Animal Life Cycle Submodule on Ruminant Farms Systems (RuFaS) Model: a Sensitivity Analysis to Evaluate Heifer Reproductive Protocols

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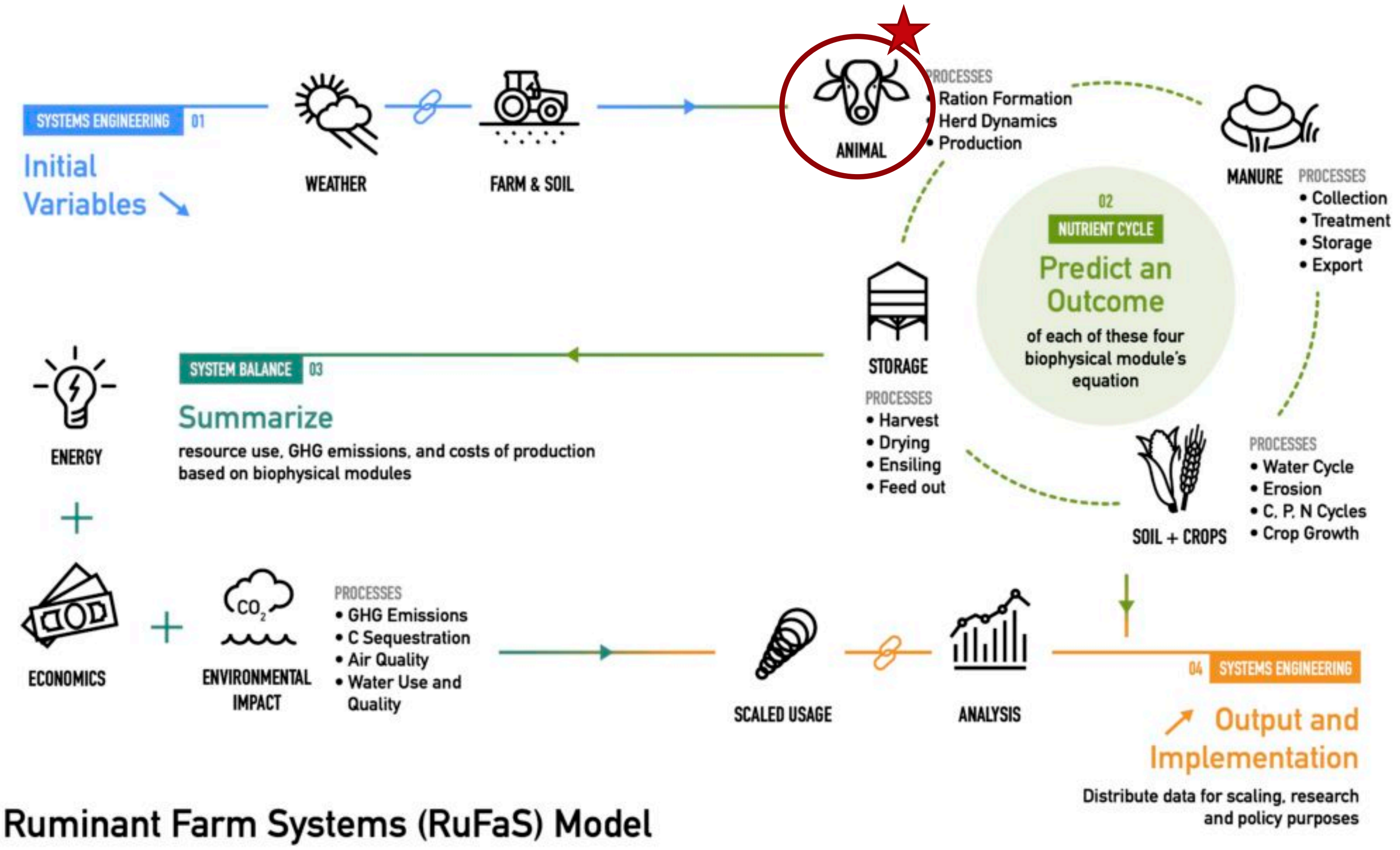
Objective

