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Simulation Systems for Exploring Socioecological Dynamics of Ancient and Modern Settlement Systems

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Introduction and Outline

This presentation ranges across many disciplines: archaeology, urban studies, agroeconomics, linguistics, and more. Two unifying themes:

- All examples illustrate a common design approach and code framework: ENKIMDU.
- All have origins in the Modeling Ancient Settlement Systems (MASS) Project
  - *Argonne DIS and the Oriental Institute of the University of Chicago*
  - *Supported by 5-year National Science Foundation grant*

- **The ENKIMDU Simulation Framework *("Virtual Ancient Mesopotamia")***

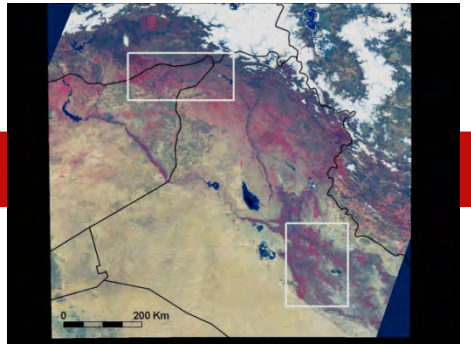
- **ENKIMDU Spinoff Projects:**
  - Zincirli / Sam'al: (Anatolian Iron Age City-State: Urban Construction)
  - BabbleOn: Computational Linguistics: Coevolution of Society and Language
  - RiotMonger: Effects of Urban Morphology on Social Behavior
  - Mae Phosop: Microeconomics and Sustainability in Modern Rural Thailand

Scope and Scale of MASS ENKIMDU Simulations For Bronze Age Mesopotamian Settlement Systems

SCOPE: Individual small settlements up to whole regions (> 100 km)

Single Settlement

North Jazira Region (Syria)



Northern and Southern Mesopotamia

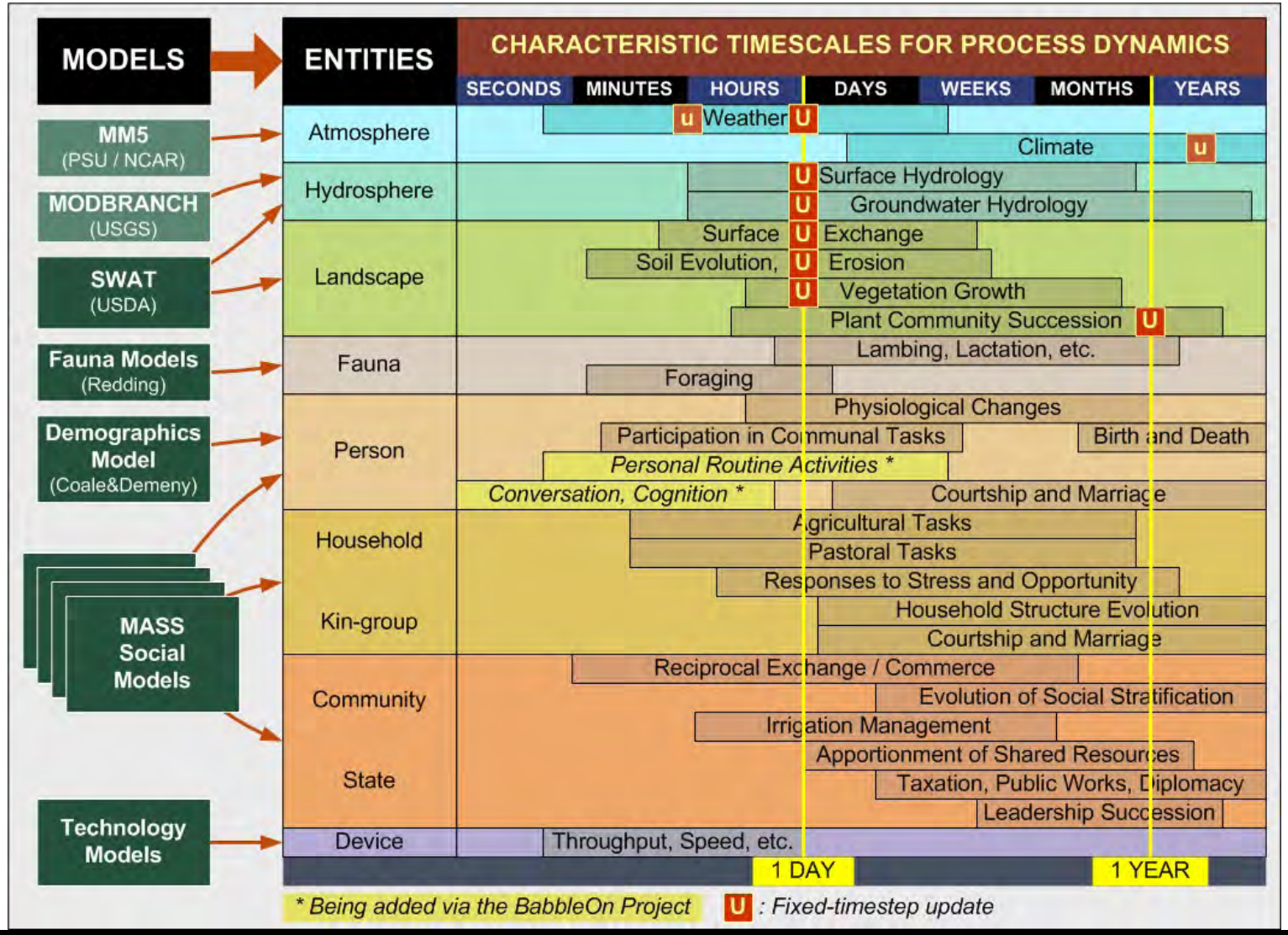
SCALE: *Entity-Level Resolution and Granularity*

- **Individual households and persons as independent social agents**
- **Individual crop fields, domesticated fauna**

