Changing Responses of Land Dynamics and Vulnerability to Flooding Under Policy and Environmental Change near Poyang Lake, China

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Land-Change Science

- Involves
  - Documenting and monitoring land-cover changes
  - Explaining coupled human-environment dynamics giving rise to these changes
  - Developing spatially explicit land-change models that are compatible with other Earth system models

Rindfuss et al. (2004) *Proc of the National Acad. Of Sci. (U.S.)*

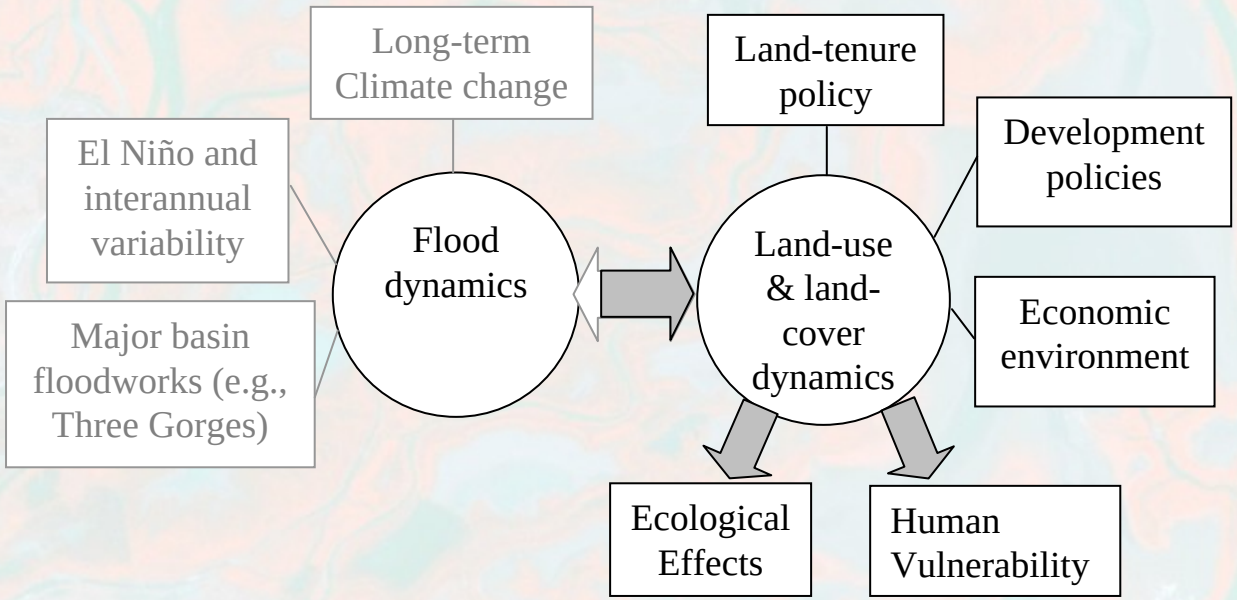
LCS and Vulnerability

Understanding vulnerability requires that we account for:

- The coupled human-environment system
- Linkages to broader human and biophysical conditions
- Perturbations and stresses that arise from these broader conditions

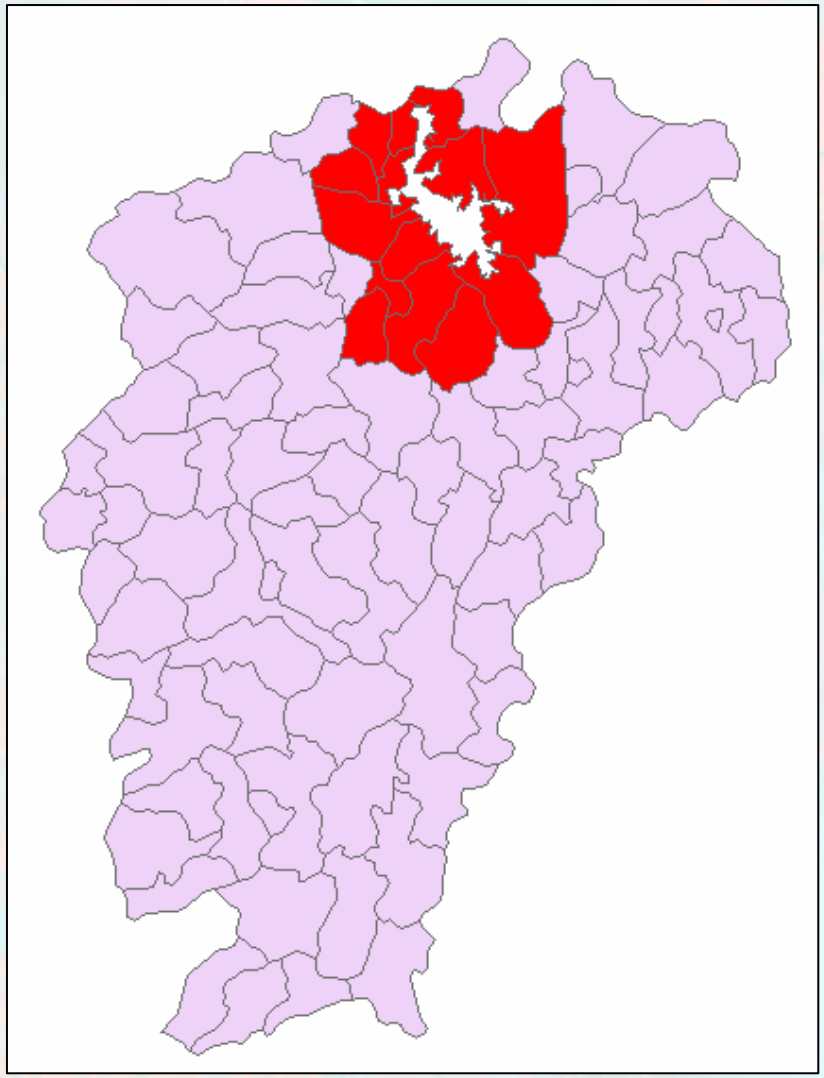
Turner et al. (2003) *Proc of the National Acad. Of Sci. (U.S.)*

LCS and Vulnerability to Flooding



Poyang Lake Region

- Poyang Lake is largest freshwater lake in China.
- Jiangxi Province
- Connected to Chang Jiang
- Average water level fluctuates seasonal from ~7 m to ~19 m a.m.s.l.
- Population of the Poyang Lake Region increased from 7.7 million to 8.7 million from 1990 to 1999.



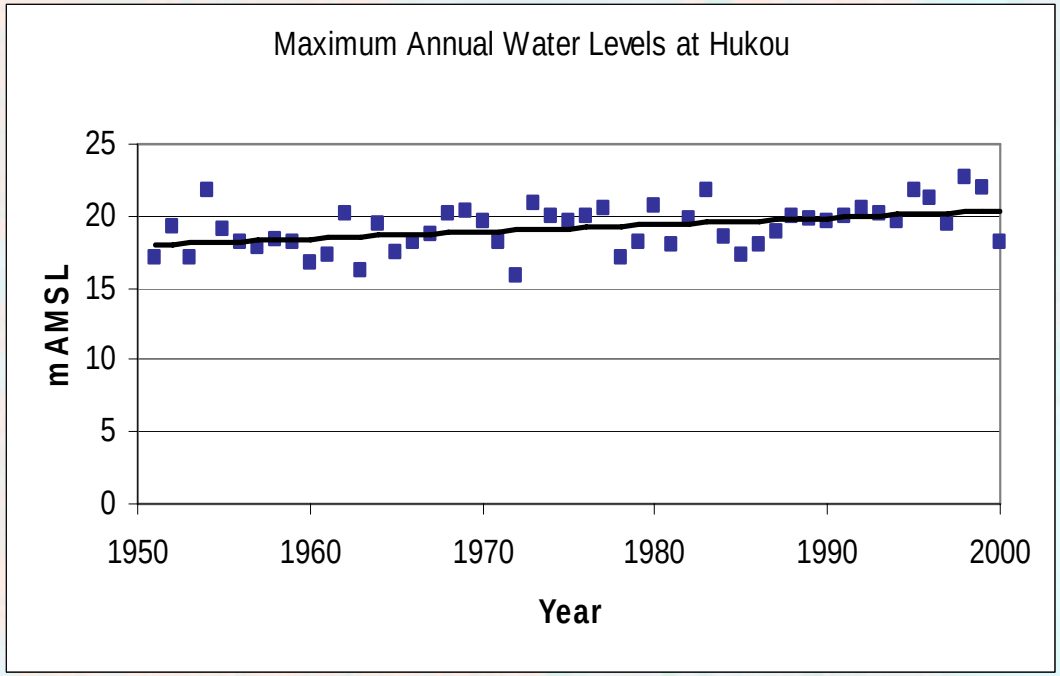
Flooding at Poyang Lake

- Highest water level ever recorded in 1998 (22.6 m)
  - 4 million households damaged
  - 97 levees broken

Causes of rising flood levels:

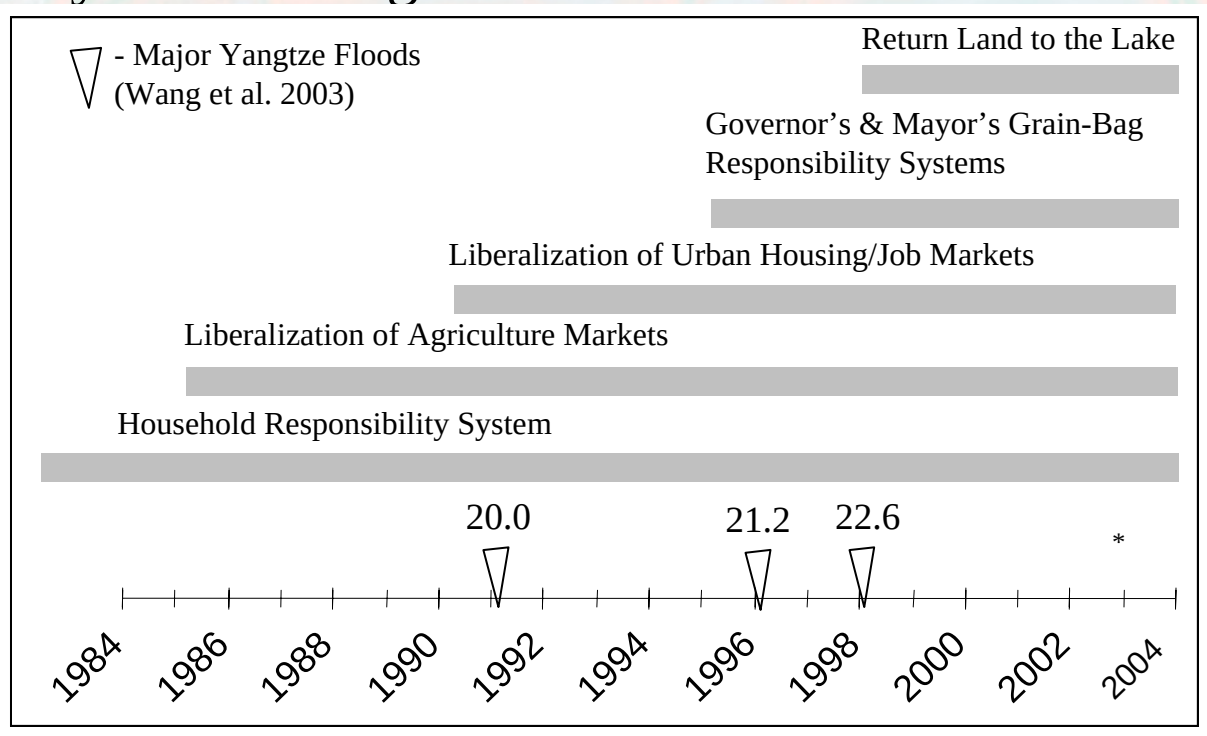
- reduced surface area (levees)
- siltation
- fluctuations in Changjiang levels
- Deviations from trend show correlation with ENSO

