - Demography model: fertility, mortality, migration, ...
  - Subsistence model: food production, transportation, foraging with energy expenditure, ...
  - Natural resource model: biomass of wildlife, species diversity, physical environment such as air and water, …
  - …
- Integration of those submodels as computer simulation program
- Difficulty of programming and long computation time
  → Those may be solved by using generative AI.
- Examples
  - NUÑOA in Peru (Brooke Thomas, Weinstein DA et al.)
  - Oriomo in Papua New Guinea (Ohtsuka R et al.) [Only submodels]
  - Tasimboko in Solomon Islands (Nakazawa M et al.) [Only submodels]
- Wood JW (2020) The Biodemography of Subsistence Farming: Population, Food and Family. Cambridge Univ. Press, https://doi.org/10.1017/9781139519700
- Direct measurement of experimental human survival within closed ecosystem enables to construct integrated model (but the population size is too small): Biosphere II
  - https://biosphere2.org/
  - https://ecotechnics.edu/wp-content/uploads/2011/08/Bioscience-1993-using-a-closed-system-to-study-the-Earth.pdf

Complex interactions in demography

(Source: Moran EF “Human Adaptability 3rd Ed., 2008, modified)



Models for energy expenditure and production, subsistence

- Kakraliya SK, Jat HS, Singh I, Gora MK, Kakraliya M, Bijarniya D, Sharma PC, Jat ML. Energy and economic efficiency of climate-smart agriculture practices in a rice-wheat cropping system of India. Sci Rep. 2022 May 24;12(1):8731. https://doi.org/10.1038/s41598-022-12686-4
- Authier R, Pillot B, Guimbretière G, Corral-Broto P, Gervet C. Towards sustainable land management in small islands: A Water-Energy-Food nexus approach. PLoS One. 2024 Nov 19;19(11):e0310632. https://doi.org/10.1371/journal.pone.0310632
- Tello, E., Sacristán, V., Olarieta, J.R. et al. Assessing the energy trap of industrial agriculture in North America and Europe: 82 balances from 1830 to 2012. Agron. Sustain. Dev. 43, 75 (2023). https://doi.org/10.1007/s13593-023-00925-5
- (cf.) As macro model, see FABIO https://fineprint.resource-use.global/wp-content/uploads/2019/01/fineprint_brief_no_3.pdf

How to integrate?

- How to match the time frame?
  - Demography can evaluate a single year vital statistics, but unstable (or unreliable) in small scale population
    - Completed parity or cohort fertility or genealogical analysis targets more than decades
  - Subsistence model for energy input-output basically considers each year
- How is the interaction between demographic variables and subsistence model's energy input/output and its stability
- Scarcity of long-term fully observation, sometimes done as ethnography, which lacks air/water quality data

NUÑOA

- https://doi.org/10.1002/ajhb.70059
- https://www.osti.gov/servlets/purl/7086450/
- https://www.jstor.org/stable/4602695
- A human ecosystem model, NUÑOA, simulates the yearly energy balance of individuals, families, and extended families in a hypothetical farming and herding community of Quechua Indians in the high Andes.
- The yearly energy demand of each family, based on the caloric requirements of its members, is computed by simulation of agricultural and herding activities in response to stochastic environmental conditions.
- The family energy balance is used in determining births, deaths, marriages, and resource sharing. The model user has the opportunity to investigate the effect of changes in marriage patterns, resource sharing patterns, or subsistence activities on the ability of the human population to survive in the harsh Andean environment.
- Results from the model suggest that the substructuring of a population into extended families provides a mechanism ,for sheltering the population from control by exogenous influences. A population without substructures for resource sharing is shown to be unstable in such an unpredictable environment.

Oriomo Papuans

- RYUTARO OHTSUKA (1994) Genealogical-Demographic Analysis of the Long-term Adaptation of a Human Population: Methodological Implications, *Anthropological Science*, 102(1): 49-57 https://doi.org/10.1537/ase.102.49
- Ryutaro Ohtsuka, Tsukasa Inaoka, Masahiro Umezaki, Nanako Nakada, Taku Abe (1995) Long-term subsistence adaptation to the diversified Papua New Guinea environment: Human ecological assessments and prospects, Global Environmental Change, 5(4): 347-353 https://doi.org/10.1016/0959-3780(95)00069-Z
- Nakazawa M, Ohtsuka R. Analysis of completed parity using microsimulation modeling. Math Popul Stud. 1997;6(3):173-86. https://doi.org/10.1080/08898489709525431
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Tasimboko

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