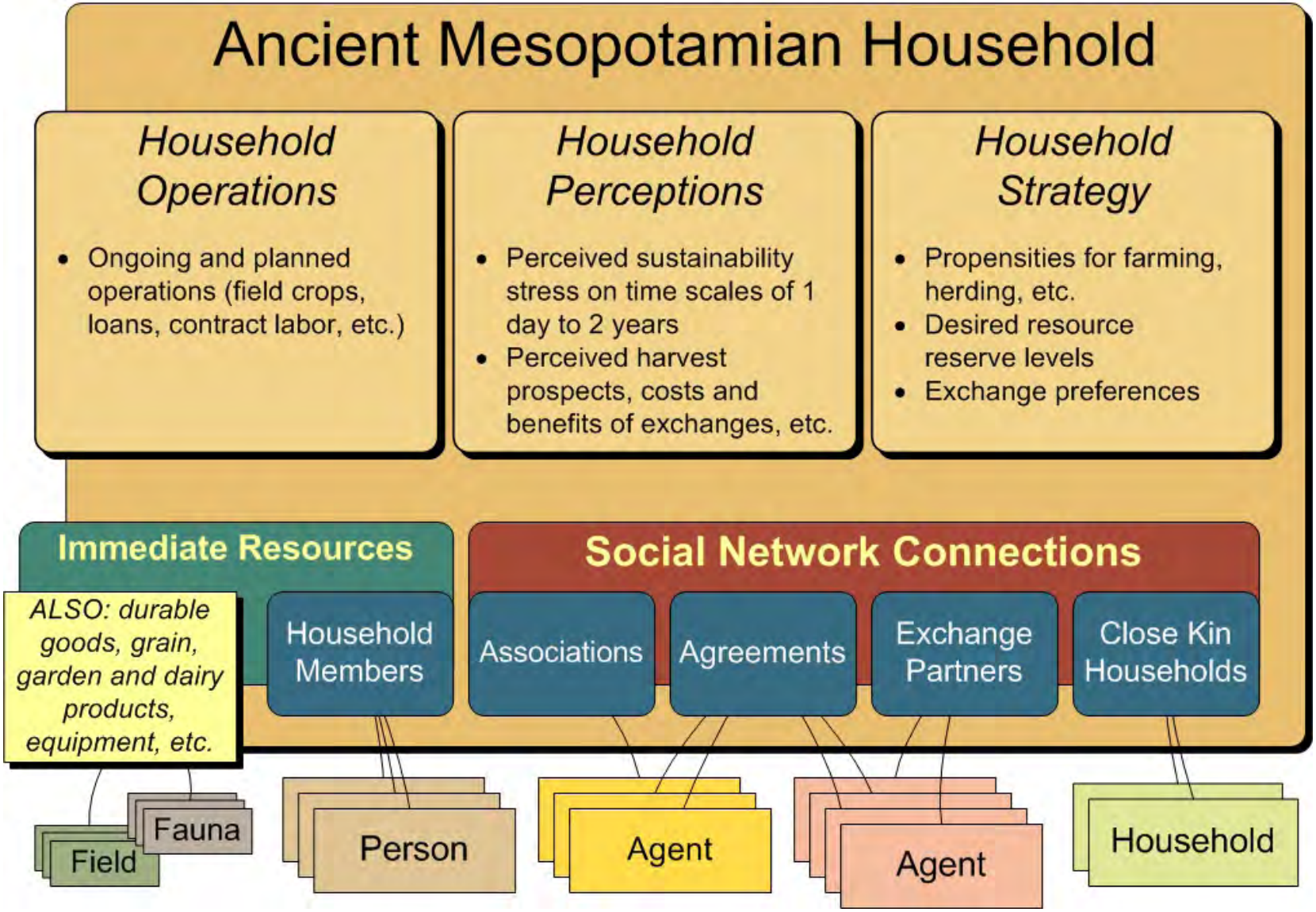
SCALE: *Dynamic Process and Temporal Resolution*

- **Daily weather, hydrologic and soil processes, vegetation dynamics**
- **Daily or finer (hours, minutes) tracking of detailed household tasks** and social interactions

Temporal Texture of Concurrently Modeled Natural and Societal Processes in ENKIMDU



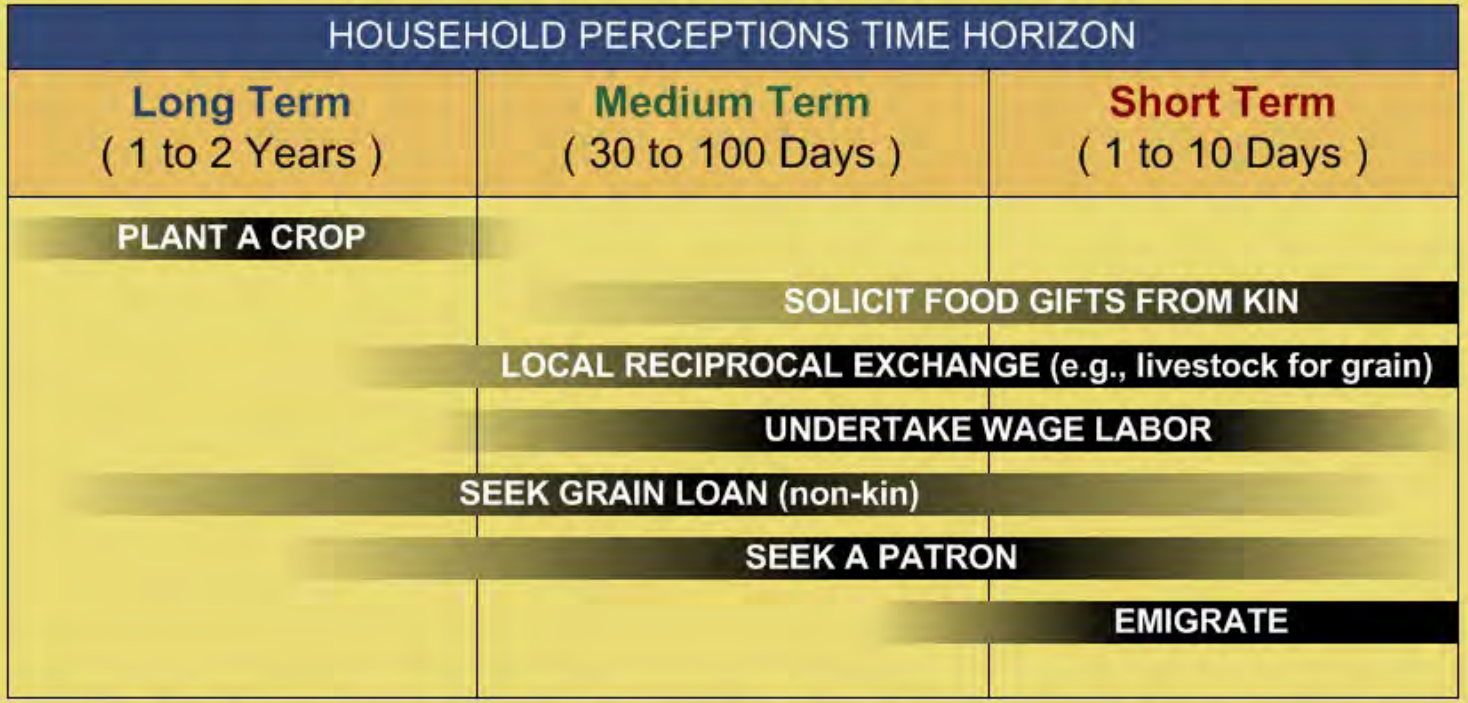
Composition of ENKIMDU Household Agent Objects