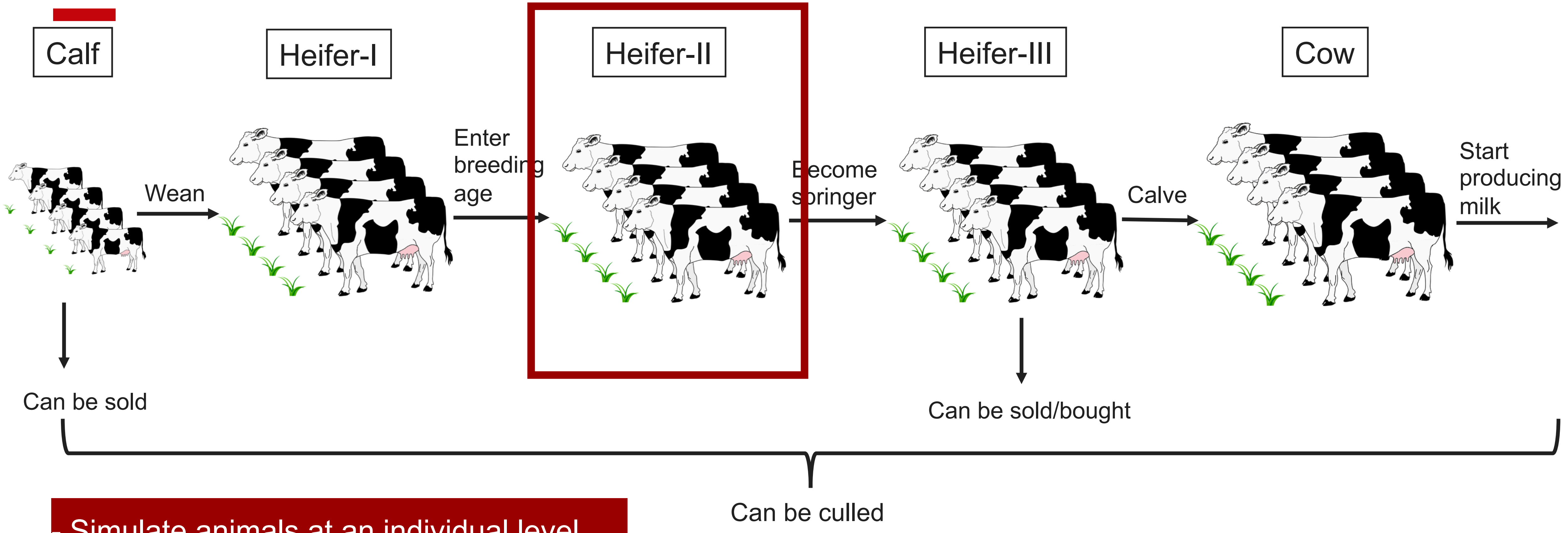
- Identify the most influential factors affecting heifer reproduction performance when the herd is managed through:
    - Pure estrus detection (ED)
    - Timed AI (TAI)
    - Synch-ED

Ruminant Farms Systems (RuFaS) Model



(Hansen et al., 2021)

