“DON'T PUT ALL YOUR EGGS IN ONE BASKET”

modelling cropping strategies and climate change in the Indus Civilisation

Andreas **Angourakis**, Jennifer **Bates**, Jean-Phillipe **Baudouin**,
Alena **Giesche**, Joanna **Walker**, M. Cemre **Ustunkaya**, Nathan **Wright**,
Ravindra N. **Singh** and Cameron A. **Petrie**

available at https://andros-spica.github.io/CAA-Angourakis-et-al-2019/
https://andros-spica.github.io/CAA-Angourakis-et-al-2019/index.html?print-pdf (printable version)

McDonald Institute for Archaeological Research
UNIVERSITY OF CAMBRIDGE
Two Trains
erc European Research Council
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BROWN

1. 'THOU SHALT BE ...

Image source (CC0 Public Domain), via Maxpixel.net

1. 'THOU SHALT BE ... DIVERSE'

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TOP DEFINITION

all of your eggs in one basket

Having all of your resources in one place; putting your money or hopes or future into one thing.

'Eggs' are **delicate**, and if all of your eggs were in one **container**, and that container was **damaged**, you might lose all of your eggs in one quick and painful moment.

*1) You don't want to keep all of your eggs in one **basket**. You might lose everything!*

*2) Tom had all of his eggs in one basket -- Yoyodyne.com stock -- and when the **stock market** crashed he was **bankrupt**.*

by VAKI5 May 10, 2005

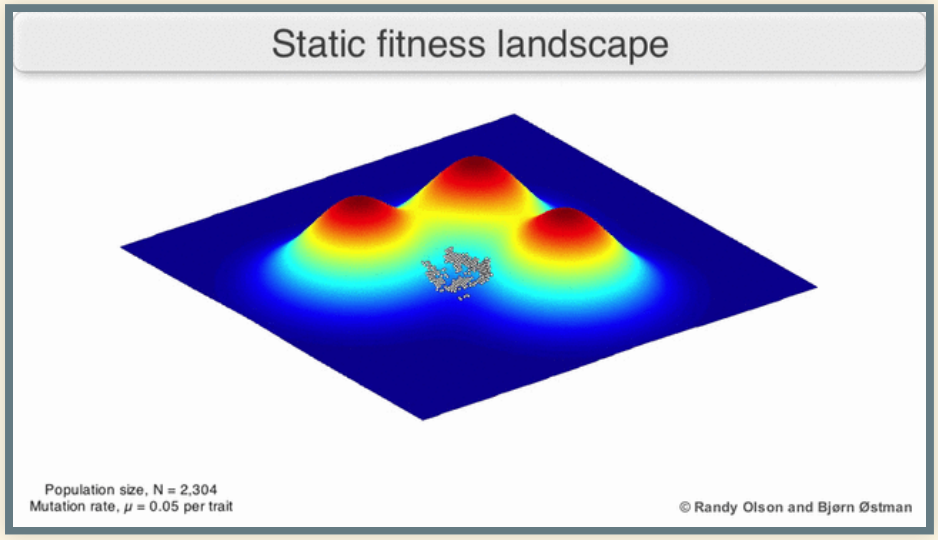
90 36

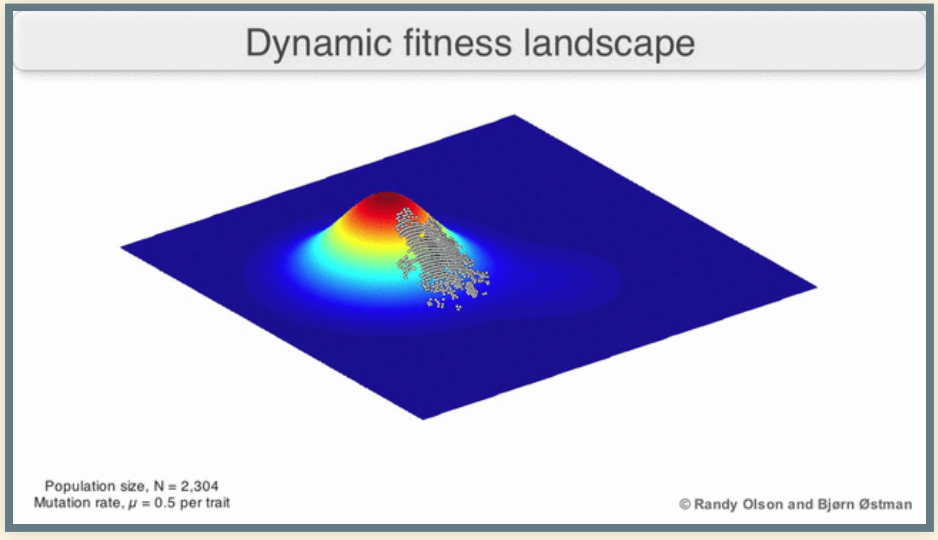
Source: https://www.urbandictionary.com/

"DIVERSITY FAVOURS ADAPTATION"

- As finance motto: **minimising risk**
- Fisher's fundamental theorem of natural selection (as genetic variance)
- Applied at multiple levels:
  - **Ecosystem**: *populations* are more diverse → *ecosystem* adapts easier/faster
  - **Population**: *individuals/groups* are more diverse → *population* adapts easier/faster
  - **Group**: *individuals* are more diverse → *group* adapts easier/faster
  - **Individual**: *practices* are more diverse → the *individual* adapts easier/faster
- A **principle**, not necessarilly a **fact**

FITNESS LANDSCAPES





- Used in eco-evo theory
- fitness x multiple dimensions
- Metaphoric/operational applications
- Caveats, *e.g., Do populations move through low fitness "valleys"?*
- "Seascapes": **dynamic** fitness landscapes

SCALES OF DIVERSITY

Local/momentum:

'hill climbing'

→ **fitness maximiser**

Regional/period:

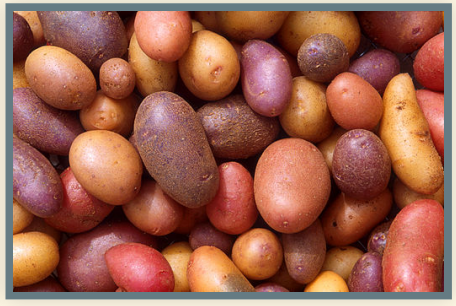
'boat stabilising'

→ **risk minimiser**

Integration of multiple instances creates an average fitness landscape that buffers the diversity of conditions

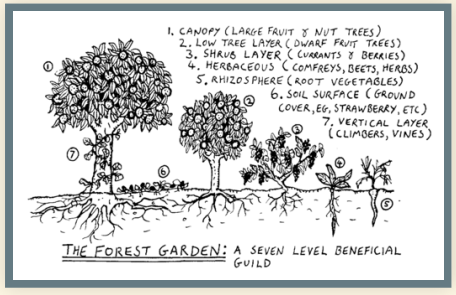
2. DIVERSITY IN FOOD PRODUCTION

DIVERSITY IN FOOD PRODUCTION



- factor of *food security*
- Increasing demand *versus* sustainability
- International trade *versus* food sovereignty
- Commercial crops, genetic engineering, landraces
- Climate change, plagues