Household Agent Adaptive Behavior Examples

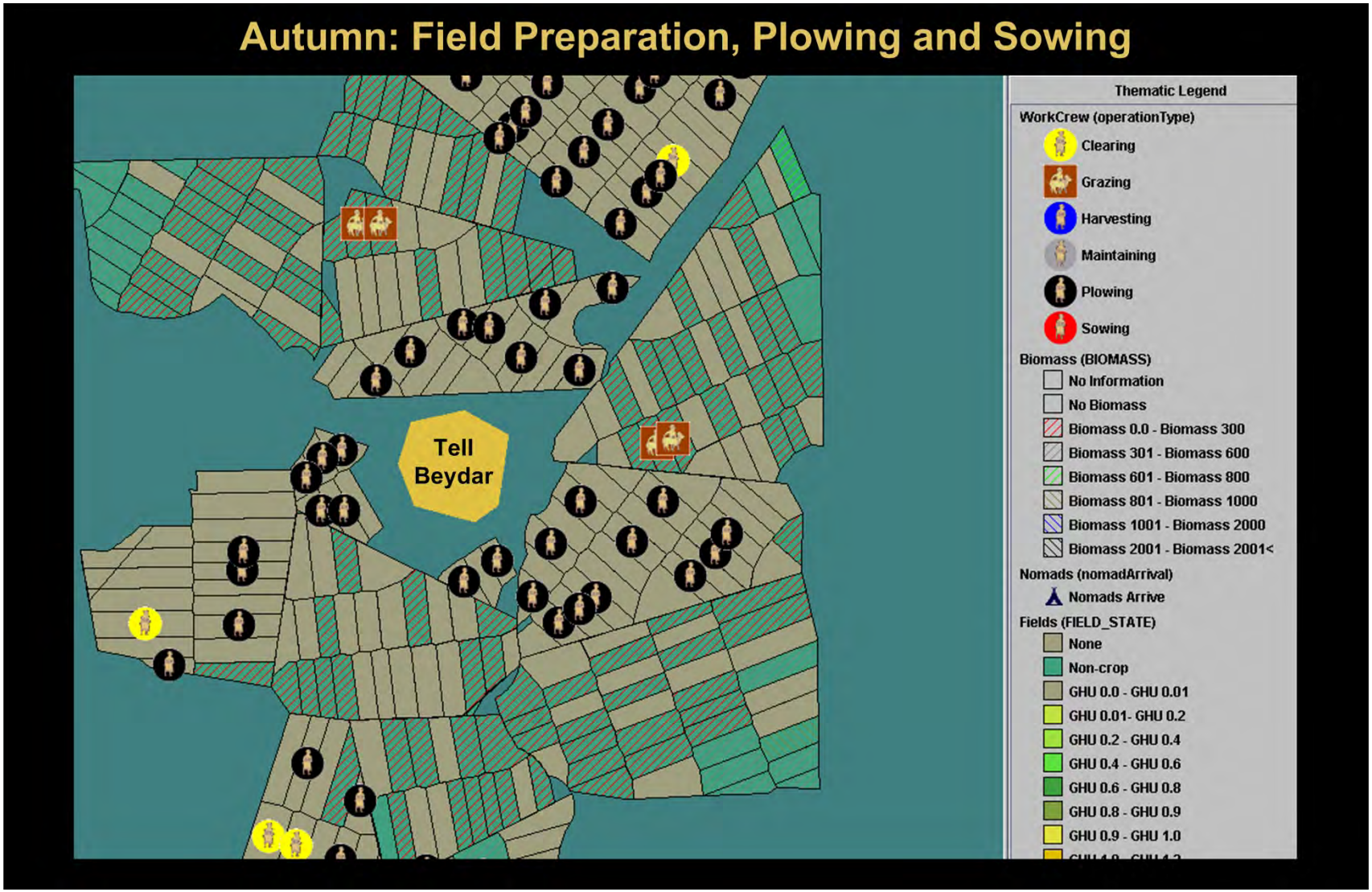
Household agents' perception of current *or future* sustainability stress can motivate them to initiate complex behavior patterns, as here...