Animal Life Cycle Submodule

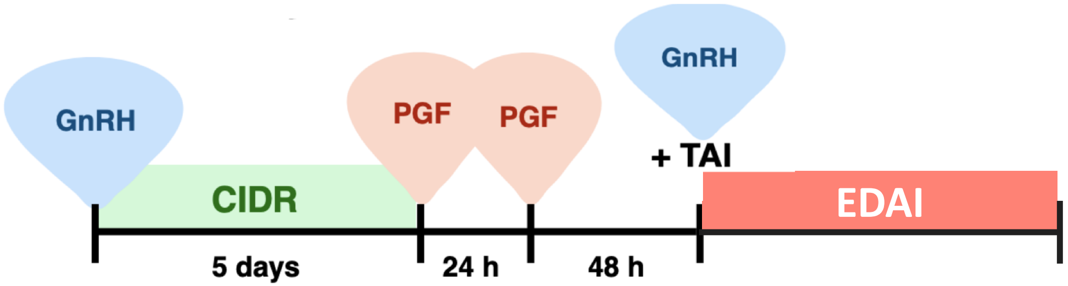


- Simulate animals at an individual level
- Monte Carlo methods

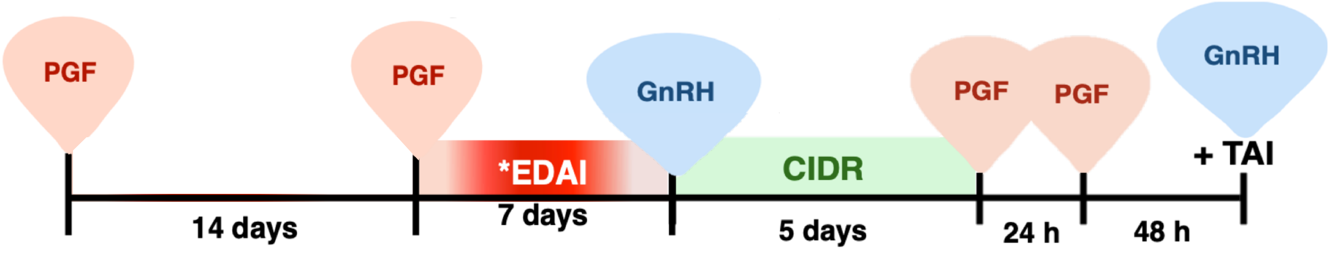
Heifer Reproductive Protocols

- Pure estrus detection (ED)

- Timed AI (TAI)
  - First breeding:
    - 5-d CIDR-Synch with GnRH and 2 PGF
  - Consequent breedings
    - EDAI



- Synch-ED
  - First breeding:
    - Two PGF followed by ED
  - Consequent breedings
    - TAI



(DCRC, 2018)

Sensitivity Analysis

- To quantify how much of the model variance each input parameter is responsible for
  - If a parameter has **large sensitivity index**, a change in this parameter can lead to a **large change in the model output**

More influential

Some of Sensitivity Analysis Methods

- Local: one-at-a-time (OAT)
- Global
  - Sampling-based methods (based on the analysis of linear models)
    - Morris method
    - Supersaturated design
    - Fractional factorial design
    - Latin Hypercube Sample
    - Uniform design
  - Variance-based method (for non-linear and non-monotonic model)
    - Sobol method
    - Fourier Amplitude Sensitivity Test (FAST)

(Bertrand Iooss and Paul Lematre, 2014; An Van Schepdael, and Aur elie Carlier and Liesbet Geris, 2016; Jing Yang, 2011)