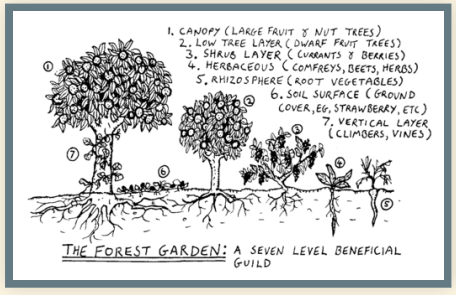
MULTI-CROPPING



- Two forms (Andrews and Kassam 1976, cited in Petrie & Bates 2017):
  - **Sequential cropping**
  - **Intercropping**
- 'Traditional' practices (*e.g., permeaculture*)
- Undermined by commercial crops but not lost

MULTI-CROPPING

What impact does it have for resilience?



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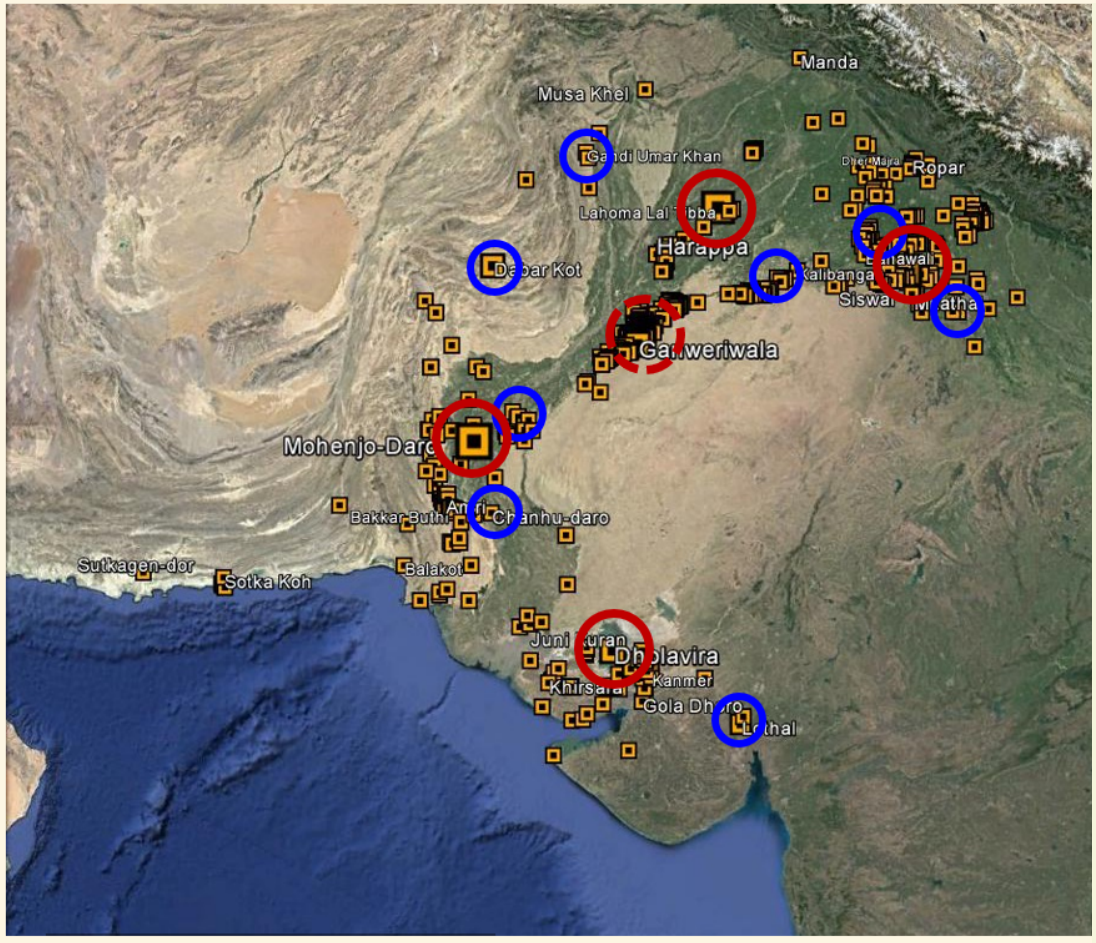
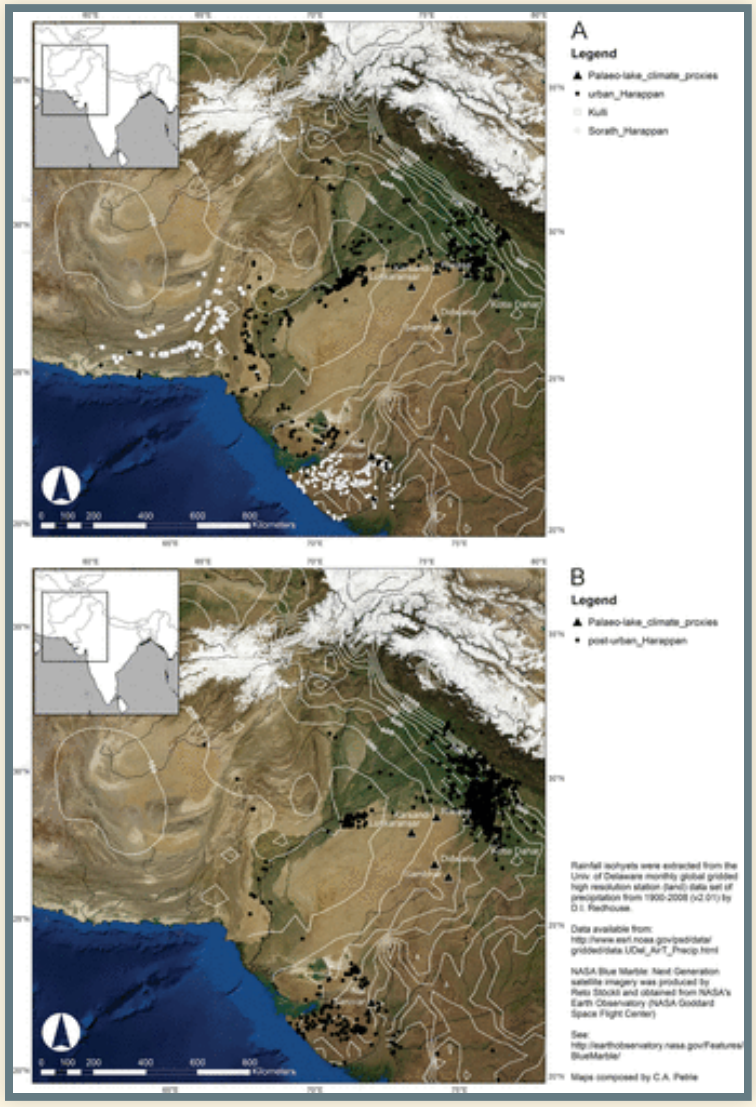
3. CASE STUDY: THE INDUS CIVILISATION