Modeled Household Food Stress Coping Mechanisms

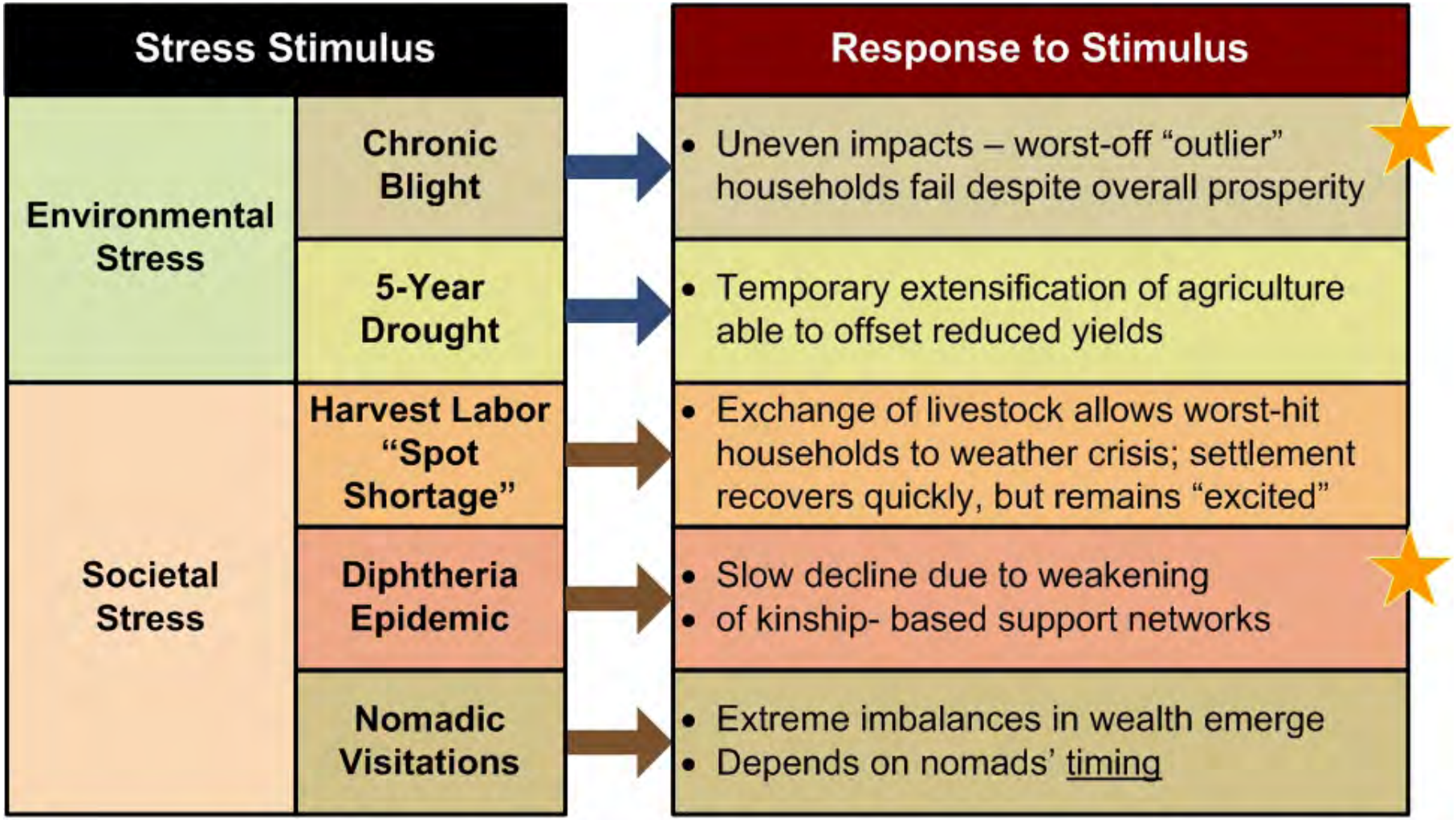


Nominal household preference order for a given time horizon is top-to-bottom

Households' Daily Agricultural and Pastoral Activities: Snapshot of Tell Beydar Community on an October Day



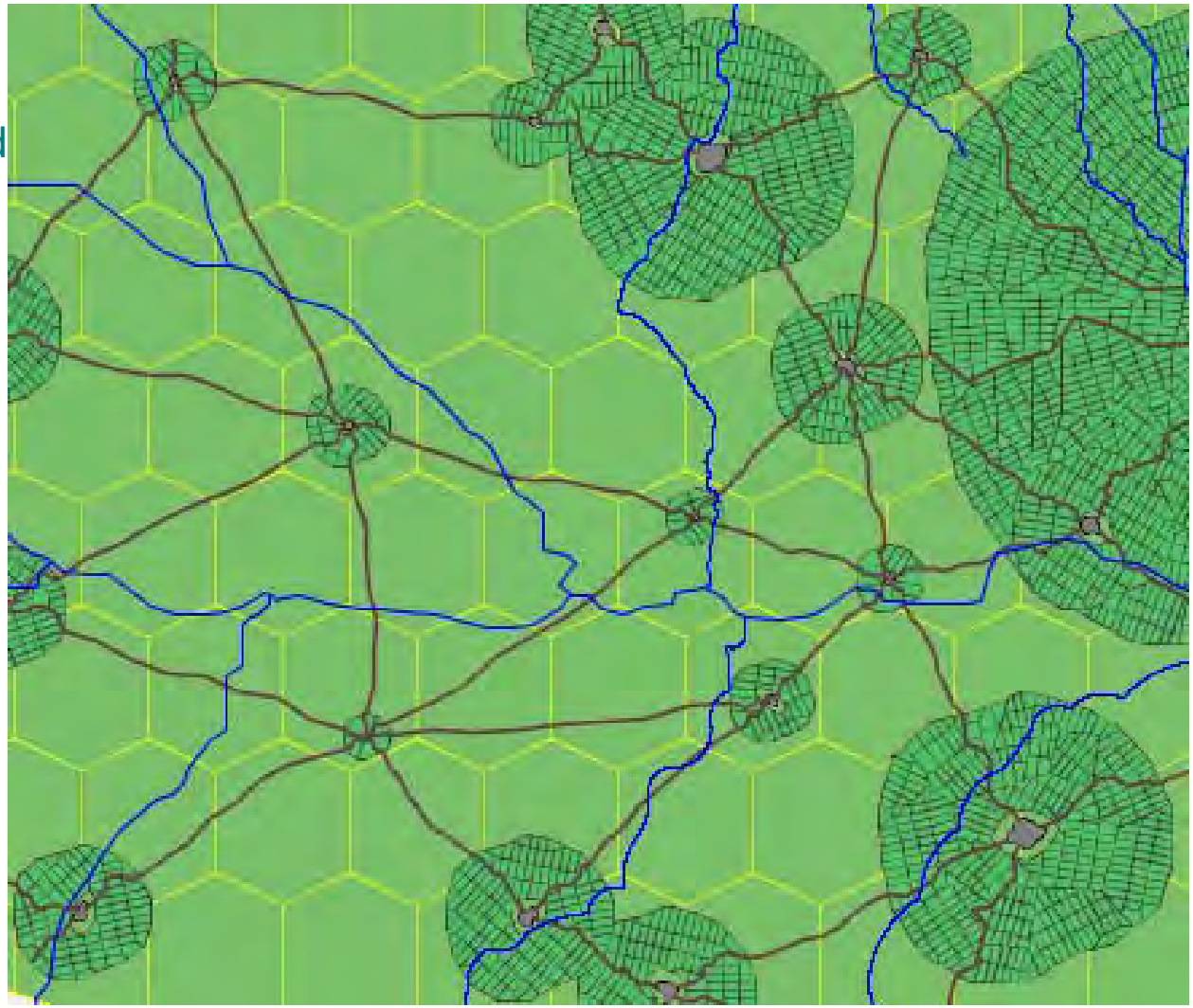
Single Settlement "Stress Scenario" Examples