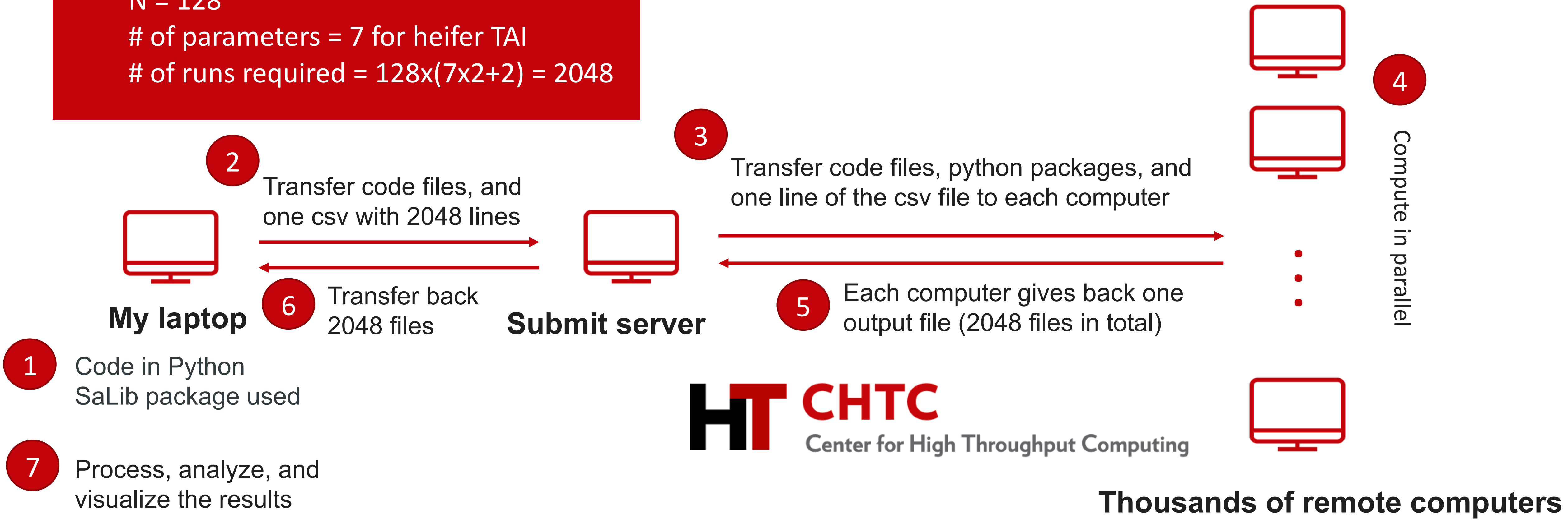
Sobol Method

- Global sensitivity analysis
  - Values of all input parameters are sampled quasi-randomly within a pre-defined range
- Variance-based
- Allow the effects of interactions between parameters
- Computational requirement is high
  - N x (# of parameters x 2 + 2)

For example:
N = 128
# of parameters = 7 for heifer TAI
# of runs required = 128x(7x2+2) = 2048

Analytic Framework

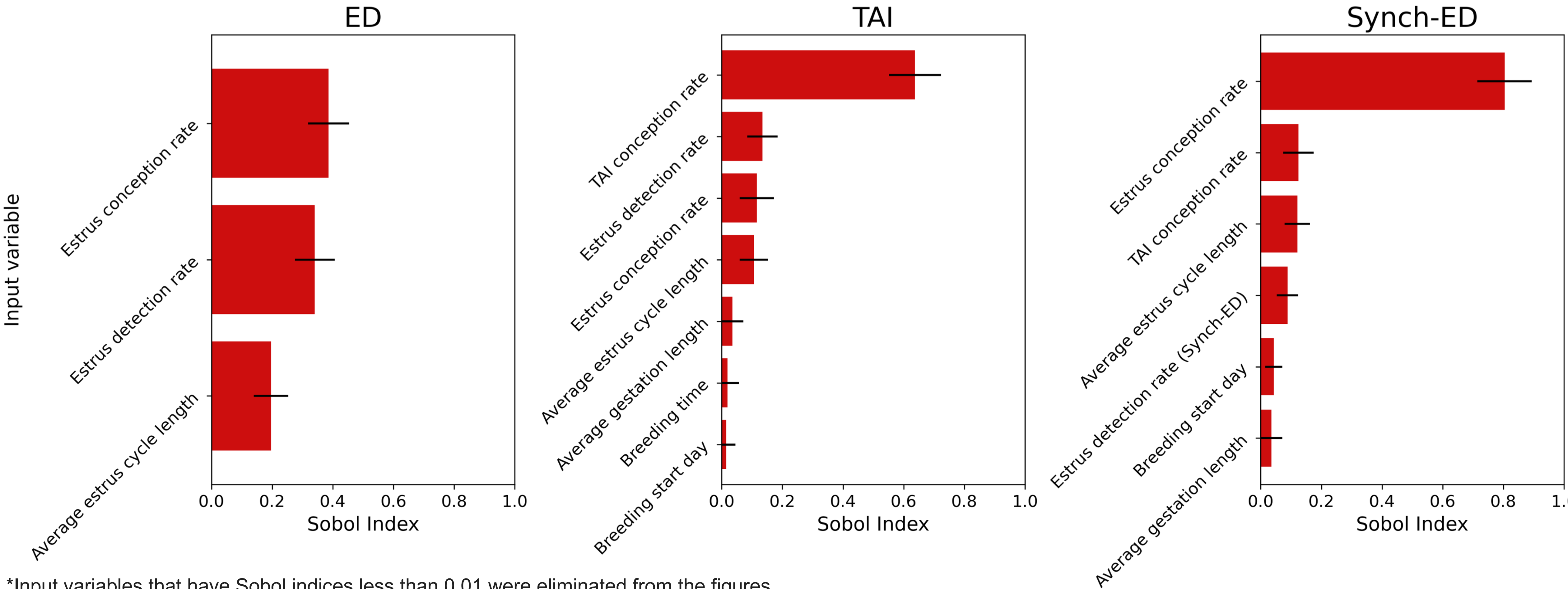
For example:
N = 128
# of parameters = 7 for heifer TAI
# of runs required = 128x(7x2+2) = 2048



