An Agent-based Model of Population and Environment in the Chitwan Valley, Nepal

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Outline

- Introduction
- ABM Update
 - Parameterization
 - Baseline model
 - Sample Model Scenarios
- Ideas for comparison with Wolong
- Future work

INTRODUCTION

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• How are demographics impacted by environmental change?

 How does environmental change influence demographic change?

Background

- Human influence on environment
 - Resource extraction
 - Land use change
 - Household dynamics
- Environment influences human society
 - Environment and first birth timing
 - Environment and family size preference
 - Land use and marriage timing

ABM Objectives

- Compare Wolong and Chitwan field site
- Examine reciprocal connections between population and environment
- Explore alternative scenarios of LULC and demographic change

Agent-based Modeling

ABM PARAMETERIZATION

Parameterization

- Baseline probabilities assigned for:
 - Live birth
 - First birth timing
 - Marriage
 - Death
- Feedbacks alter the baseline probabilities
- LULC determined by action of household agents

Parameterization of Life Processes

- Household registry data used to parameterize life events (births, deaths, marriages)
- Subsequent births
 - Based on the probability of live birth dependent on age
 - Number of births per age group bin counted, divided by number of months in bin

Baseline Probability of Death



Baseline Probability of Marriage



- Only to married women
- Only after marriage
- 1. At marriage, first birth time selected from prob. dist.
- 2. After first birth, births occur according to woman's age
- 3. Desired family size (hard limit) is
 - Based on empirical data
 - (or) taken from CVFS

First Birth Timing Distribution



Desired Number of Children Distribution



Baseline Probability of Live Birth



LULC categories

- LULC classes are defined as in Axinn and Ghimire (2007):
 - Agricultural vegetation ("agveg")
 - Non-agricultural vegetation ("nonagveg")
 - Private buildings ("privbldg")
 - Public infrastructure ("pubbldg")
 - Other (ponds, silted riverbanks, etc.)

LULC Change

- Private built infrastructure (new households) deduct from agricultural vegetation
- Fuelwood harvesting deducts from nonagricultural vegetation and forest cover
- Birth event leads to higher vegetation consumption
- Public infrastructure (NFOs) deduct from agricultural vegetation or nonagveg

New Household Land Area

- Where are new households established?
 - Agveg land (based on neighborhood mapping data)
- How much land is occupied by a household?
 - Based on my analyis of BASIC datafiles from ISER
 - Mean household area = 1176 m²
 - Standard deviation = 1484 m²
 - n = 769
- In the ABM, the area of each new household is drawn from a probability distribution

Actual Distribution of Household Land Area



Model Distribution of Household Land Area



NFO Land Area

- NFO land area less clear
- Using 2008 data there are:
 - 15 Temples
 - 9 Schools
 - 1 Health center
- Very few datapoints
 - Mean NFO area = 3229 m^2
 - Standard deviation = 3735 m^2

– n = 27

NFO Land Area



NFO Land Area



Agent-based Modeling

ABM SCENARIOS

Actual Monthly Life Events (household registry)



Single Model Run (baseline) – Life Events



Actual LULC (from neighborhood mapping)



Single Model Run (baseline) – LULC

Baseline Ensemble – Life Events

Baseline Ensemble – LULC

Later First Birth Timing

Later First Birth Timing – Life Events

Later First Birth Timing - LULC

Later First Birth Timing – Age Structure

• Show population pyramids.

Model Sample Population

Actual CVFS Sample Population

Downloading ABM

- Free for a limited time only! (just kidding)
- ABM is available online
- Works on Linux / Windows / MacOS

http://rohan.sdsu.edu/~zvoleff/ChitwanABM.php

Discussion – Remaining ABM Items

- Marriage and household fission
 - When do new households form? Why?
 - Where do new married couples locate?

- Migration
 - How to handle the conflict?

COMPARISONS WITH WOLONG SITE

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1) Household Size and LULC

Q: How does changing household size and composition impact LULC?

- Examples:
 - Impact of household fission (leading to changes in household size)
 - Impact of changing in population age structure
- Data needs:
 - Household fission how to tell?
- ABM coding required
 - Better parameterization of household fission

Biomass Usage Model – Per person

Actual Trends in Household Size in Chitwan

2) Demographic Change and Habitat Change

- Q: How does changing fertility impact habitat quality?
- Examples:
 - Impact of delayed first birth timing
 - LULC \rightarrow change in marriage timing
 - Changes in contraceptive use patterns (analogous to shifts in family planning policies in China?)
- Data needs:
 - Definition and parameterization of habitat quality
- ABM coding required:
 - Parameterization of contraceptive use

3) LULC and the Spread of NFOs

Q: How does the spread of non-family organizations connect to LULC?

- Examples:
 - NFOs $\rightarrow \downarrow \downarrow$ direct consumption
 - − NFOs \rightarrow \uparrow contraceptive usage \rightarrow \downarrow birth rates
- Data needs:
 - Where are NFOs established? What is their direct impact on LULC?
- ABM coding required:
 - Parameterization of NFO formation and spread
 - More detailed representation of contraceptive use

3) LULC and the Spread of NFOs

• Show diagram.

DISCUSSION

Population and Biomass - Future work

- Biomass data finalized this suummer
 - This fall: complete biomass mapping using IKONOS and field data
 - Focus ABM on south-east Chitwan (area of my survey)
- Biomass mapping will allow linking fuelwood harvesting directly to forest cover and to demographic change

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EXTRA SLIDES

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Major Decisions

Objectives

- Study the influence of demographic characteristics on wood collection
- Examine links between
 wood collection and
 environmental change in
 the Western Chitwan
 Valley, Nepal

Household Fuelwood Usage Survey: Part 1

- Question:
 - What are the (wood) resource requirements for an average household in Chitwan? How do these requirements relate to social variables?
- What is a household?
 - Defined as a group of people who eat and sleep in the same place at least 5 days per week.
- Approach:
 - 2 part survey of 80 households in southeastern Chitwan:
 - 80 households detailed survey
 - 40 households followed for 15 days (with visits every 3 days)

Household Fuelwood Usage Survey: Part 2

- Measurement of wood usage
 - Wood used within the household (on their grounds)
 - For cooking, heating, livestock, etc.
 - Not wood for construction
 - Wood used within the 15 day survey period

- Sample 40 households
 - Resource usage and collection measured over five 3-day periods

- Question:
 - What are the direct impacts of fuelwood and timber collection on land cover in the Chitwan Valley?
- Approach:
 - Survey of fifty-eight 20 m \times 20 m field plots
 - Survey focuses on woody biomass
 - Standing woody biomass (live)
 - Woody detritus (dead)

Wood usage - summary statistics

Variable	Mean	Standard Deviation
Household size	4.57 (num. people)	1.83
Wood usage	2.43 (dry Kg / HH × day)	1.22
Ethnicity 0 = Other 1 = Hill Tibeto Burmese	.13	
Own any non-wood stove 0=No 1=Yes	.76	

37 households total, 5 observation periods

Household Size (number of persons)

Dry Biomass Used for Cooking

Biomass Usage Model

Biomass Usage Model

Variable	Regression Coefficient	2-sided p-value
Intercept	2.07	.001
Mean household size	0.22	.025
Ethnicity	0.88	.088
Own any non-wood stove	-1.02	.015

Regression equation (using OLS):

FWMass = 2.07 + .22×HHSize + .88×Ethnicity -1.02×NWStove

Adjusted $R^2 = .28$