ENKIMDU Regional-Scale Simulations

Additional **environmental** processes become relevant at this scale, e.g. distributed surface hydrology and mesoscale weather.

Additional **societal** complexity at this scale: territorial states, taxation, public works, diplomacy, warfare; social stratification, including patron / client dynamics, sharecropping.
More interesting repertoire of behaviors for nomadic communities.
Regional-scale transport and trade.



Zincirli / Sam'al Studies

U. Chicago / Argonne Joint Theory Institute Pilot Project

- ***PI's David Schloen, Oriental Institute of U. Chicago; John Christiansen, Argonne DIS***

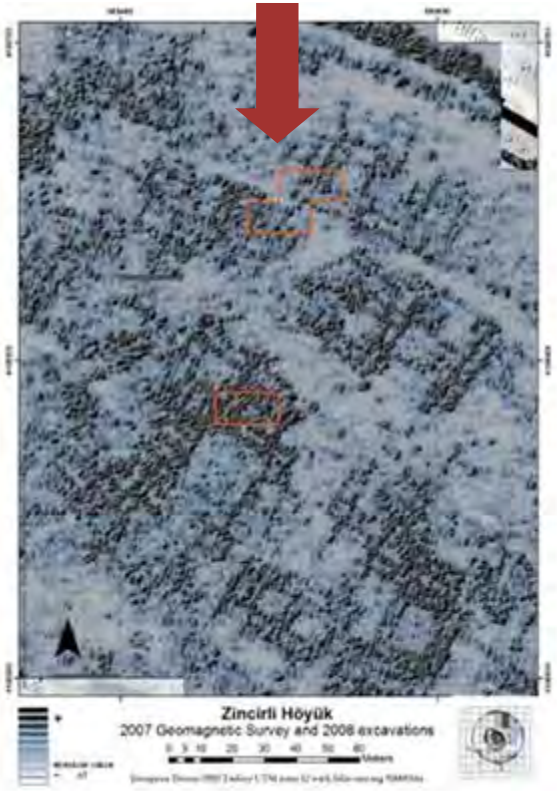
Study Focus: the Iron Age (ca. 1,000 BC) City-State of Sam'al, now Zincirli, Southern Turkey:

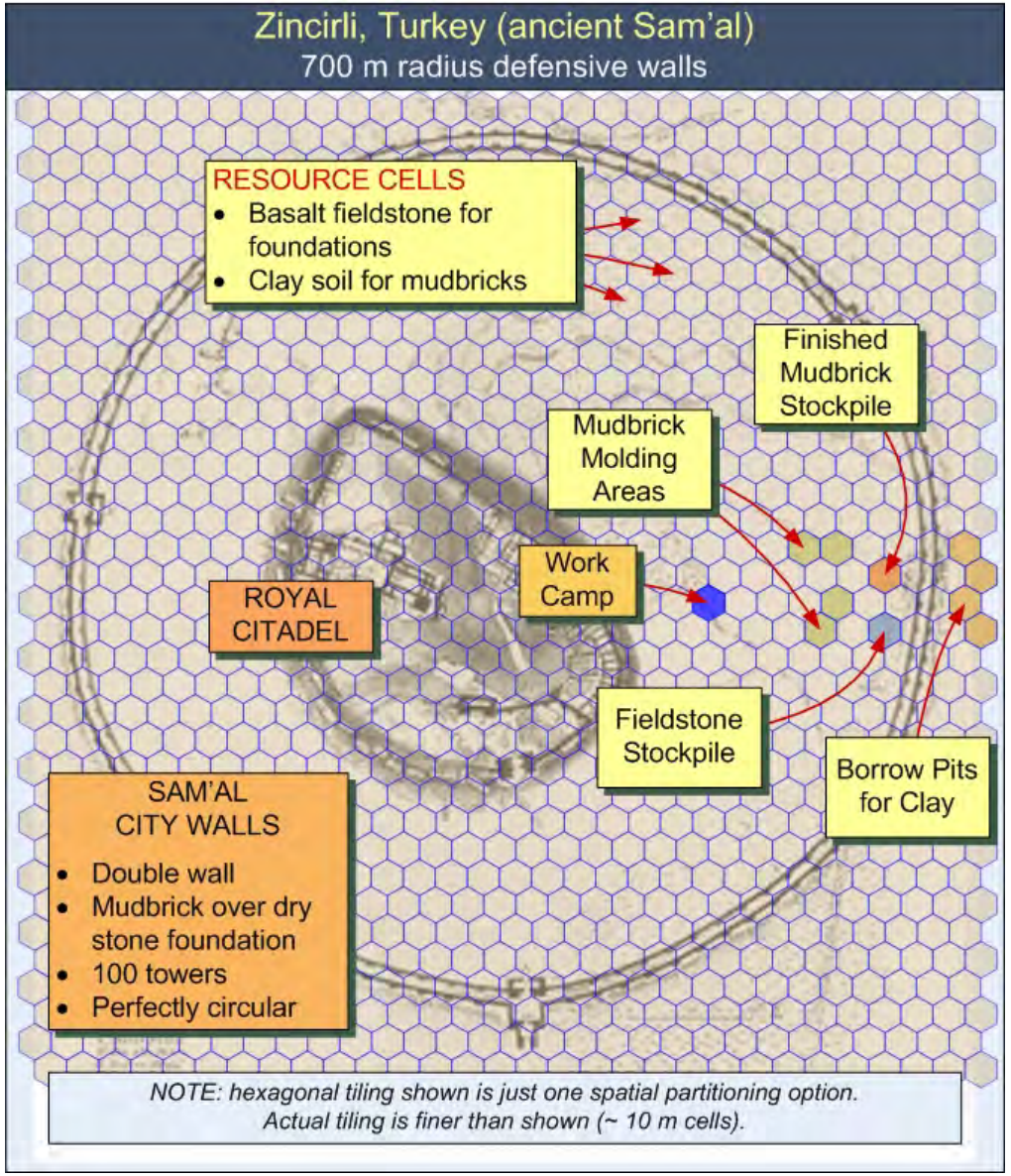
Societal and environmental issues surrounding a massive public works project

Societal and environmental sustainability and stability of a ~ 40,000 person polity in a mixed-resource region (agriculture, pastoralism, hunting, trade)

Holistic Simulations of Iron-Age Sam'al

- **Test hypotheses on means of construction of defensive works**
- **Simulate social processes driving subsequent urban infill**





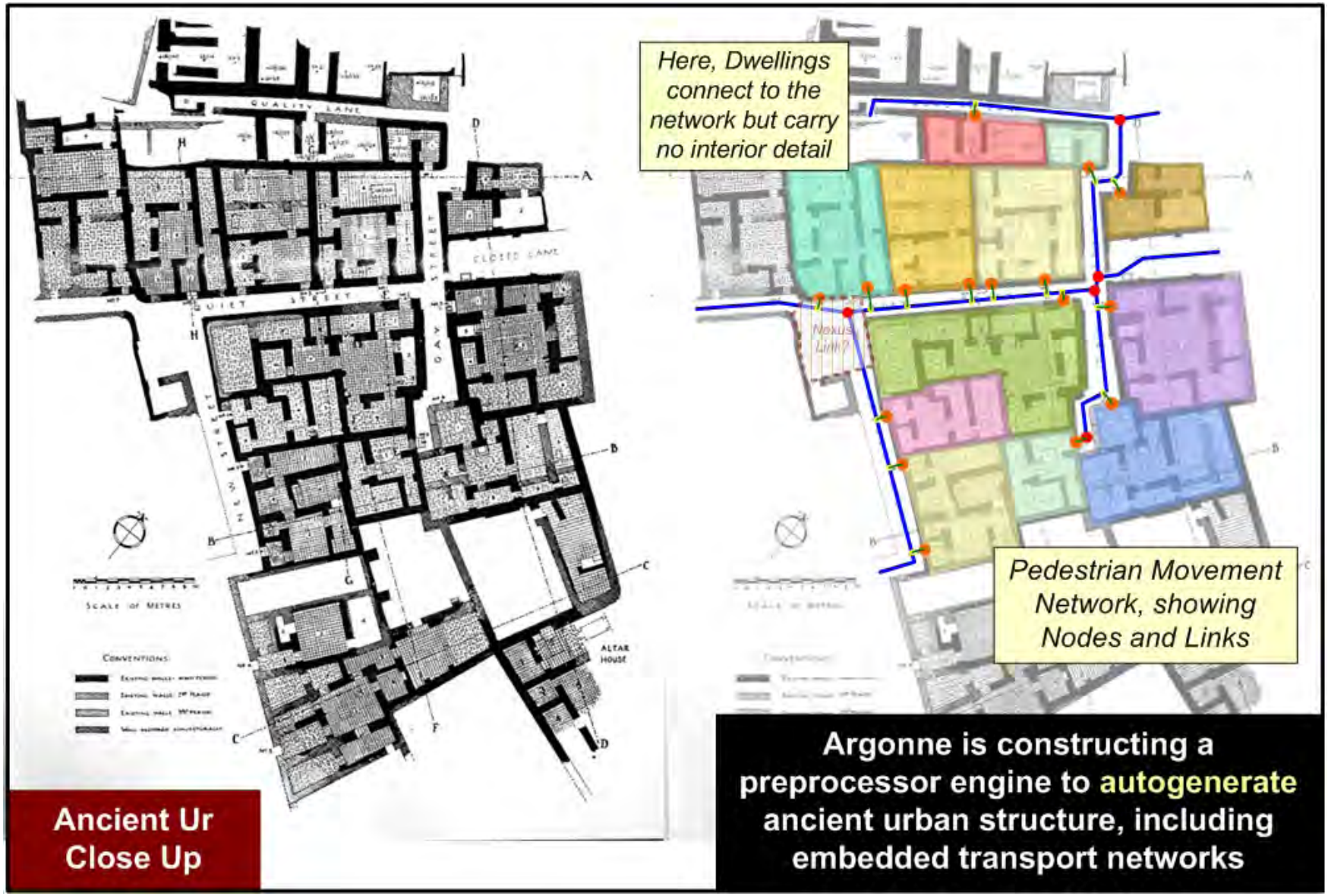
The BabbleOn Project: Adding Language Agency to Social Agents

Collaboration between Argonne DIS and Chicago Language Modeling Lab team at the University of Chicago led by Dr. Jason Riggle. Joint Theory Institute pilot study: computational linguistics modeling of evolution of ancient Akkadian language in Bronze Age social context.