Shankman and Liang 2003



Broader Policy Context

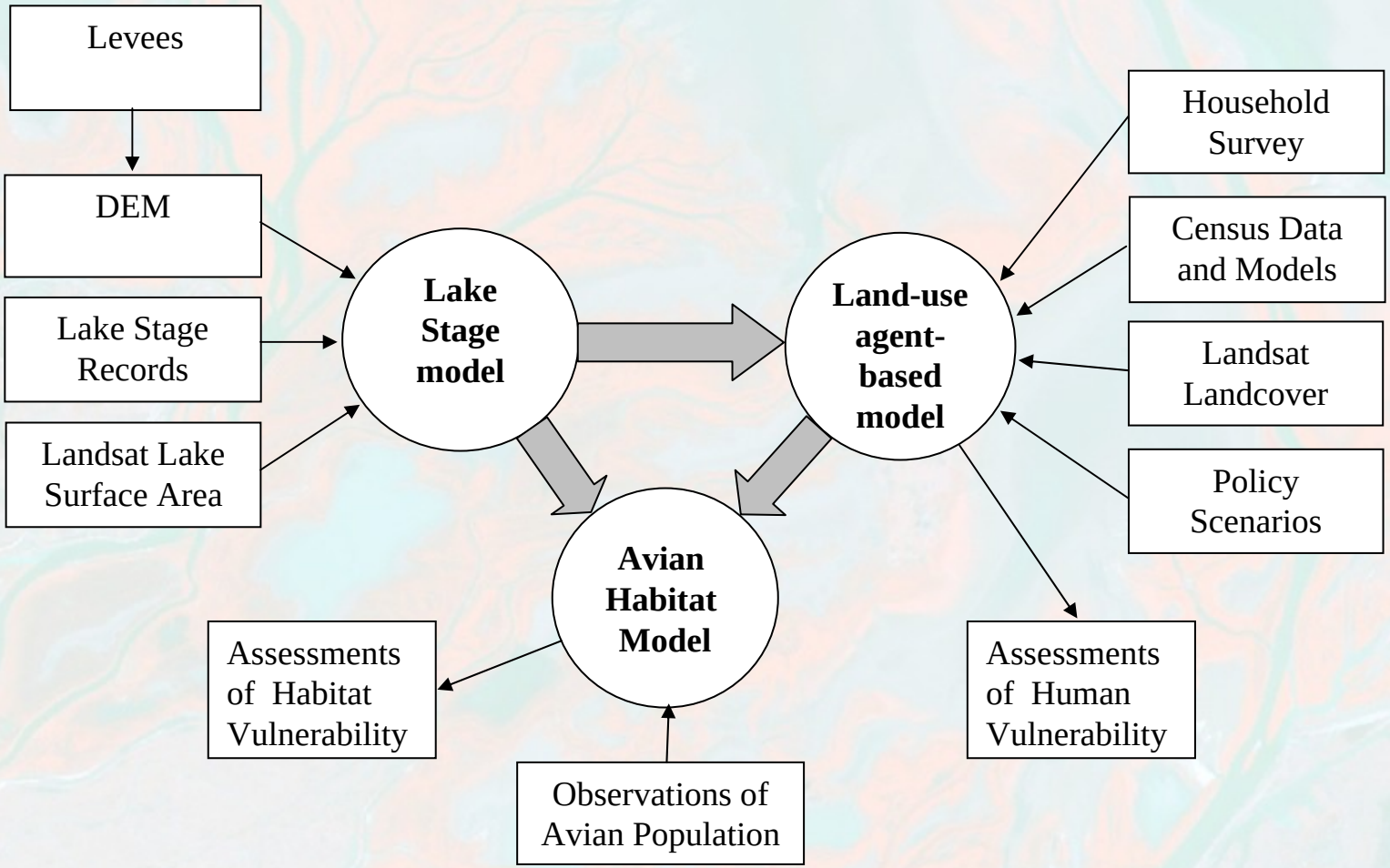
- Economic liberalization has presented increasing opportunities for Chinese citizens.
- Changes in land-use and their effects on vulnerability are driven by these changes.



Our Proposal

- Research questions
  - How have LCLUC patterns and dynamics changed as a consequence of flood dynamics and changes in land and economic policies?
  - How have changes in LCLUC patterns and dynamics affected *vulnerability* of people and economy to flooding?
  - What are the implications of changes for amount of *wetland habitat*?
  - How might future changes in lake levels affect vulnerability of humans and wetland habitats?

Overall Framework



Activities

1. Land-cover characterization
2. Digital elevation/flood modeling
3. Social survey and data analysis
4. Agent-based modeling
5. Ecological/habitat data modeling

1: Land-Cover

Overall:

Goal is to observe, understand, and model changes

Year 1 Goals

- Acquire Landsat images.
- Analysis of alternative land-cover characterization approaches and development of protocol

Year 2 Goals

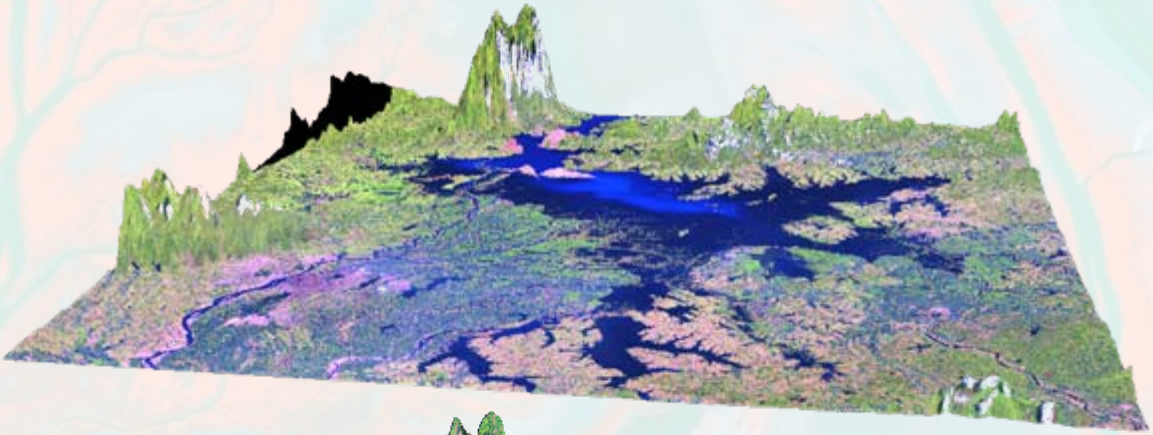
- Implement protocol for processing Landsat images.
- Spatial modeling of land-cover dynamics in comparison with (a) variations in flood dynamics and (b) trends in the demographic and economic context based on spatial statistical models.

Important land-use changes

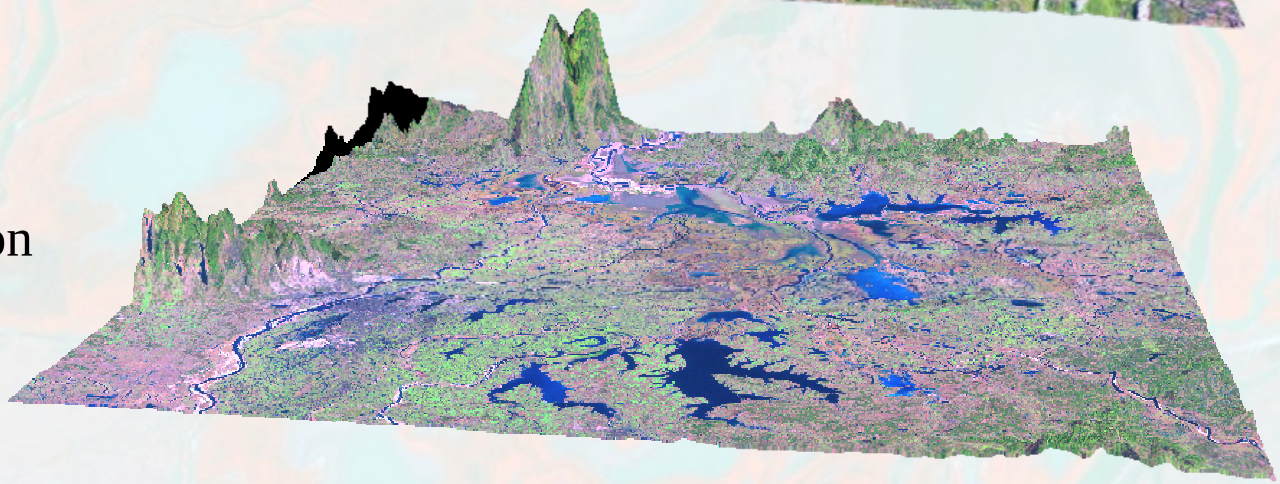
- Factors: flooding, policy, changes in agricultural market structure (Vegetables are 5-6 times profitable of rice), land-use tradition
- Early period (before 1980s) – rice, build aquaculture ponds
- ~mid-1990s – farmland abandonment begins, less profit
    - Mostly rice (e.g., go from 2 plantings to 1)
- Increase in area of market crops (e.g., tea, vegetables)
- Forest area (planted monoculture) increase: source of energy, out migration, switch to coal/gas
- Agricultural response to flooding: short-term effect, but increased risk, may combine with market changes to encourage 1 season instead of 2.

Multi-Season Image Pairs

Summer Flood Season



Winter Low Water Season



Landsat Images

- Dates of acquired data.