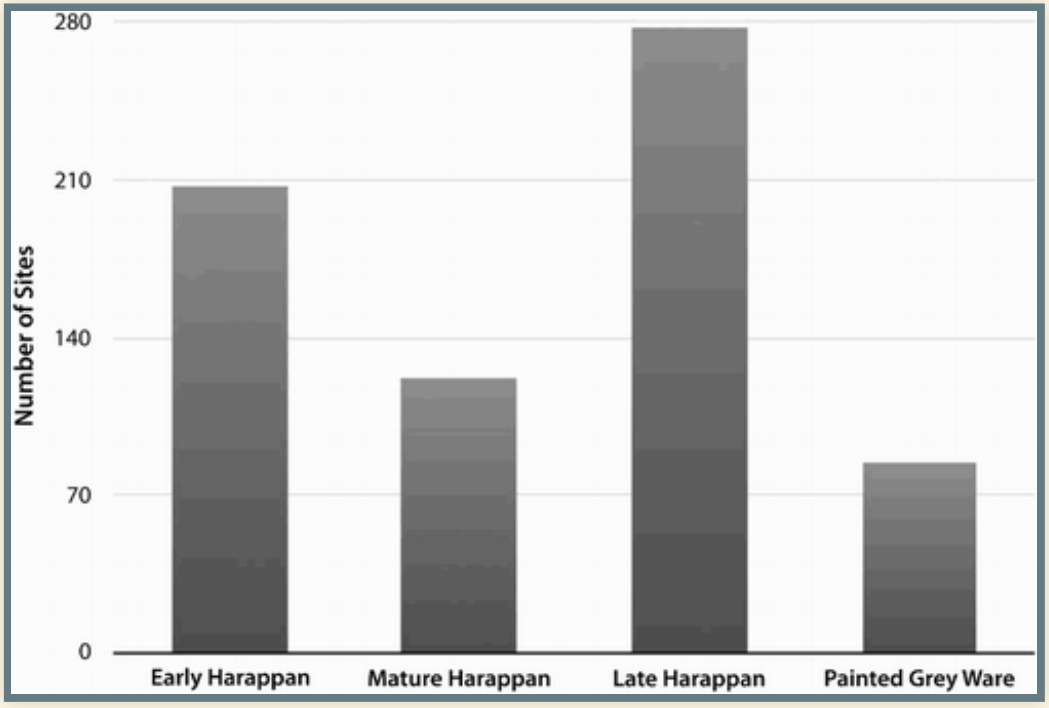
- One of the great ‘Old World’ Bronze Age civilisations
- First cities in South Asia ('Mature Harappan', c.2500-1900 BC)
- Five (or four) known major urban centres