Input Parameter Interval

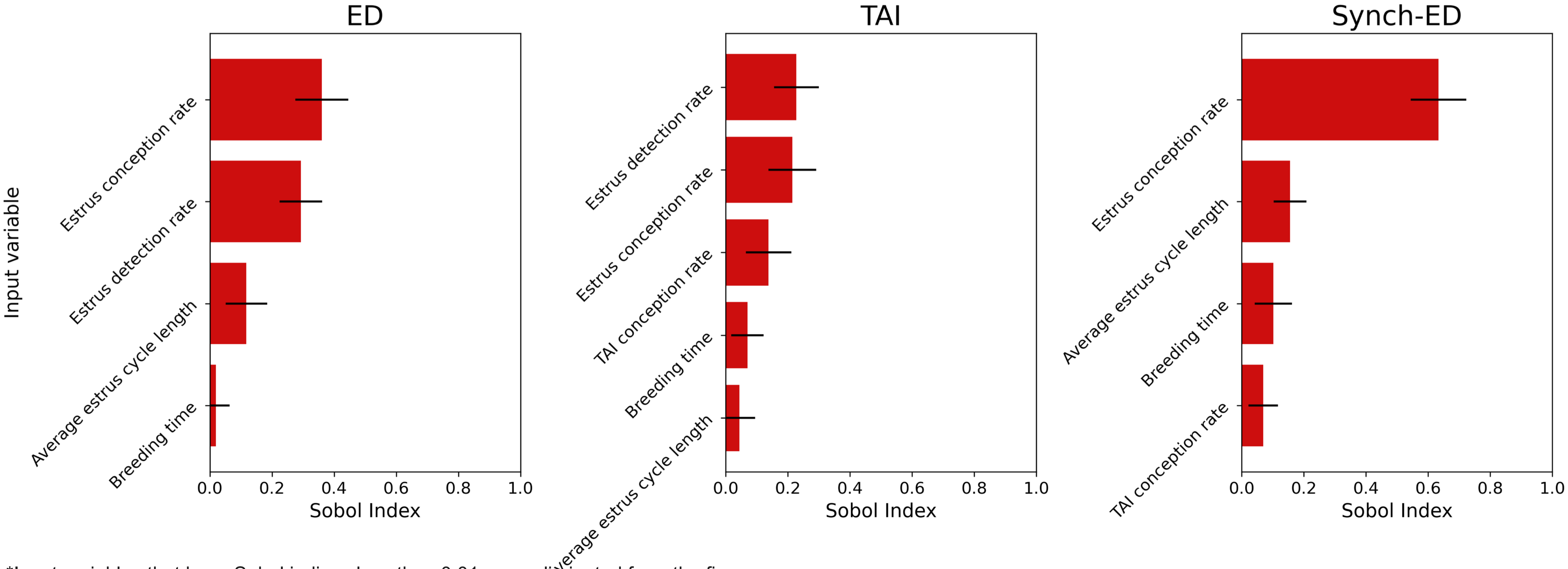
Input variables	ED	TAI	Synch-ED
Breeding start day (d)		(342, 418)	
Breeding time (d)		(126, 154)	
TAI conception rate (%)	NA	(48, 72)	(48, 72)
Estrus detection rate (%)	(48, 72)	(48, 72)	(56, 84)
Estrus conception rate (%)		(48, 72)	
Average estrus cycle length (d)		(18, 24)	
Average gestation length (d)		(272, 284)	