Dates of Image Pairs	1983/84	1987/89	1993	1999/2000	2004
Winter	1983/11/28	1987/12/17	1993/1/31	1999/12/10*	2004/3/10
Summer	1984/8/2	1989/7/15*	1993/7/10	2000/7/5	2004/7/24

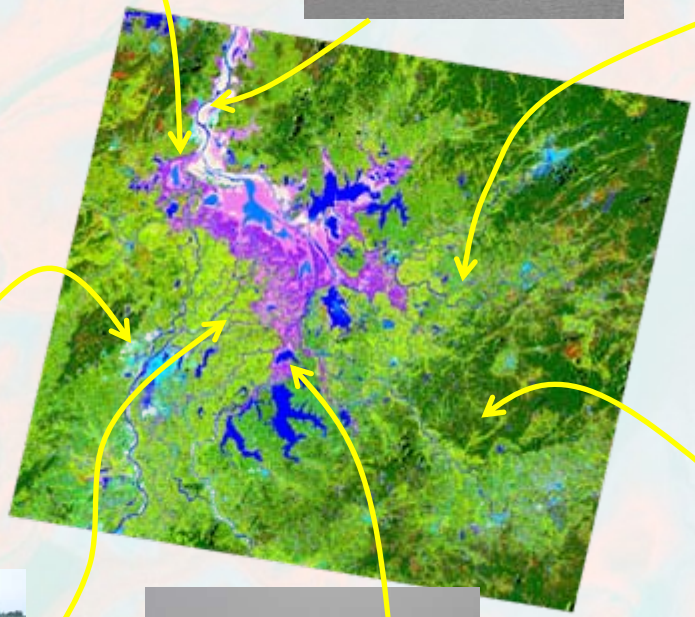
1995/1998 Floods

Land Covers – Jan/June 2006

Levee

Lake/River Shore

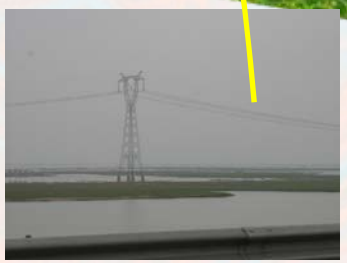
Upland Crops



Village

Forests

Rice Paddy



Seasonally Flooded

2: DEM/flooding

Overall:

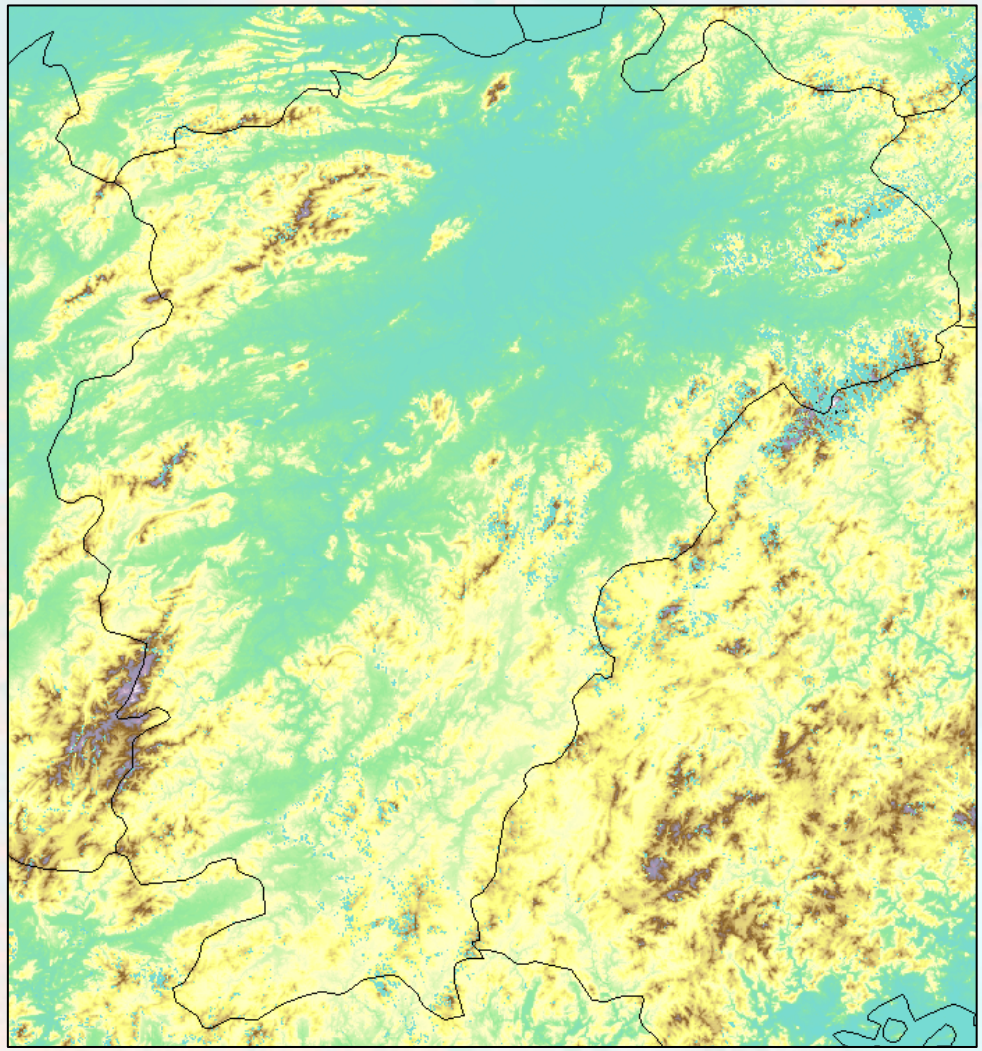
Goal is to characterize spatial-temporal dynamics in flood levels based on DEM.

Year 1 Goals

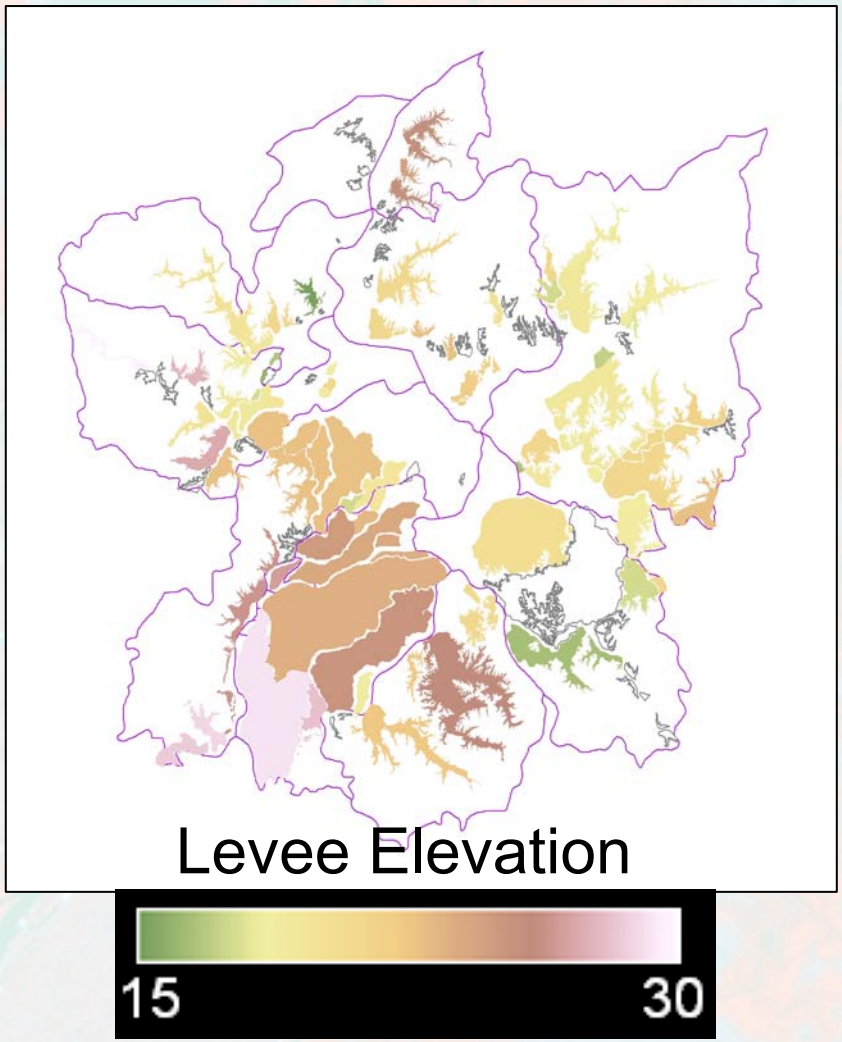
- Edited and validated DEM.
- Calibrated level-area relationship for Poyang Lake, based on the best available DEM data, historical lake levels and Landsat images.
- Identification and digitization of archival GIS and other data.

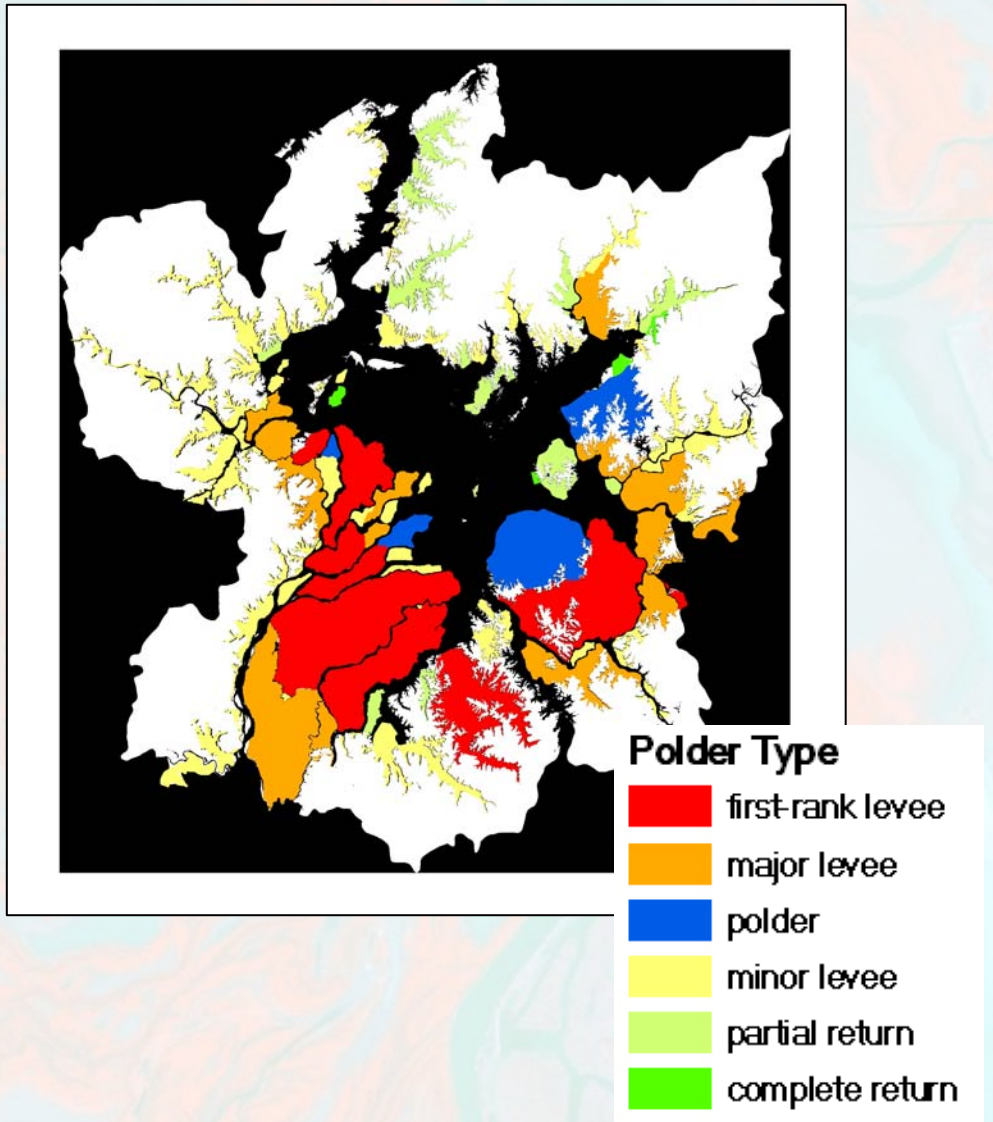
Shuttle Radar Topographic Mapping (STRM)

- Digital terrain data collected Jan-Feb 2001
  - Lake at low level
- Resolution: 90 m
- We are supplementing with data on levees.
- Relation between lake volume and water levels used to characterize flood dynamics.