Petrie et al. 2017, Current Anthropology



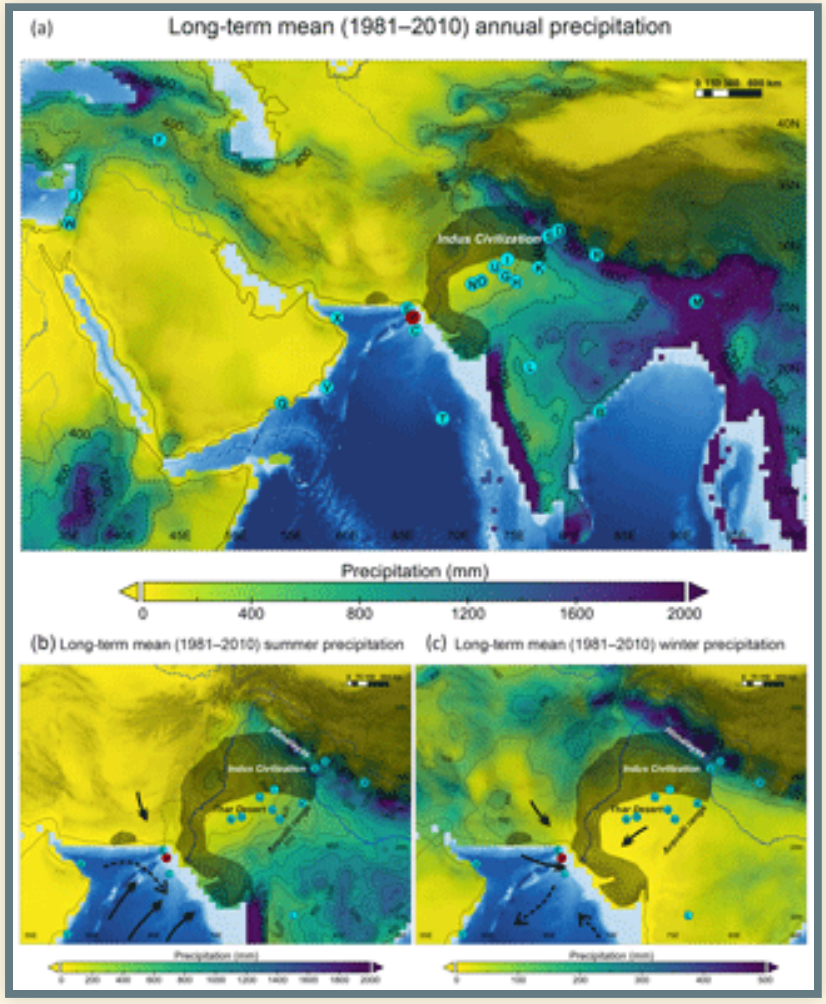
URBANISATION AND *DE*-URBANISATION

Green & Petrie 2018, Journal of Field Archaeology

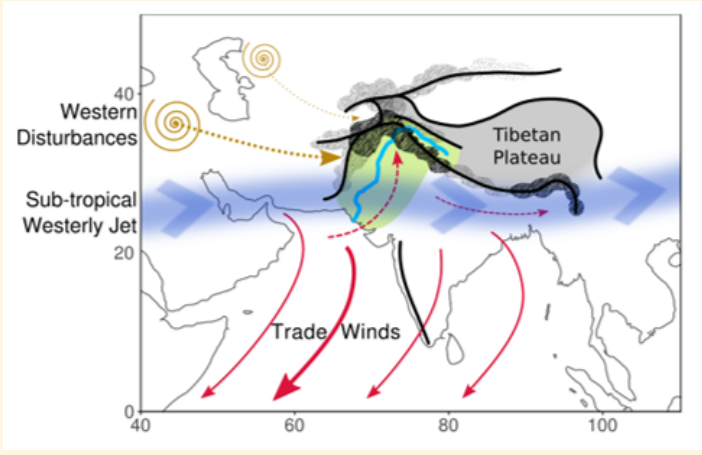


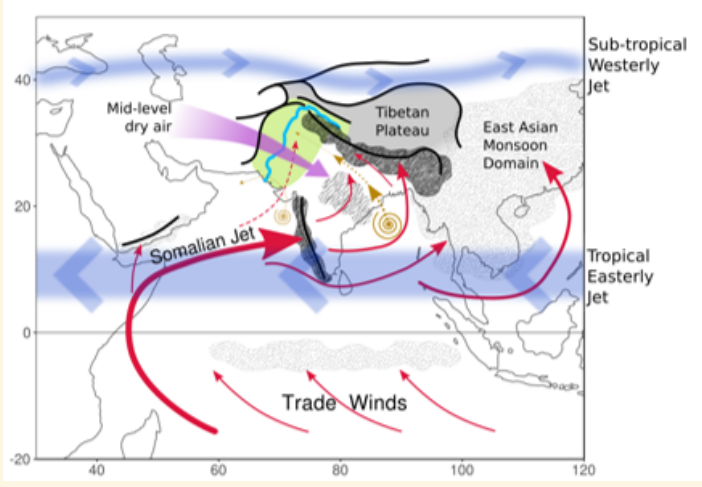
SUMMER RAIN, WINTER RAIN

Giesche et al. 2019, Clim. Past



J.-P. Baudouin (in preparation)

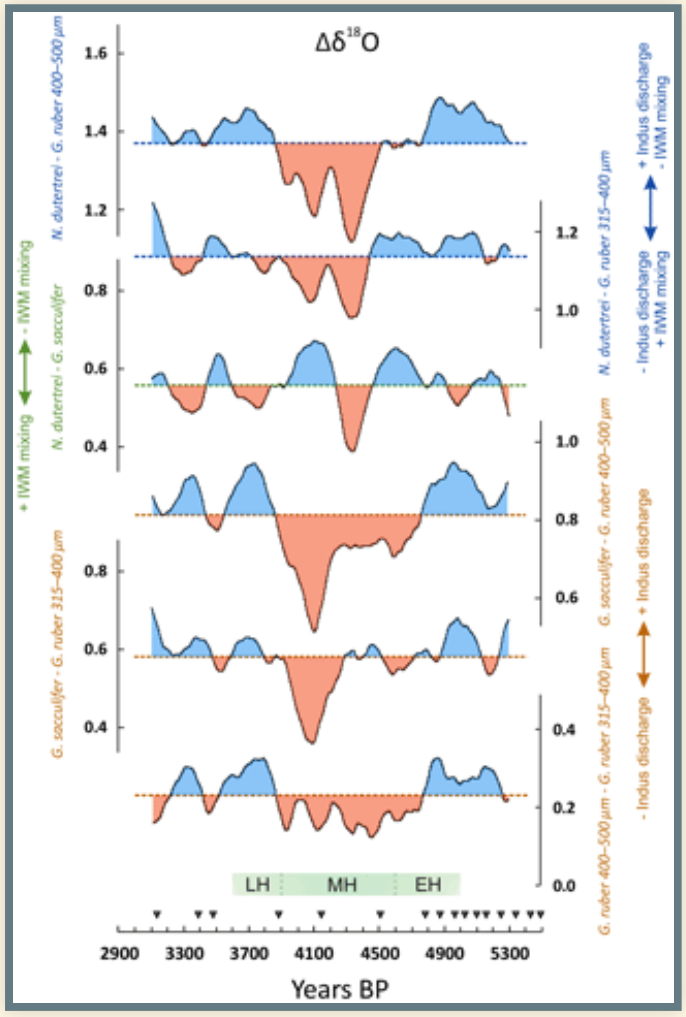




“Predictable unpredictability”

CLIMATE CHANGE

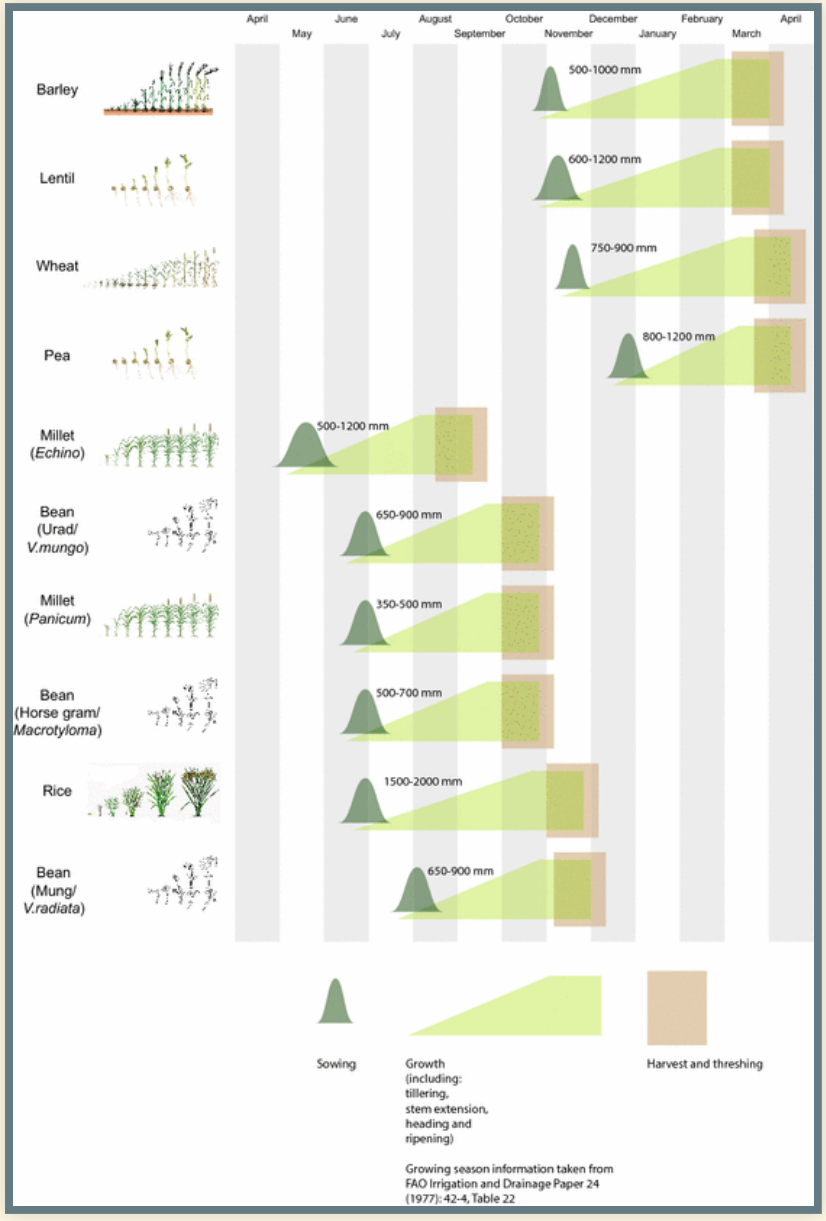
Giesche et al. 2019, Clim. Past



- **Urban phase**
  (MH, 4.5 and 4.3 ka)
  → stronger winter precipitation

- **End of urban phase**
  (MH-LH, 4.1 ka)
  → decrease in both the summer and winter precipitation

Petrie & Bates 2017, J. J World Prehist



FOOD PRODUCTION

- Main crops:
  - barley/wheat (winter)
  - millet/rice (summer)
- Pulses
- Other

Bates, Petrie & Singh 2018, Archaeol Anthropol Sci

FOOD PRODUCTION

- **Animal husbandry:** zebu, water buffalo, sheep, goat, pigs (?)
- Fishing, hunting
- Role of herding?