- **What ENKIMDU adds to BabbleOn:**
  - Substantial, consistent social context. Access to ENKIMDU-derived contextual information (e.g., spatiotemporal sequences of each agents' "linguistic cliques" – an agent's local acoustic universe of speakers and listeners – is priceless. Too big a task for linguists to tackle on their own.

- **What BabbleOn adds to ENKIMDU:**
  - Language differences as modulating context for social situations.
  - Supports more realistic mechanisms for construction and maintenance of social bonds and communities.

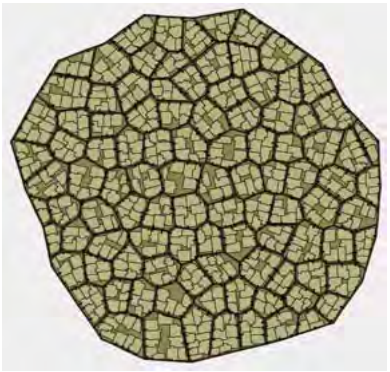
Urban Texture: Pedestrian Movement Networks

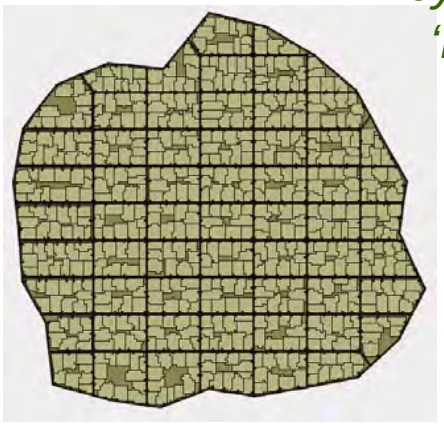


RiotMonger Simulator Prototype

Simulation-based investigation of effects of urban morphology, urban texture on group social behavior *(e.g., riots).*

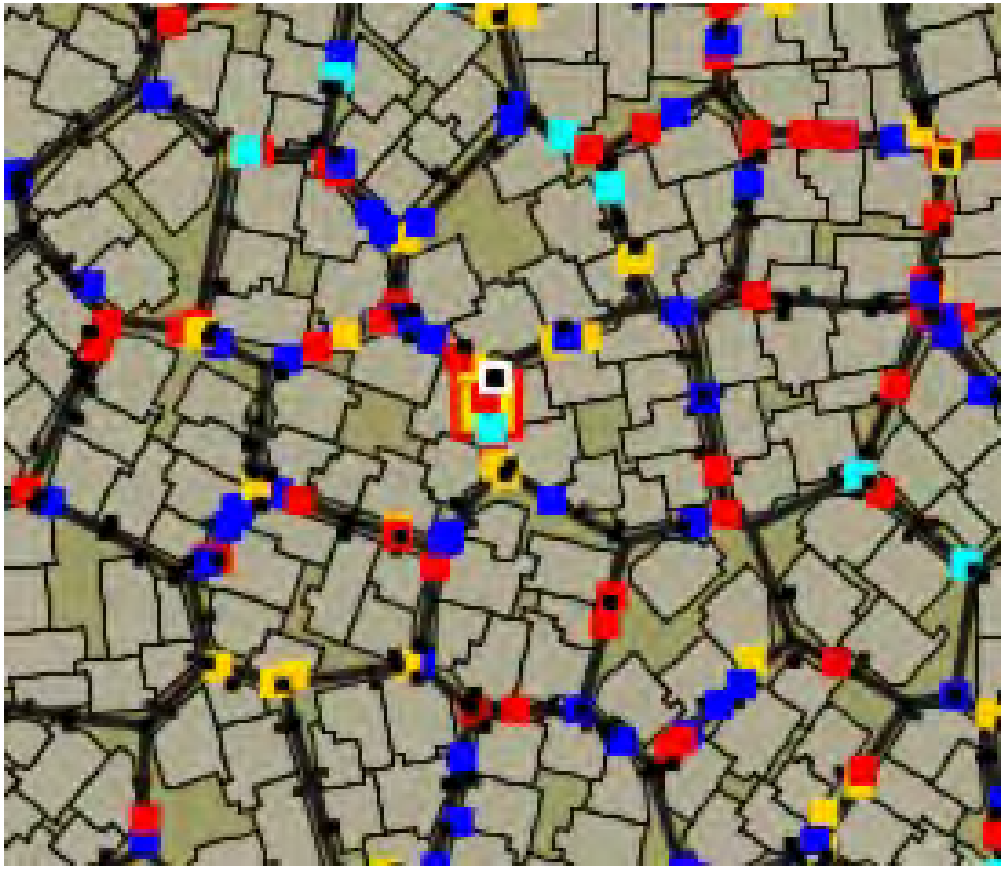
Originated in U. Chicago senior honors project by Sarah Wise, ANL DIS intern, 2008-9.