Levee Information

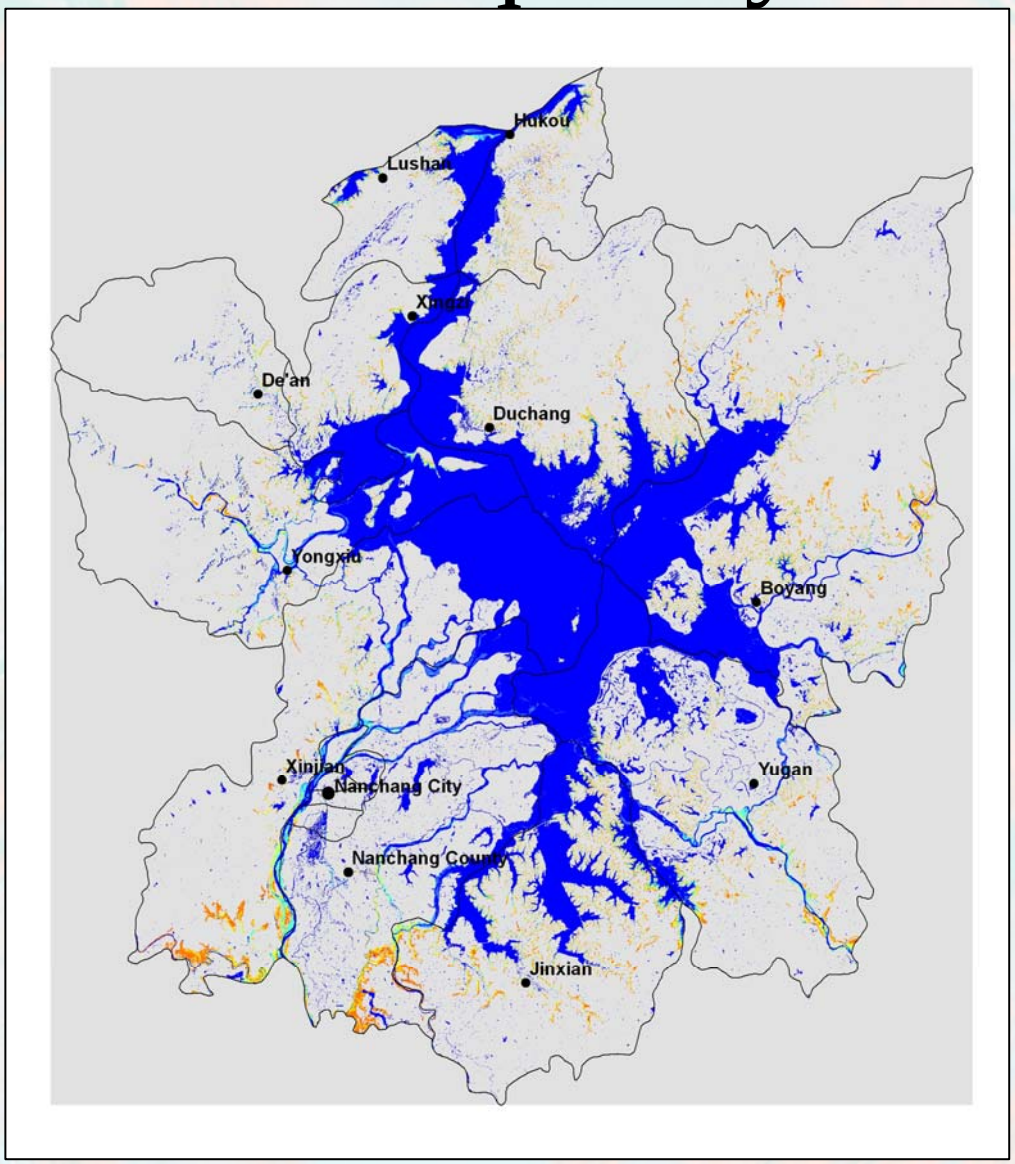




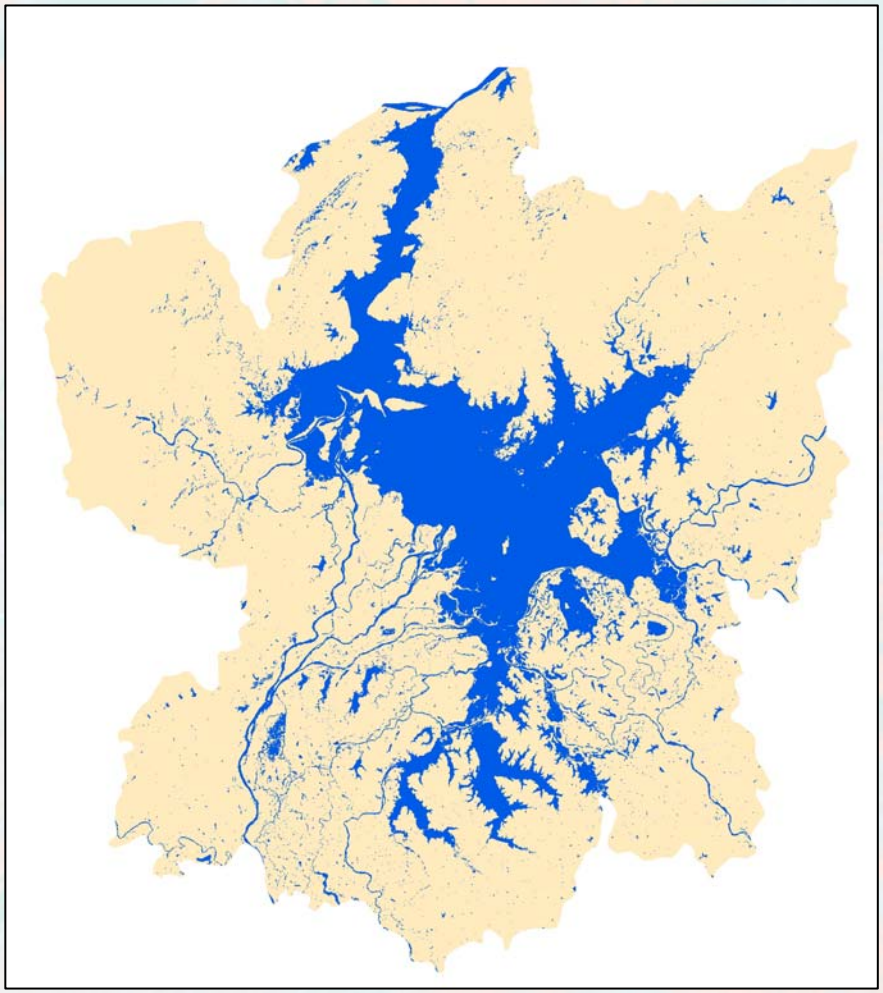
Lake Levels

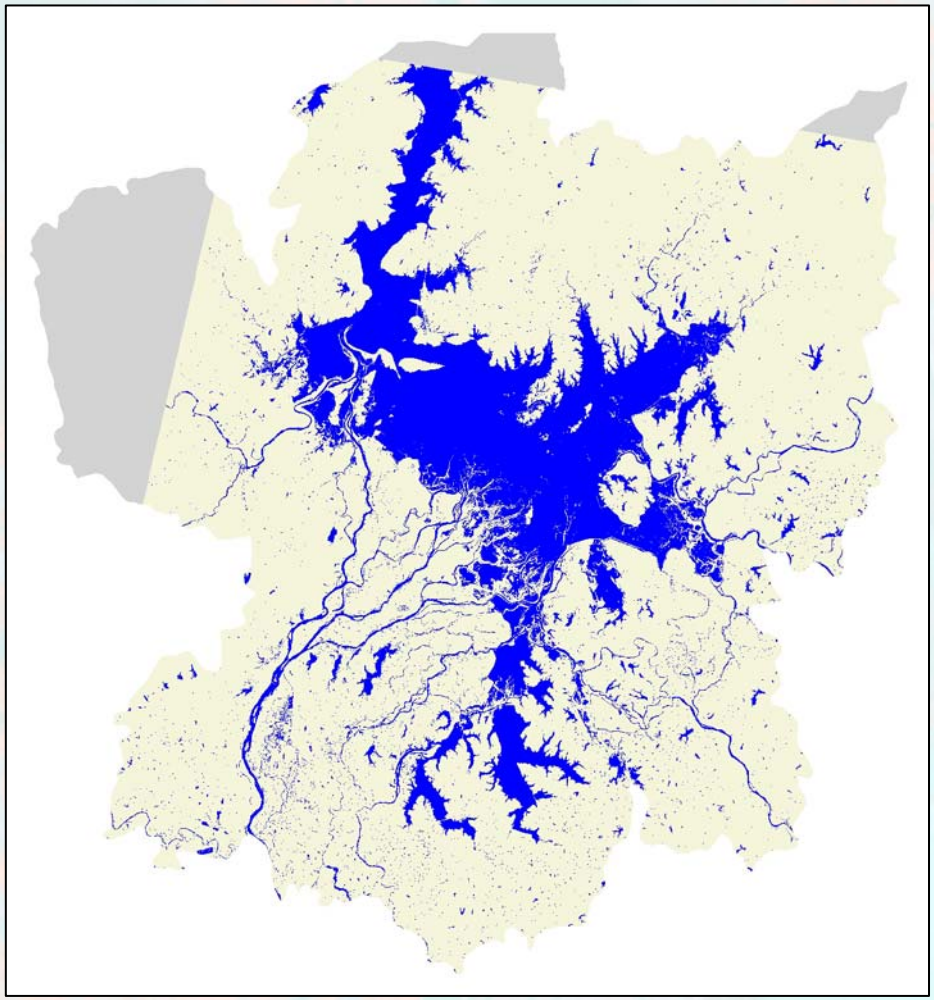
- Statistical summaries of lake levels from last 50 years (including trends) provide basic probabilistic model.
- Estimated distributions can be modified to evaluate flooding scenarios based on basin LU change, hydrologic and climate changes.