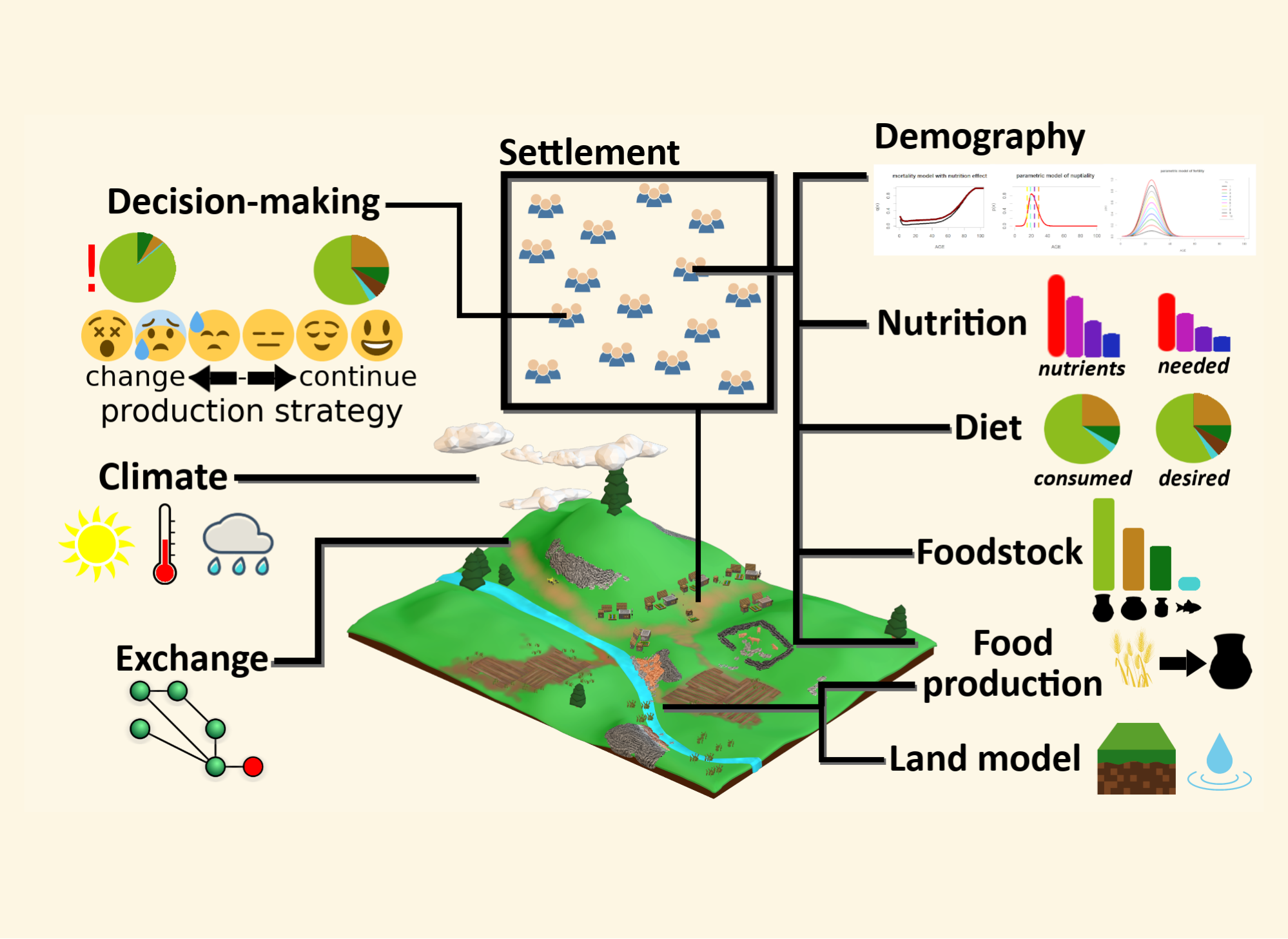
4. MODELLING CROPPING STRATEGIES

GOAL

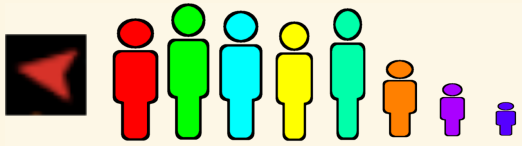
to explore human *adaptation to the diverse landscapes* of NW India and expose the *sustainability* of different types of *food production regimes*, mainly in terms of *cropping strategies*, in front of *abrupt climate change*

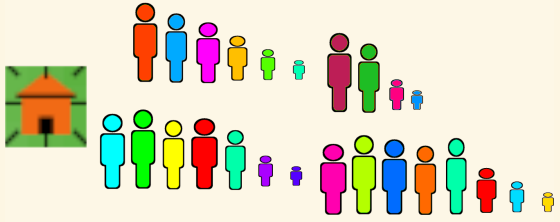
RATIONALE

- rural settlement(s)
- local scale
- food production/consumption
- Explore parameters/scenarios
- Questions:
  - Does diversity favours adaptation?
  - Is it detrimental to generating surplus?