Results: Heifer Pregnant Rate



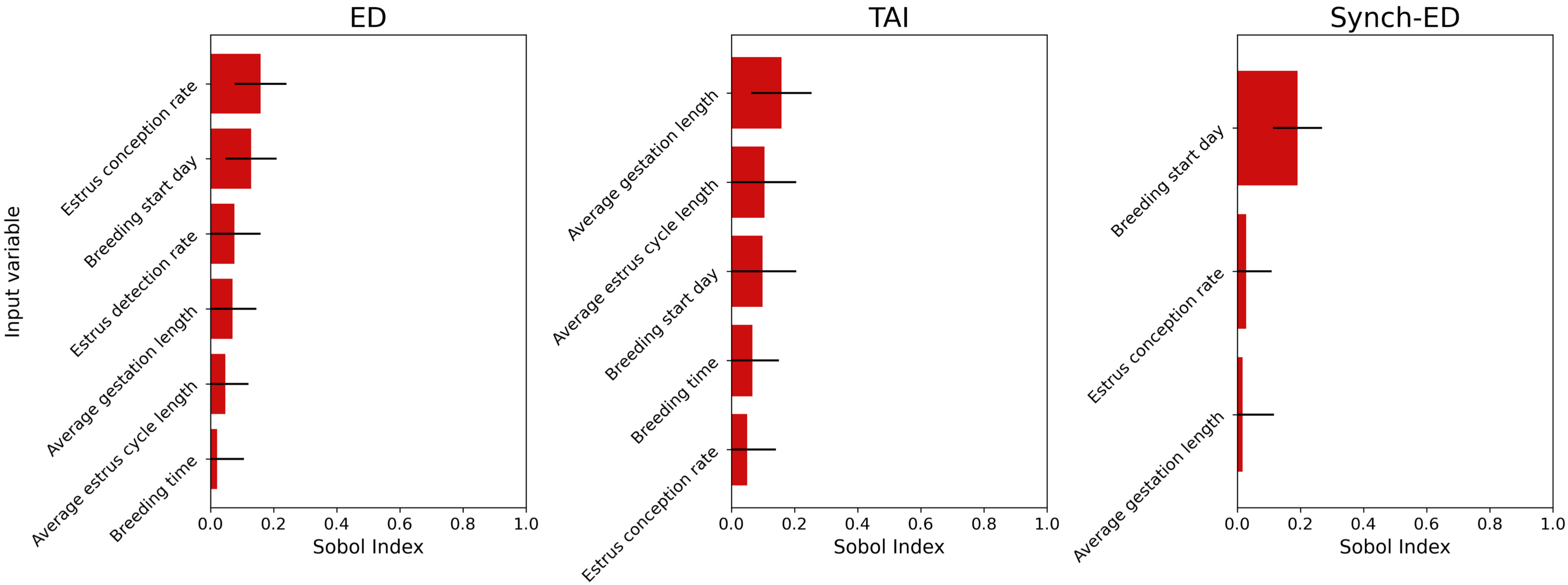
*Input variables that have Sobol indices less than 0.01 were eliminated from the figures

Results: Culled Heifer Last Year



*Input variables that have Sobol indices less than 0.01 were eliminated from the figures

Results: Net Return



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Take-home Messages

- ED
  - Estrus conception rate and estrus detection rate are similarly important to both pregnant rate and the number of culled heifer last year.
- TAI
  - TAI conception rate is the most influential factor to pregnant rate.
  - Estrus conception rate and estrus detection rate are the top two influential factors to the number of culled heifer last year.
- Synch-ED
  - Estrus conception rate is the dominant factor to pregnant rate and the number of culled heifer last year.
- Breeding start day, Estrus related variables, gestation length and are important factors to net return.

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