Flood Frequency from DEM



Comparison of DEM and TM





3: Social Data Analysis & Survey

Overall

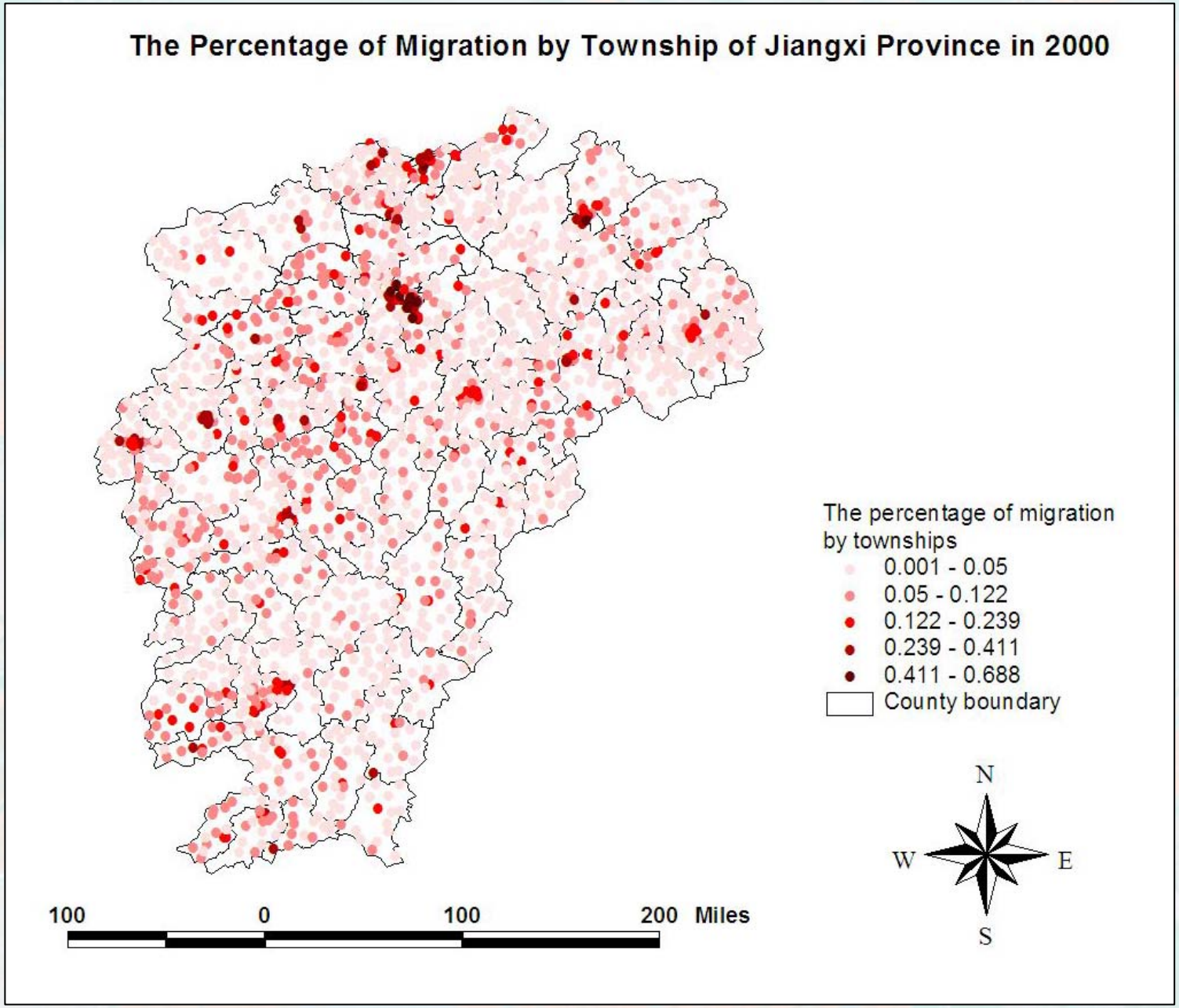
We want to characterize and understand the factors affecting decision making related to out migration and land-use.

Year 1 Goals

- Development of spatial statistical models of economic and demographic context of Jiangxi Province and the Poyang Lake Region.

Year 2 Goals

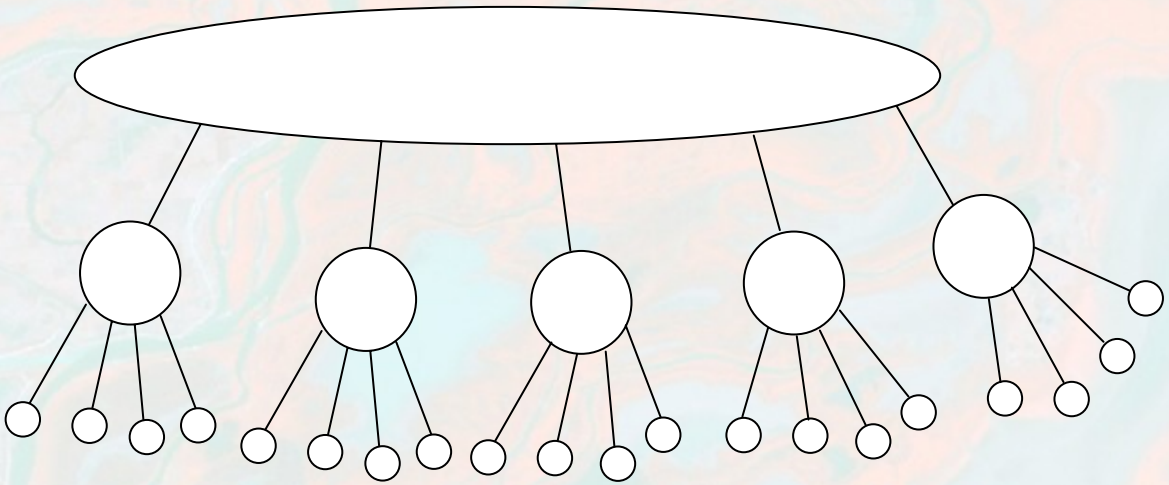
- Survey of with village leaders and sampled landowners and farmers.


The Percentage of Migration by Township of Jiangxi Province in 2000
The percentage of migration by townships
0.001 - 0.05
0.05 - 0.122
0.122 - 0.239
0.239 - 0.411
0.411 - 0.688
County boundary
N
W
E
S
100
0
100
200 Miles

Household Survey

- Sample of villages (n=4-8) stratified by flood risk.
- Sample of households within villages (~50)
- Questions structured to identify economic inputs and outputs at the household level, as well as perceptions of flood risk.

Village Structure



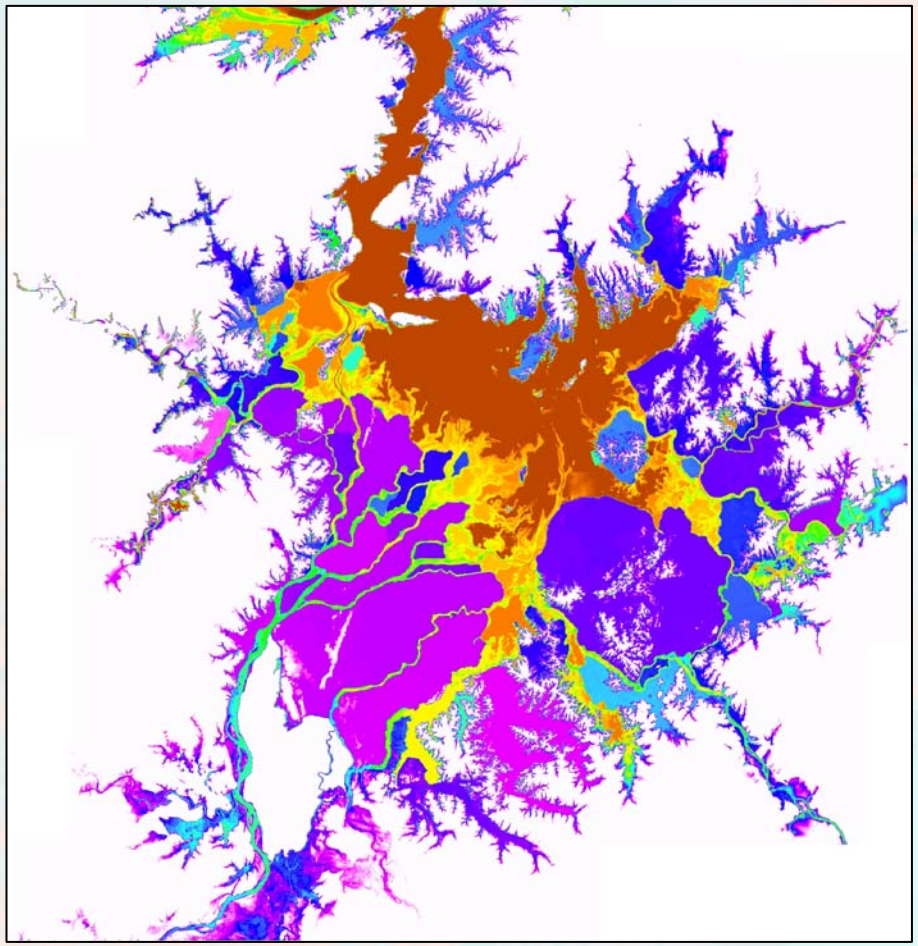
Administrative Village

Natural Village
(~10 per A. Vill.)

Households
(10-200 per N. Vill.)

Flood Risk Mapping

- Used to stratify village sample.
- Combination of ground elevation (DEM), levee height, and levee quality.
- Purples and blues are low
- Orange and red are high.



4: Agent-Based Modeling

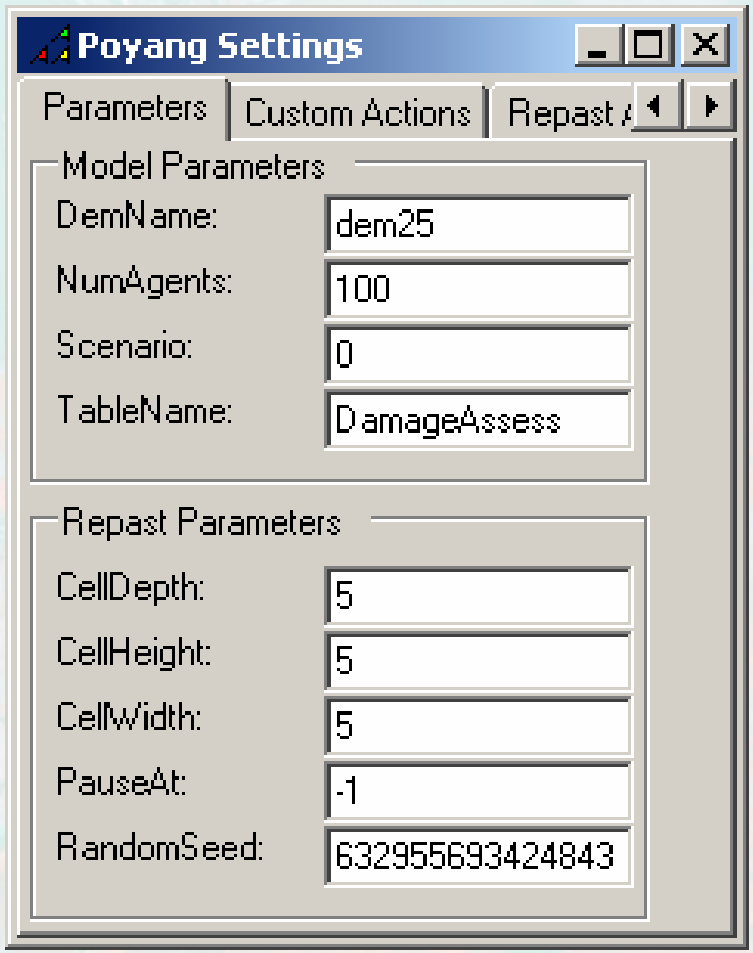
Overall

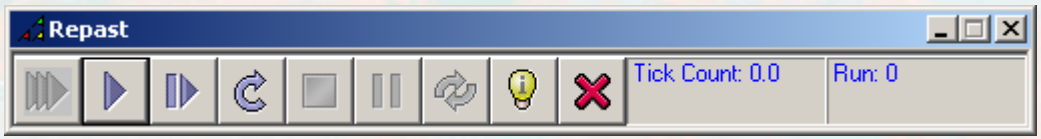
The goal is to represent dynamics of decision making that affects land use in the context of economic conditions and policies as well as flood risk.

Outputs are land-use maps and vulnerability measures.