Settlement
Demography
Decision-making
change
continue
production strategy
Nutrition
nutrients
needed
Diet
consumed
desired
Climate
Foodstock
Exchange
Food
production
Land model

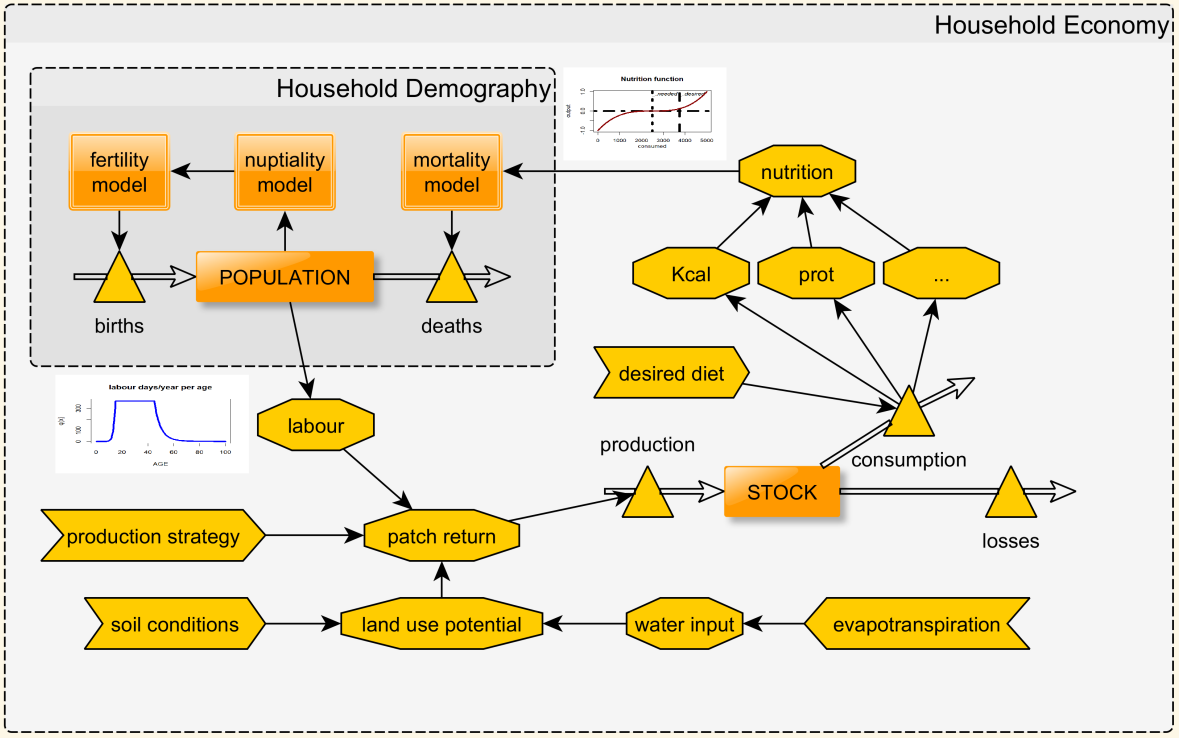
ELEMENTS





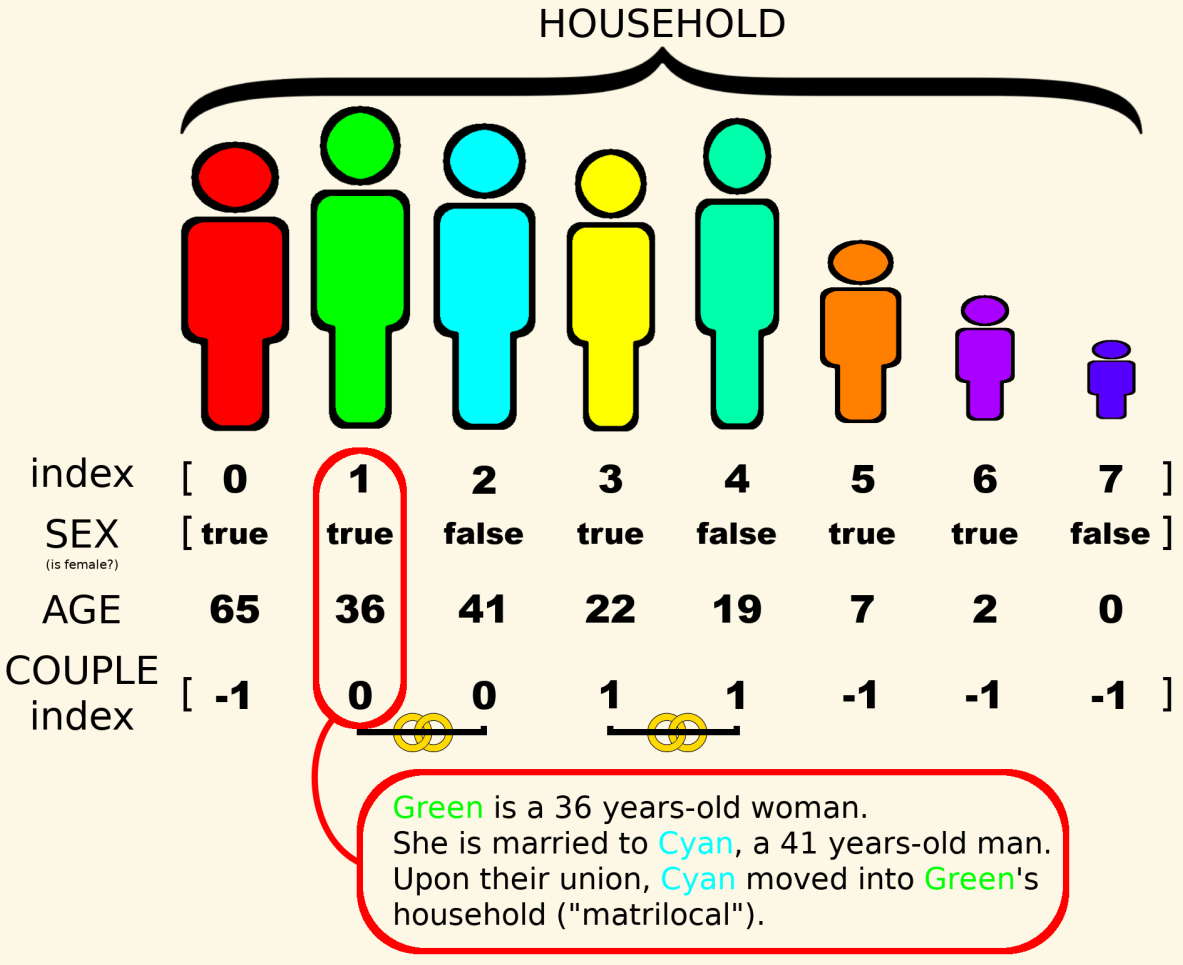
- **Household**: *propinquity* and *co-residence*, rather than *kinship*
- **Group**: set of households, united by *kinship* or *coexistence*; may form a '*settlement*'
- **Patches**: 1 hectare, vary in *soil*, *water balance*, and *land use*

MODEL DESIGN, INSOFAR



HOUSEHOLD *DEMOGRAPHY*

STRUCTURE



HOUSEHOLD *DEMOGRAPHY*

DYNAMICS

- Age/sex-specific submodels: *mortality* (Coale-Demeny, from demogR package), *nuptiality* and *fertility* (Peristeva & Kostaki 2007, 2015)
- Open population
- Couples: residence rule and kinship tabu
- Sensitivity to population size
- Local instabiliy, stability, and exponential growth