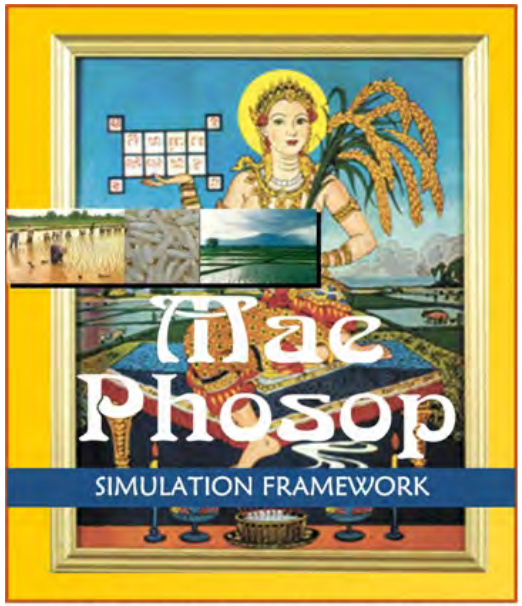


Examples of urban textures autogenerated by the ANL DIS 'Kabta' urban partitioning engine

RiotMonger Social Simulation in Action



Mae Phosop: Extending ENKIMDU to Address Modern Southeast Asian Sustainability Issues



(Mae Phosop: Thai Rice Goddess)

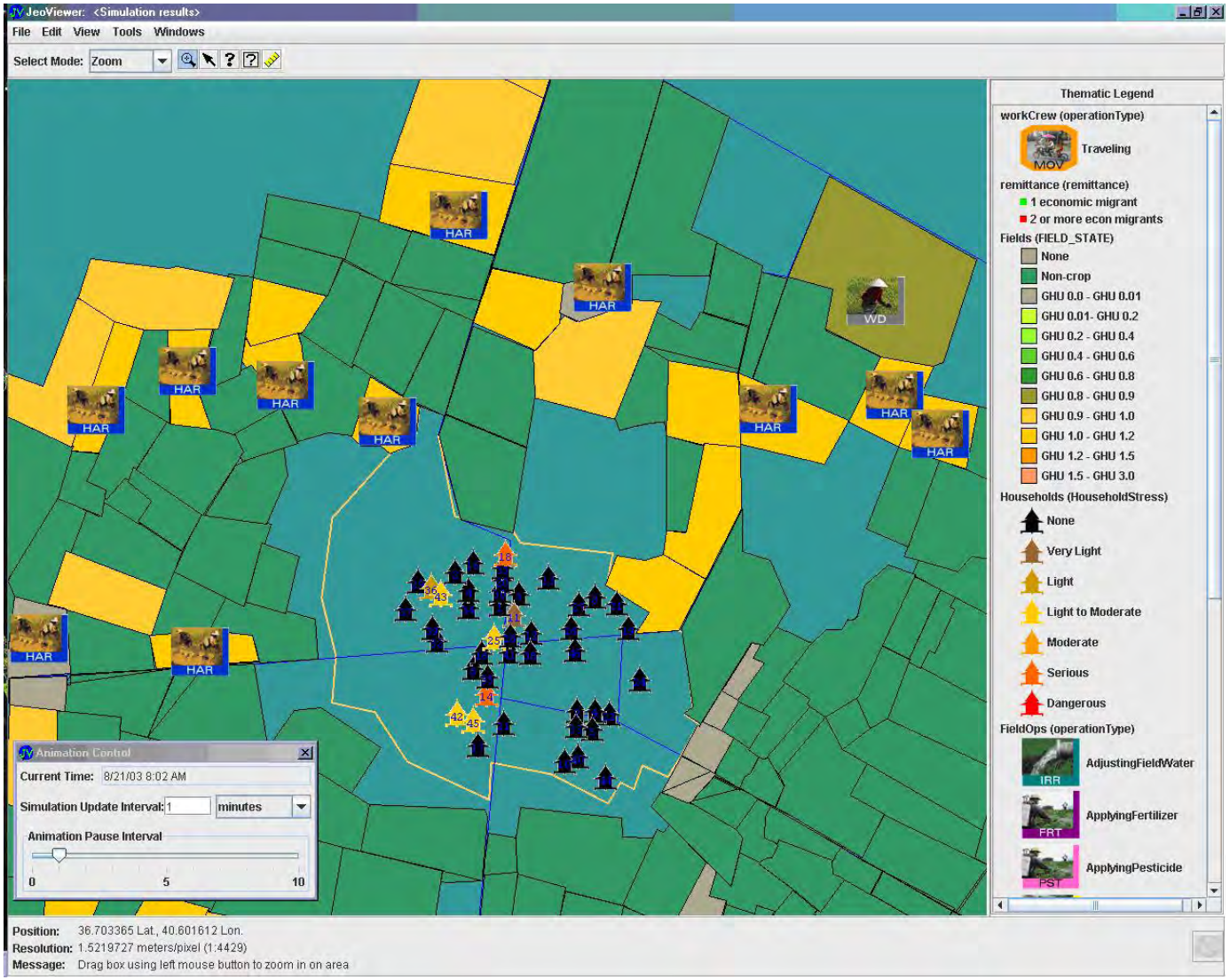
Mae Phosop Pilot Study Goal: Test ability of cross-discipline, agent-based simulations to help economists address modern socioeconomic sustainability issues in rural northern Thailand.

Data: Microeconomic data, site surveys, aerial photographs, weather data, soil reports, and ethnographies, from ongoing long-timebase studies conducted by U. Chicago Economics Professor Robert Townsend and colleagues.

ENKIMDU Modifications and Extensions Required:

- Landscape Processes: virtually no changes.
- Societal Processes: necessary to accommodate different cultural norms as well as millennia of social and technological change …

Mae Phosop Simulation Animation Snapshot: Banseaw, Thailand August 21: Weeding, Harvesting Tasks Underway in Fields



Mae Phosop Test Use Case: Impacts of External Factors on Village-Level Economic Sustainability

- In 2001, Thaksin Shinawatra formed the 54th government in Thailand; in 2006 he was deposed in a coup
- The new regime has changed many of Thaksin's policies focused on improving village economies

The Mae Phosop simulation engine has been the testbed for use cases highlighting modern societies' responses to stimuli and stresses, e.g.:

- Simulation of a Thaksin initiative: direct infusion of money at village level.
- Simulation outcomes: additional funds tended to delay onset of economic migration, reduce flow of remittance payments back to village.