Year 1 Goals

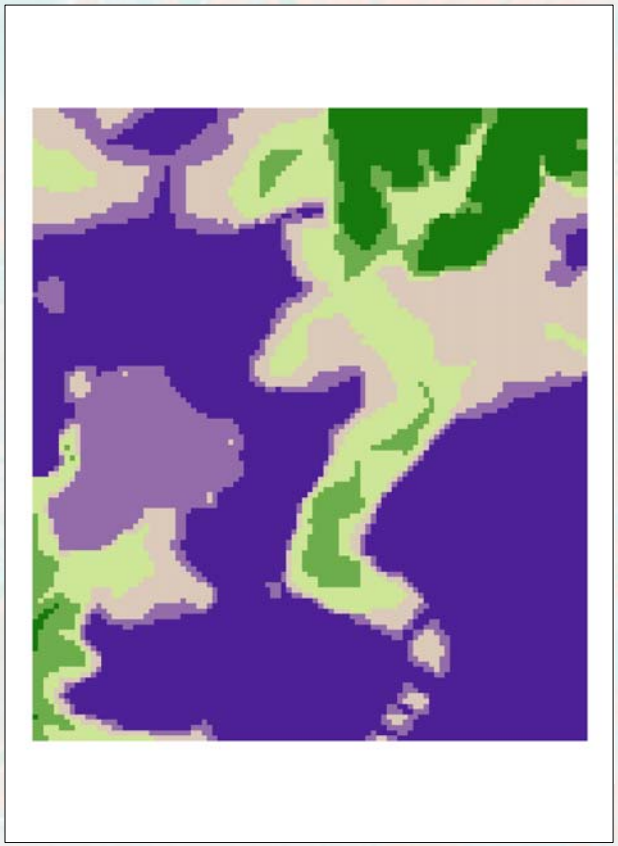
- Development of conceptual framework for agent-based model with Chinese colleagues.
- Programming and analysis of skeletal agent-based models, presentation to and discussion with Chinese collaborators.

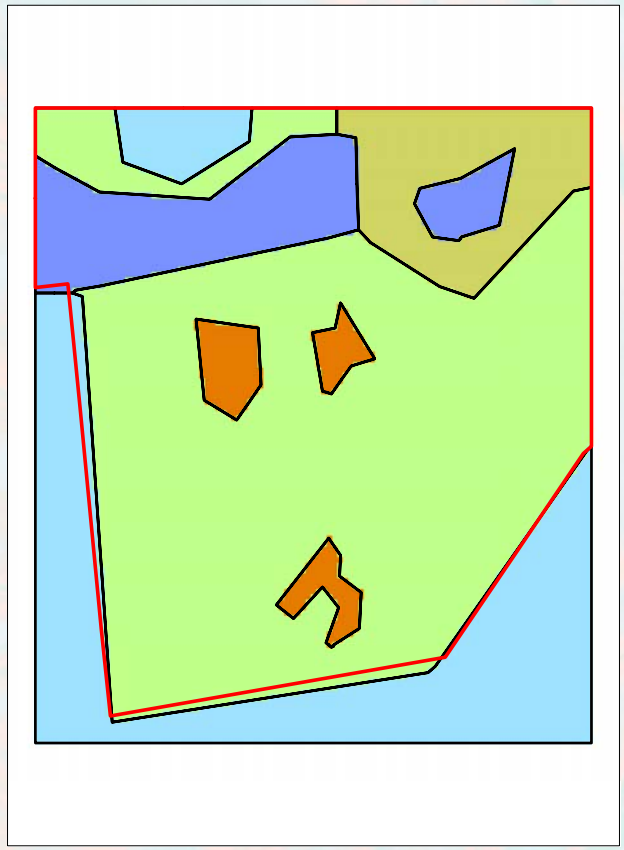




Skeletal model created using RePast and ArcObjects.

Data Sets:
DEM, levee map, land capability zones





Legend

dem25m

Value

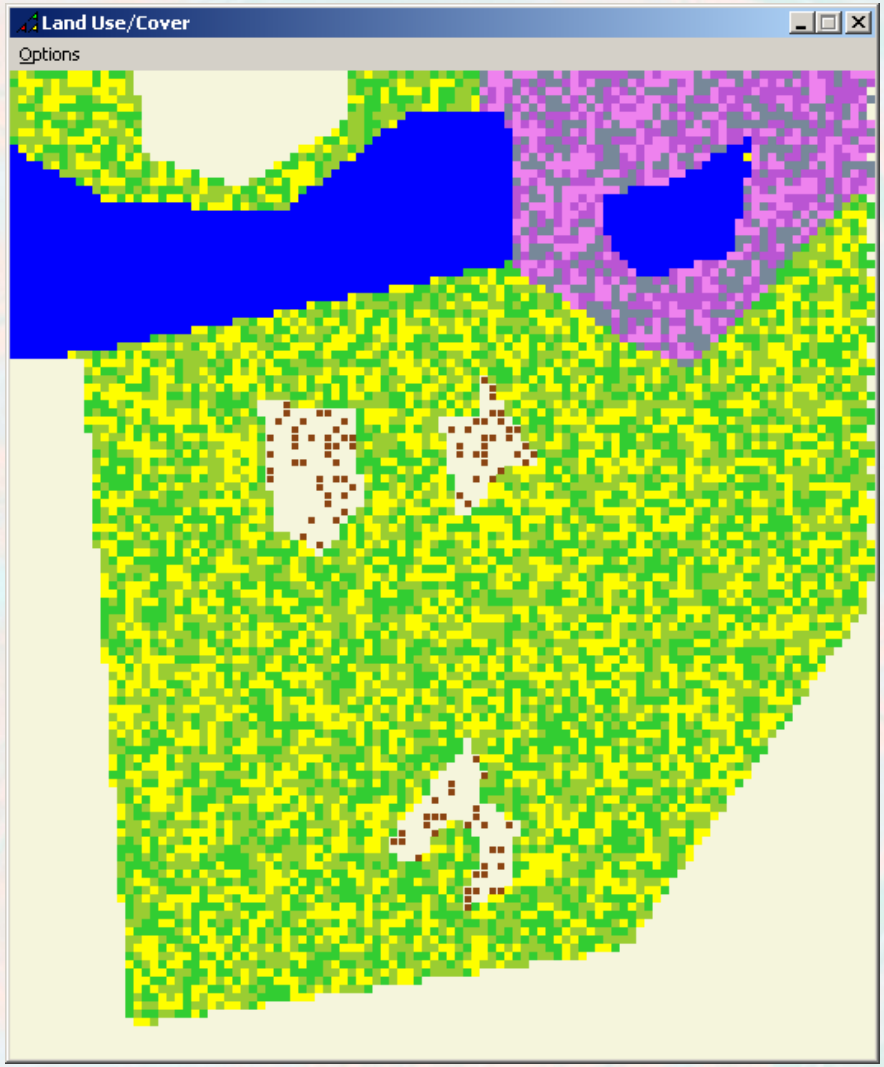
- 126
- 126 - 129
- 129 - 135
- 135 - 140
- 140 - 150
- 150 - 326

Legend

- levee
- wetland
- aquaculture
- residential area
- lowland
- highland

Scenario1: levee is removed

At the beginning



Scenario1: levee is removed

5: Ecological Modeling

Overall

Goal is to develop an empirical habitat model that we can use to relate changes in water levels and land-cover to ecological impacts on water birds

Year 1 Goals

- Collection of field-based land-cover and bird-observation data.

Data

- In-country collaborators working with conservation agencies to acquire existing observational data.
- World Wildlife Fund International Crane Foundation collected observations of white crane since 1994 (other birds since 2000) at 40 points in lake.
- Poyang Lake Nature Reserve Office also has observational data

Scenarios

Integration of components to evaluate economic, human, and ecological impacts of changing policy and flood levels

Flooding component

- Recent trends continue
- Recent trends continue, but more levees are removed
- Flooding trends altered by Three Gorges Dam

Policy component

- No change
- Further liberalization of land and migration policies
- More rapid development of Poyang Lake Region

Next Steps

- Develop five dates of land-cover classification (Q2 2007)
- Implement spatial statistical model of migration (Q1 2007)
- Conduct survey (Q1 2007)
- Continue ABM model development (on-going)
- Further definition of scenarios


谢谢

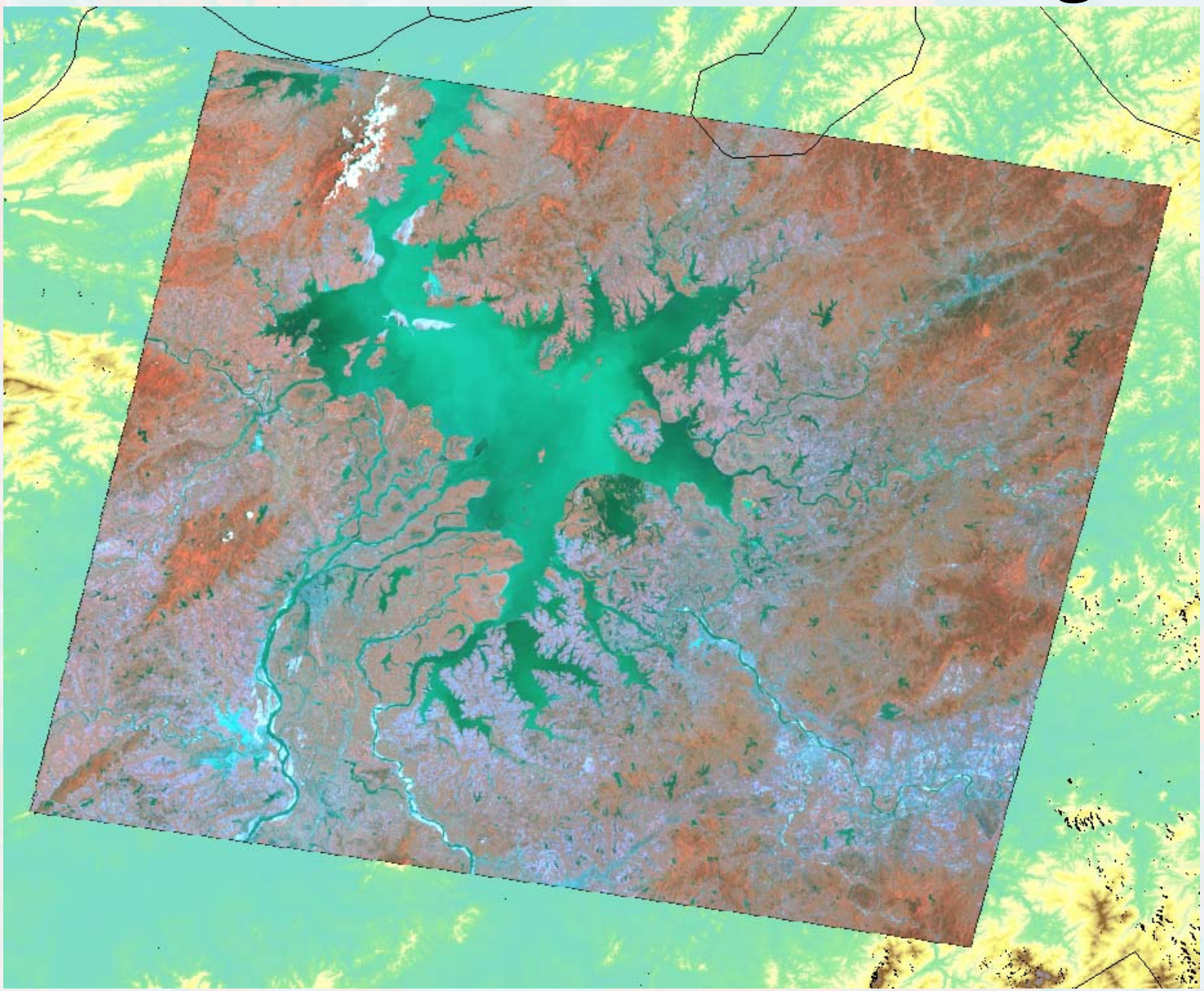
Jiangxi Poyang Lake Nat'l Nature Reserve (talk with Ji Wei Tao, Director)

1. ICF – four sites within preserve area counted every week, four times per month, count only big birds. 1994-2005
2. WWF – 49 points over lake, 2004-2005.
   - Talk to WWF, office in Beijing, www.wwfchina.org, 010-65227100
3. Jiangxi Natural Preserve Office –
   a) mark locations of birds within the preserve area on the 3's and 8's of the month.
   b) observe from fix locations (3)
      a) Chapter in Poyang Lake research book.