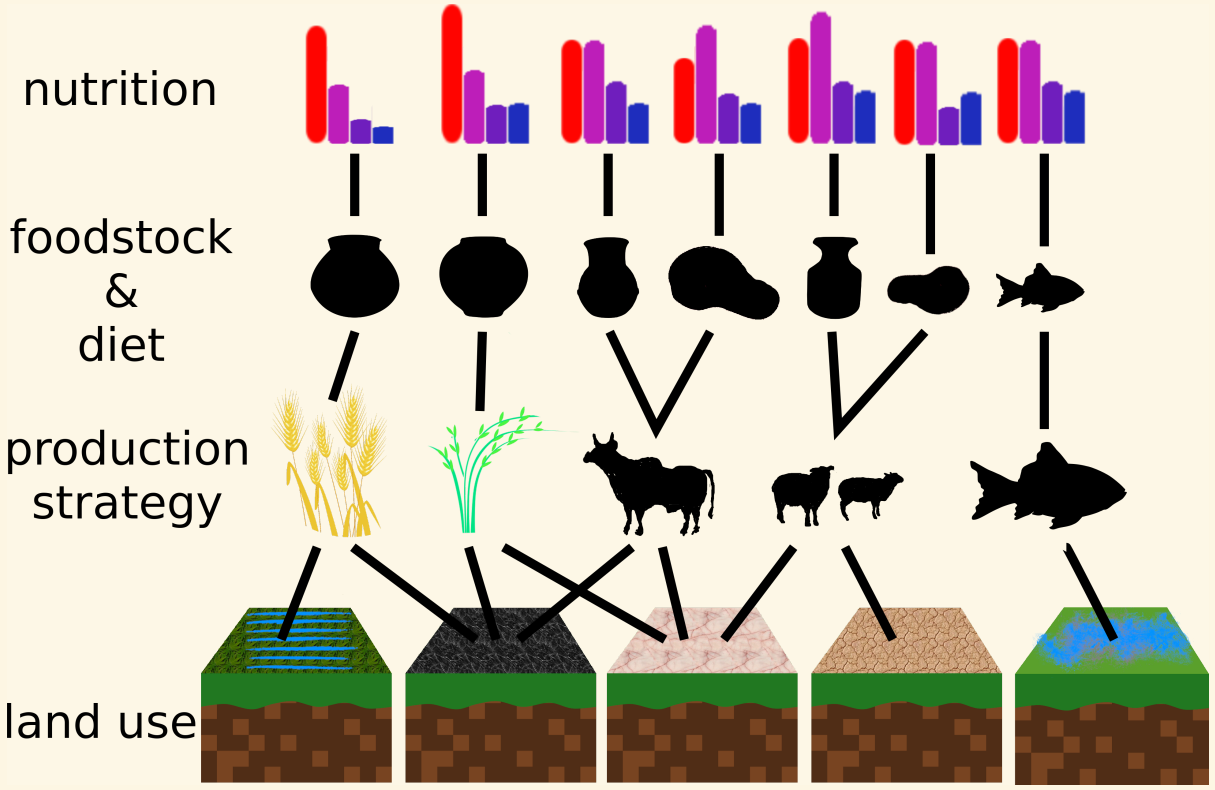
HOUSEHOLD *ECONOMY*

FROM LAND USE TO DIET

- *Food production* at household-level
- *Diet* and *nutrition*
- Specific *strategies* applied to patches with specific (changing) *conditions*
- Sharing/exchange to be realised at group-level

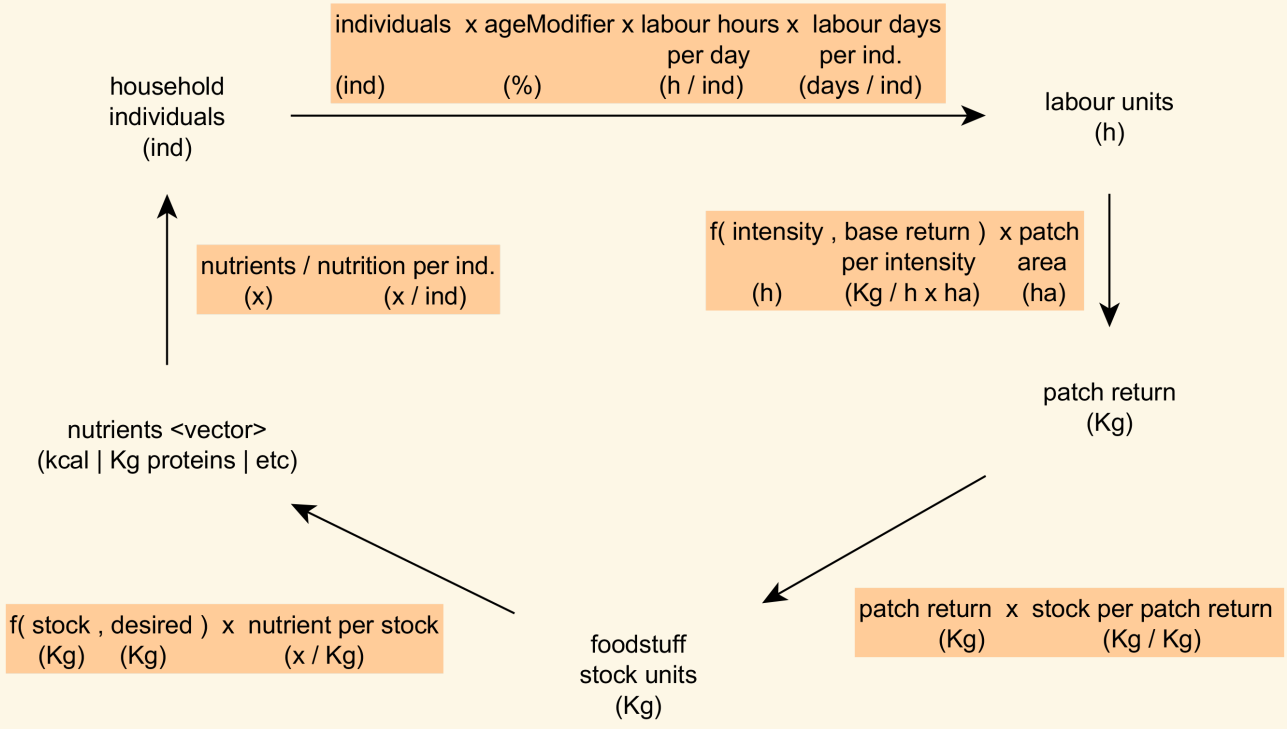
HOUSEHOLD *ECONOMY*

STRUCTURE



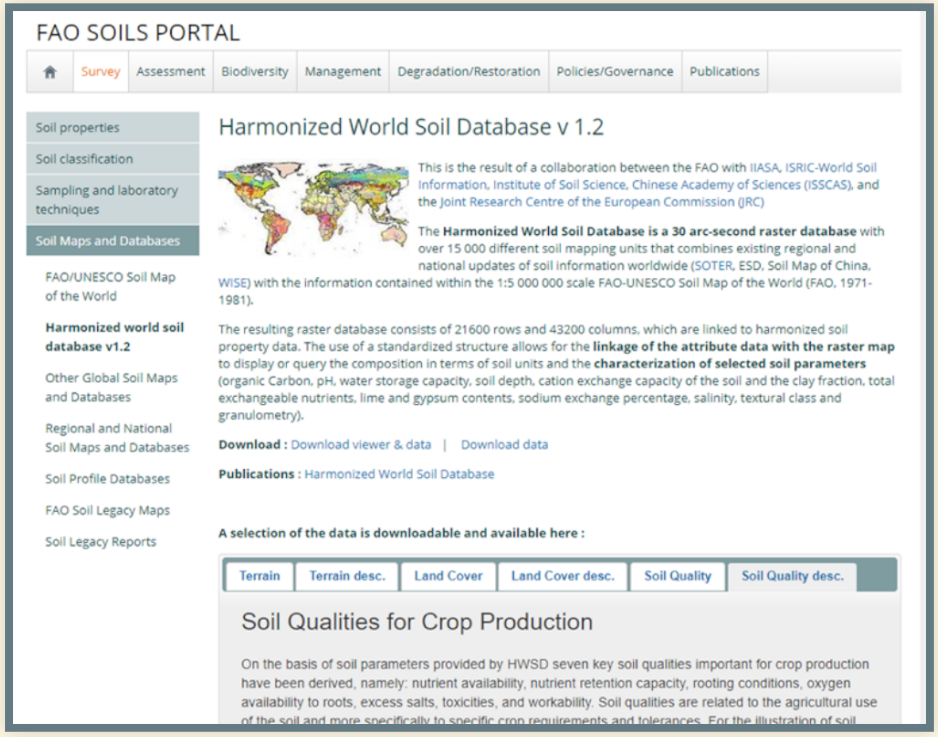
HOUSEHOLD *ECONOMY*

DYNAMICS

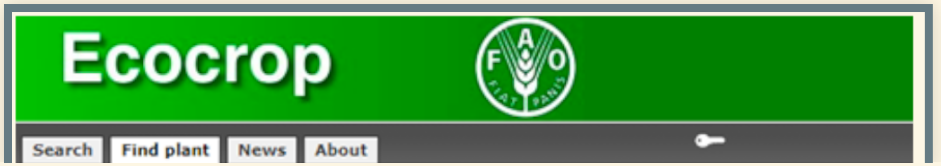


DATA INPUT

SOILS AND CROP CONDITIONS



Challenge: model animal husbandry


Ecocrop
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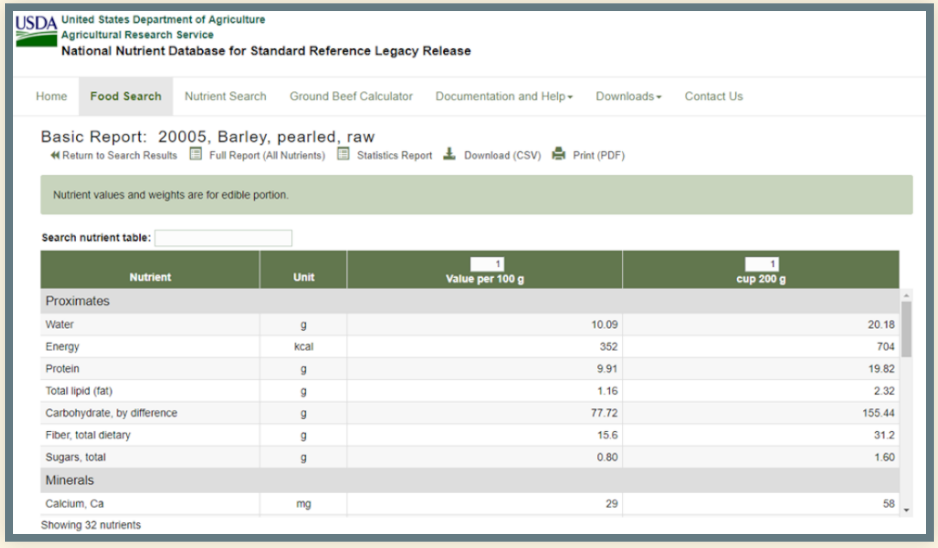
FOODSTUFF NUTRITION VALUES



USDA United States Department of Agriculture
Agricultural Research Service
National Nutrient Database for Standard Reference Legacy Release

Home | Food Search | Nutrient Search | Ground Beef Calculator | Documentation and Help | Downloads | Contact Us

Basic Report: 20005, Barley, pearled, raw

Return to Search Results | Full Report (All Nutrients) | Statistics Report | Download (CSV) | Print (PDF)

Nutrient values and weights are for edible portion.

Search nutrient table:

Nutrient	Unit	1 Value per 100 g	1 cup 200 g
Proximates			
Water	g	10.09	20.18
Energy	kcal	352	704
Protein	g	9.91	19.82
Total lipid (fat)	g	1.16	2.32
Carbohydrate, by difference	g	77.72	155.44
Fiber, total dietary	g	15.6	31.2
Sugars, total	g	0.80	1.60
Minerals			
Calcium, Ca	mg	29	58

Showing 32 nutrients

Challenge: raw or cooked?

Archaeol Anthropol Sci (2018) 10:1703–1716
DOI 10.1007/s12520-017-0489-2

CrossMark

ORIGINAL PAPER

Cereals, calories and change: exploring approaches to quantification in Indus archaeobotany

J. Bates[1,2] · C.A. Petrie[1,3] · R.N. Singh[4]

CONCLUSIONS I

- The effects of *diversity in food production* can vary with the time and spatial scale
- Case studies in archaeology can offer insight on the '*long durée*'...
- But modelling (particularly, ABM) can *connect* small/short with large/long scales

CONCLUSIONS II

- Connections made with ABM can be built on *meaningful mechanisms*
- Accounting for:
  - Variability of *environmental conditions*
  - *Social dynamics* of various complexity
  - Sets of *assumptions* that can be flexible and testable (alternative designs, scenarios)
- *Challenge*: still lack a shared, coherent, reproducible *framework* for modelling food production across cultures and for many generations

'TWORAINS' PROJECT

ERC, 2015-2020

Follow our updates!

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ACKNOWLEDGEMENTS

Thanks to the **Land, Water and Settlement** and **TwoRains** teams:

Aftab Alam, Alessandro Ceccarelli, Sagorika Chakraborty, Sudarshan Chakradhari, Arti Chowdhary, Yama Dixit, Charly French, Adam Green, Henry Green, Lily Green, David Hodell, Penny Jones, Carla Lancelotti, Emma Lightfoot, Frank Lynam, Sayantani Neogi, Hector Orengo, Arun Kumar Pandey, Danika Parikh, Vikas Pawar, Amit Ranjan, David Redhouse, Dheerendra Pratab Singh, & Akshyeta Suryanarayan.

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