WWF report

- ISBN 7-5038-3857-4
- Waterbird Survey of the Middle and Lower Yangtze River Floodplain in Late January and Early February 2004
- by Mark Barter, Chen Liwei, Cao Lei, and Lei Gang
- China Forestry Publishing House
- 49 wetlands observed

Historical Landsat Images



Low-water image:

10 Dec 1999

High-water image:

15 Jul 1989

History

- 1960s lots of levee construction for farmers
- 1978 – last levee built (1970s levees built for flood protection)
- 1980s – reforms started, households start to have more of influence on land use (now gov’t and hh)
- 1998 – levee destruction begins
- 2004 – food security plan - gov’t eliminate agriculture tax, provide subsidy and penalize abandonment

Seasonal Changes

- Rice
  - Planted in two seasons:
    - Apr-Jul
    - Aug-Oct
- Natural Wetlands
  - Jan-Feb: low water
  - June: grass productivity peaks
  - July: wet, water peaks

DEMs

- 1:50,000 DEM – UM cost sharing ($500)
  - 1977
- 1:25,000 topos – in process (AutoCAD)
  - 1952, December
  - Includes levees, contours, land cover, roads
  - 1 meter interval
  - Yangtze River Hydrological Commission
- 1:25,000 topos – MRL has coverage
  - 1983
  - Jiangxi Survey Agency updated 1952 maps
  - 3 sources: Army, previous maps, additional surveys

Survey Suggestions

- When asking about land-use types, use same categories as government statisticsn
- Change question about party membership to “position in government”
- Drop question about army.

Issues

- MRL has 1:50,000 township boundaries
- County level most have 50 years of social data

- Estimate net migration.
- Develop models and select variables to describe push/pull factors that affect migration.
- Develop and pre-test questionnaire – draft available.

Polder Conditions

- Not impoldered – uplands
- Not impoldered – lowlands
- Impoldered – farm fields and residents
  - different heights = different risks
- Partially restored polders – farm fields only (but residents still there)
- Restored polders – no farms or residents

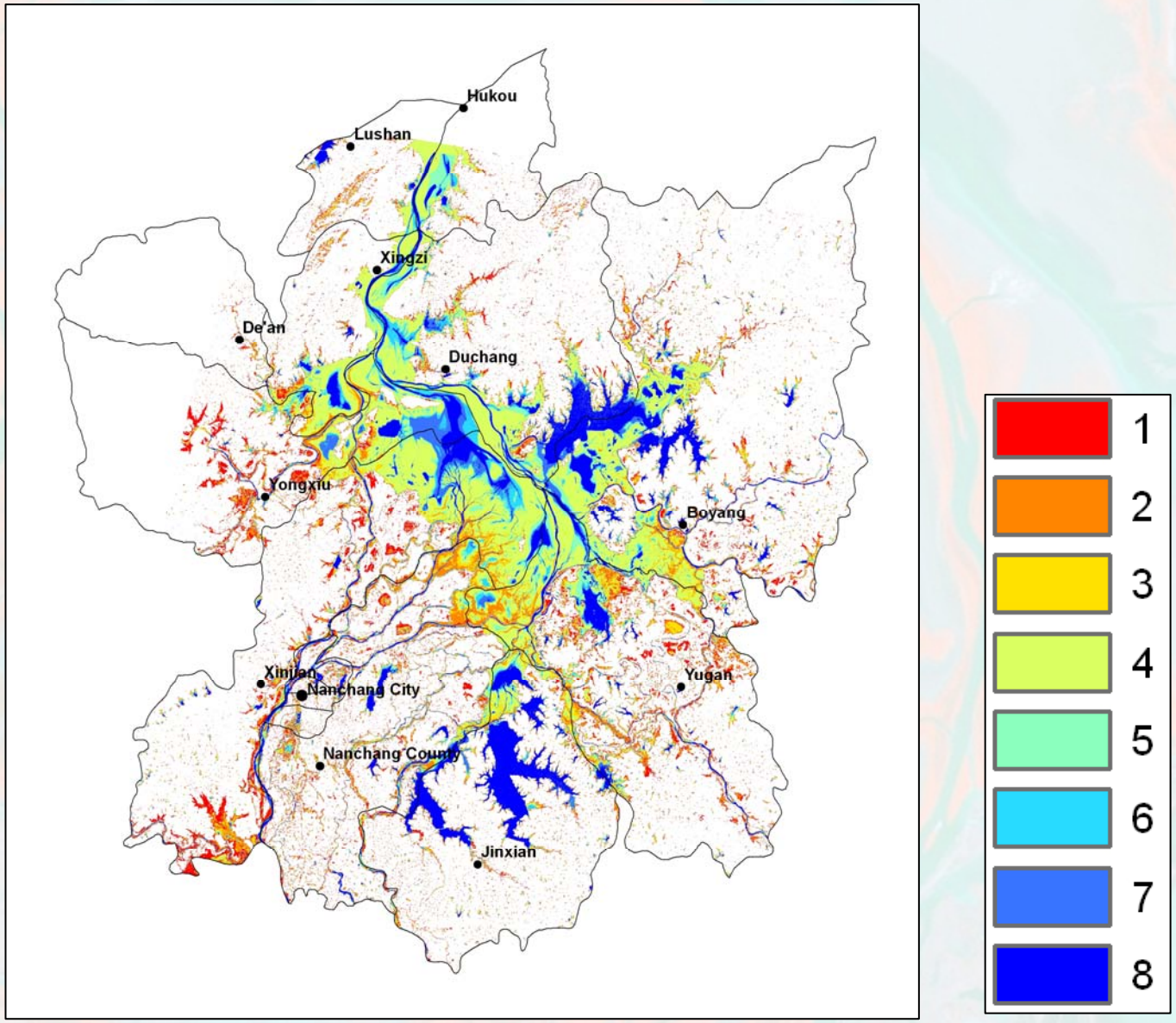
Issues

- Who are the primary actors?
- What are their key decisions with respect to land-use?
- What attributes of the actors or of their context (environment, policy, social/economic context) affect those decisions?
- How are the decisions made?

Actors and decisions

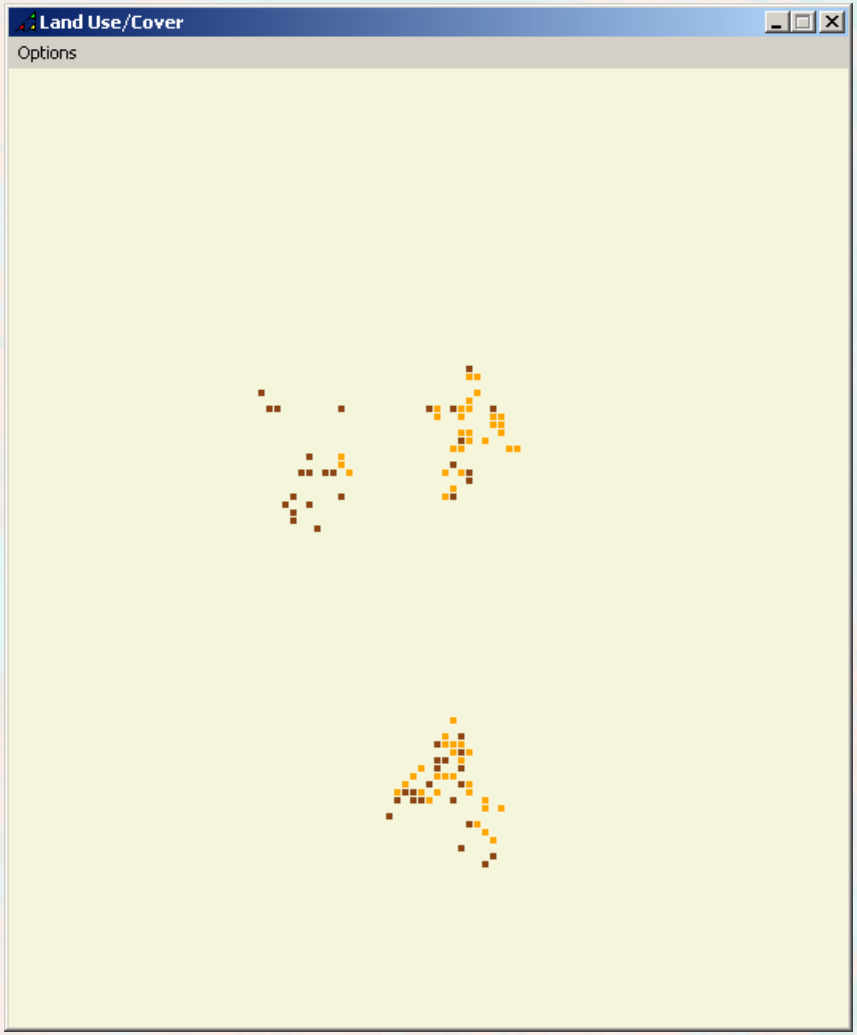
- Households
  - To move
    - Temporary migration but maintain house – abandon crops
    - Forced movement for flood protection, improved infrastructure
    - Farmers can buy house in city or move from area
  - How to earn a living
    - What crops? – affected by technical support from gov't
      - decisions affected by neighbors
    - Raising ducks/chickens
    - To abandon crops? – crops unprofitable
    - Off-farm income? – primary income w/ farming
- Government (central)
  - decide policy, actions affected by economic situation
  - establishes wildlife protection laws
- Government (agency local offices)
  - infrastructure investment
  - upland areas managed by forest dept., underwater by Agriculture
- Market

Frequency of Water from Images



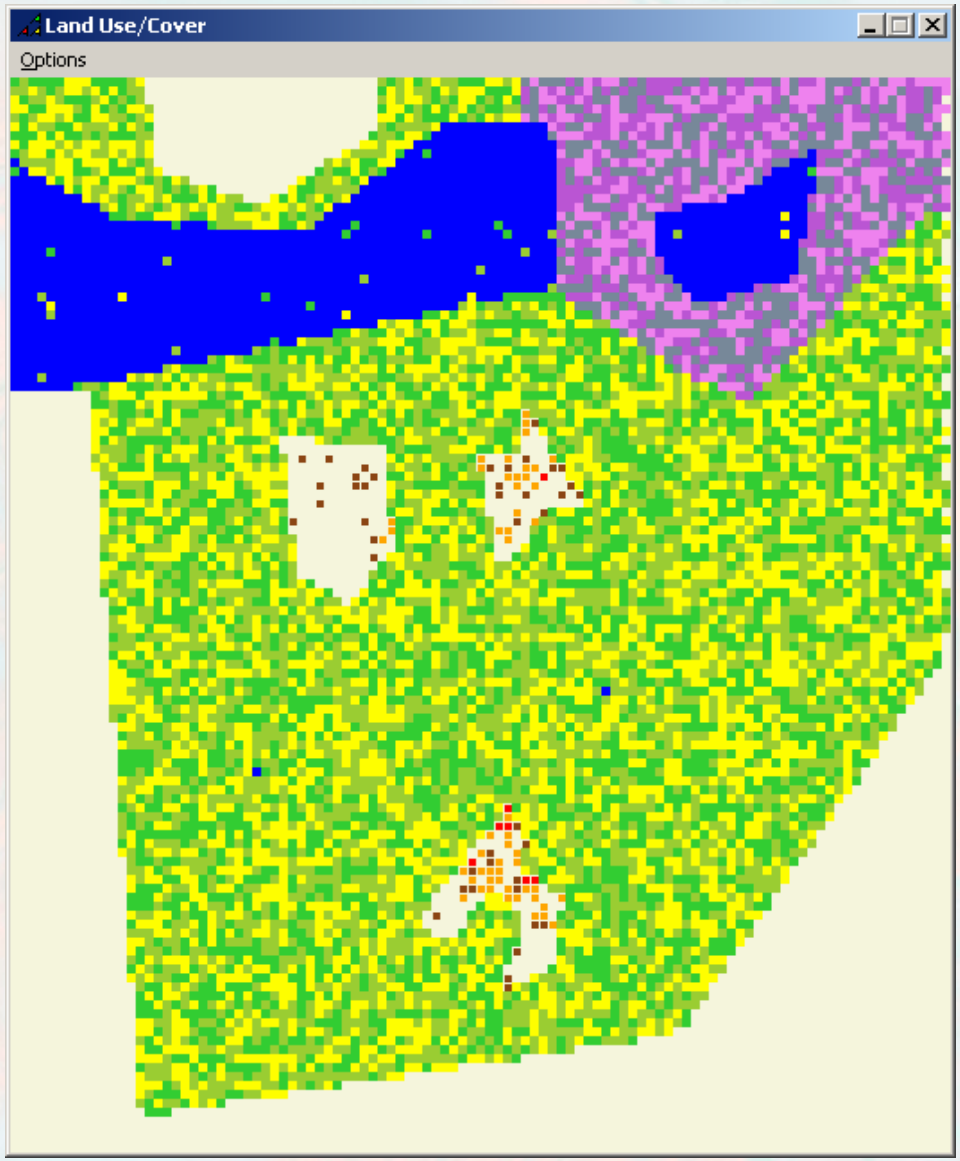
Scenario1: levee is removed

After harvest



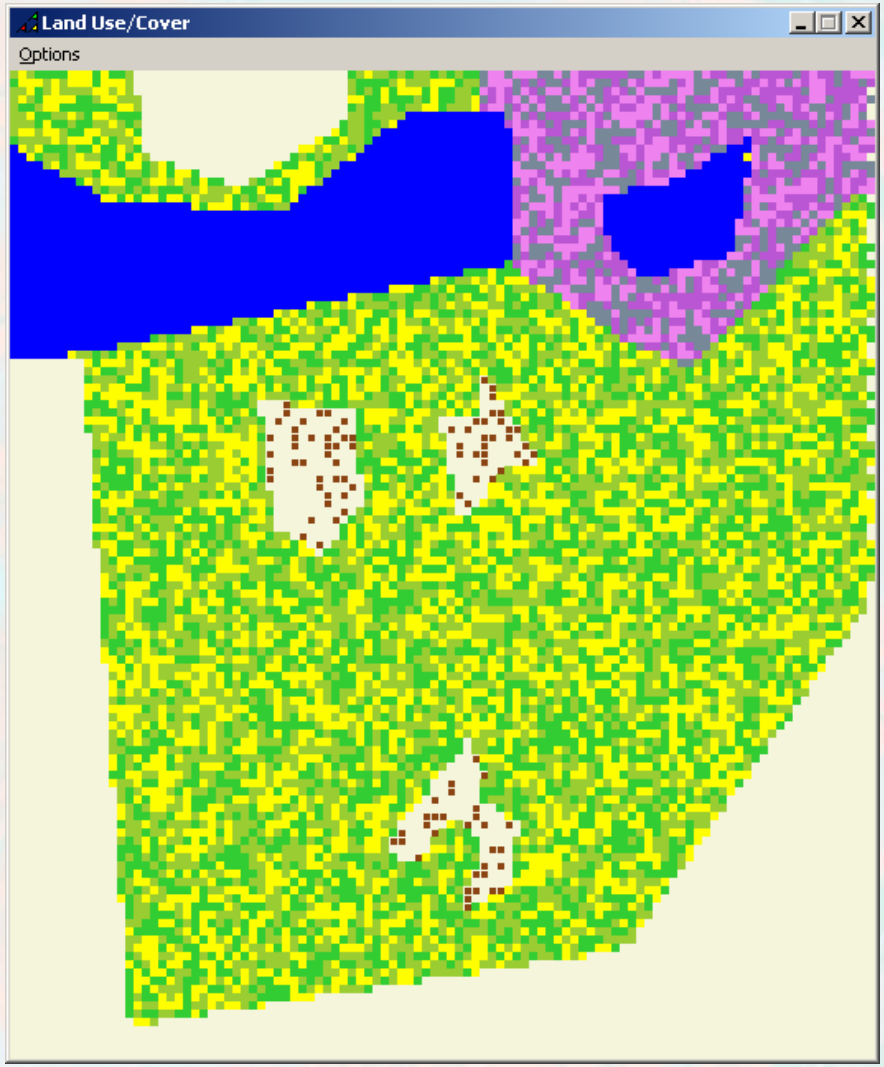
Scenario1: levee is removed

some years later



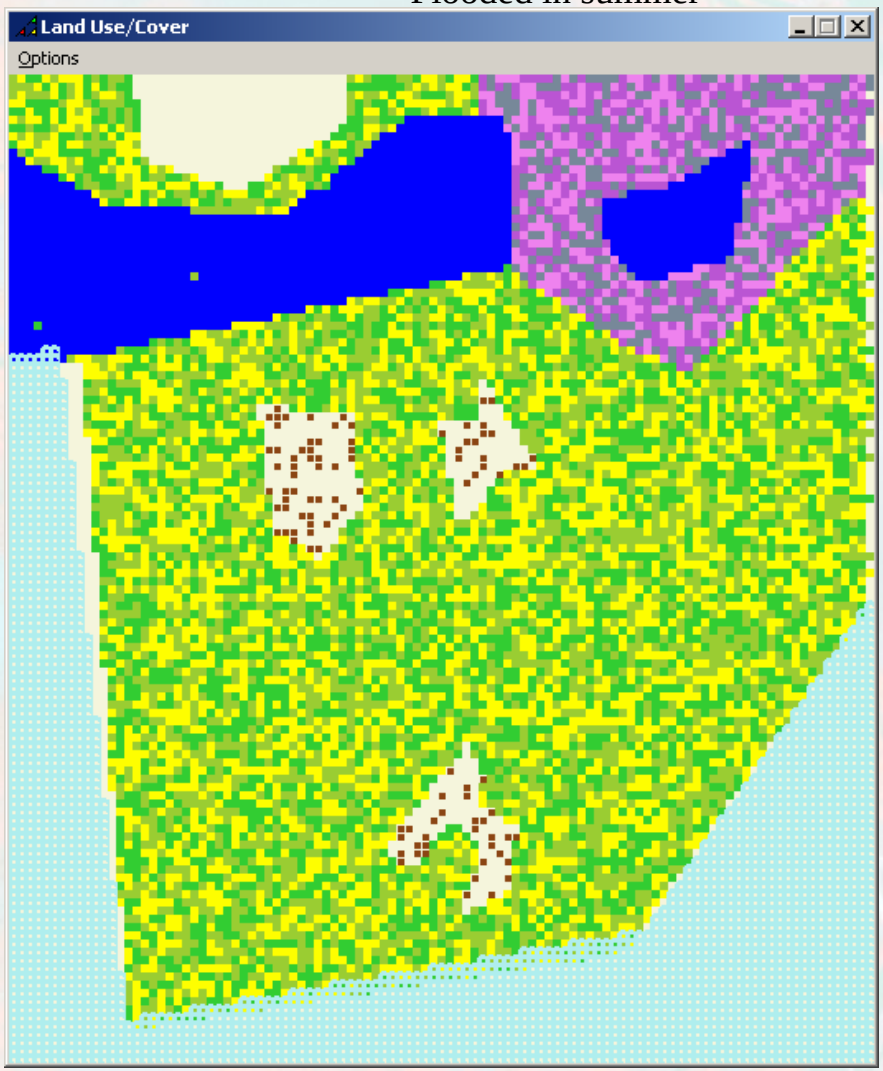
Scenario1: levee is present

At the beginning



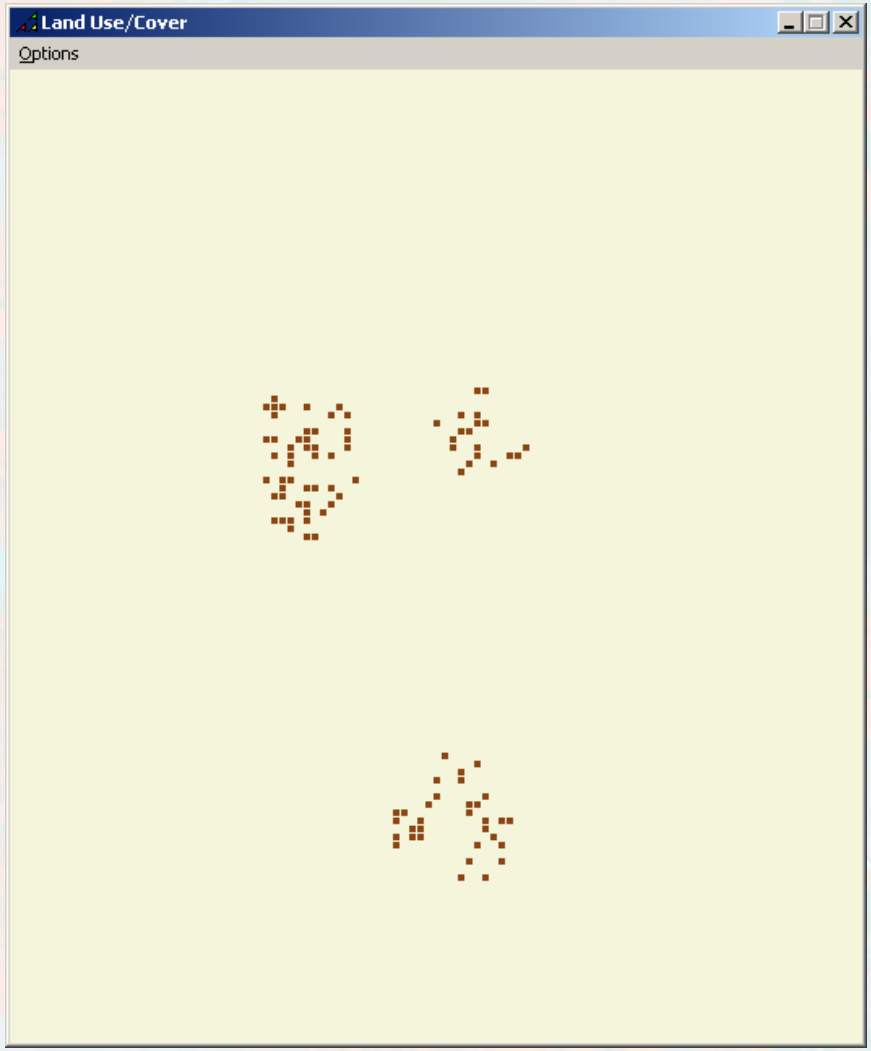
Scenario1: levee is present

Flooded in summer



Scenario1: levee is present

After harvest



Scenario1: levee is present

The same years later