African Sustainable Livestock 2050

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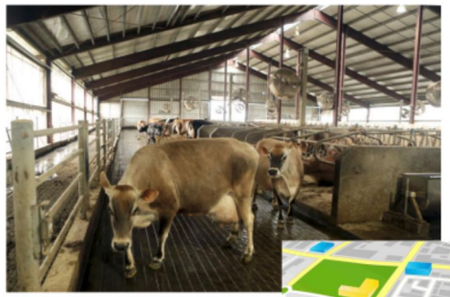
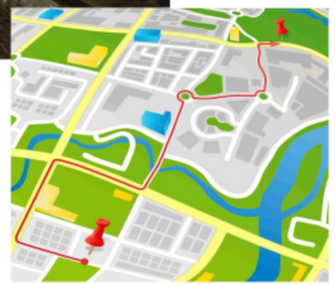
EcoHealth Net Research Exchange Intern, Summer 2017

EcoHealth Alliance

Local conservation.
Global health.

About Me





About Me

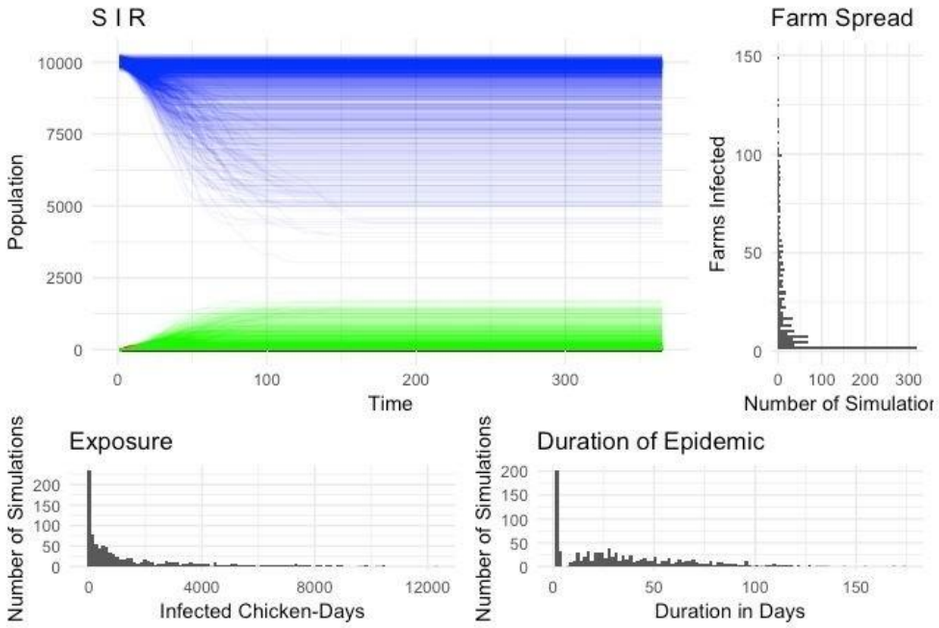
African Sustainable Livestock (ASL) 2050

- FAO project funded by USAID
- Goals:
  - identify opportunities and threats associated with the long-term development of livestock
  - agree upon priority reforms and investments, and the capacity needed for their implementation, to ensure sustainable development of the livestock sector in the next three or four decades.

- Countries: Burkina Faso, Egypt, Ethiopia, Kenya, Nigeria and Uganda

EHA & ASL 2050

- Metaflu (Hosseini et al, 2013) package to simulate propagation and impacts of seeded avian influenza outbreaks
  - Kate: variable farm sizes, growth, culling
  - John: presence/absence of markets, effect on households and farms
  - Me: spatial data collection, developing pipeline for 'real world' data input into Metaflu



Key Actors

Households

- Key exposure points for humans
- 60-85% of livestock sector in ASL countries is driven by household/backyard poultry farming
- Easy targets for interventions and incentives

Commercial Farms

- Operations of scale, most impacted by avian influenza outbreaks
- Most ASL2050 countries aim to expand commercial poultry operations in next decade-incentive for improved biosecurity

Markets

- Daily, weekly markets frequented by majority of people
- Locations of high chicken movement between actors

Knowns & Unknowns

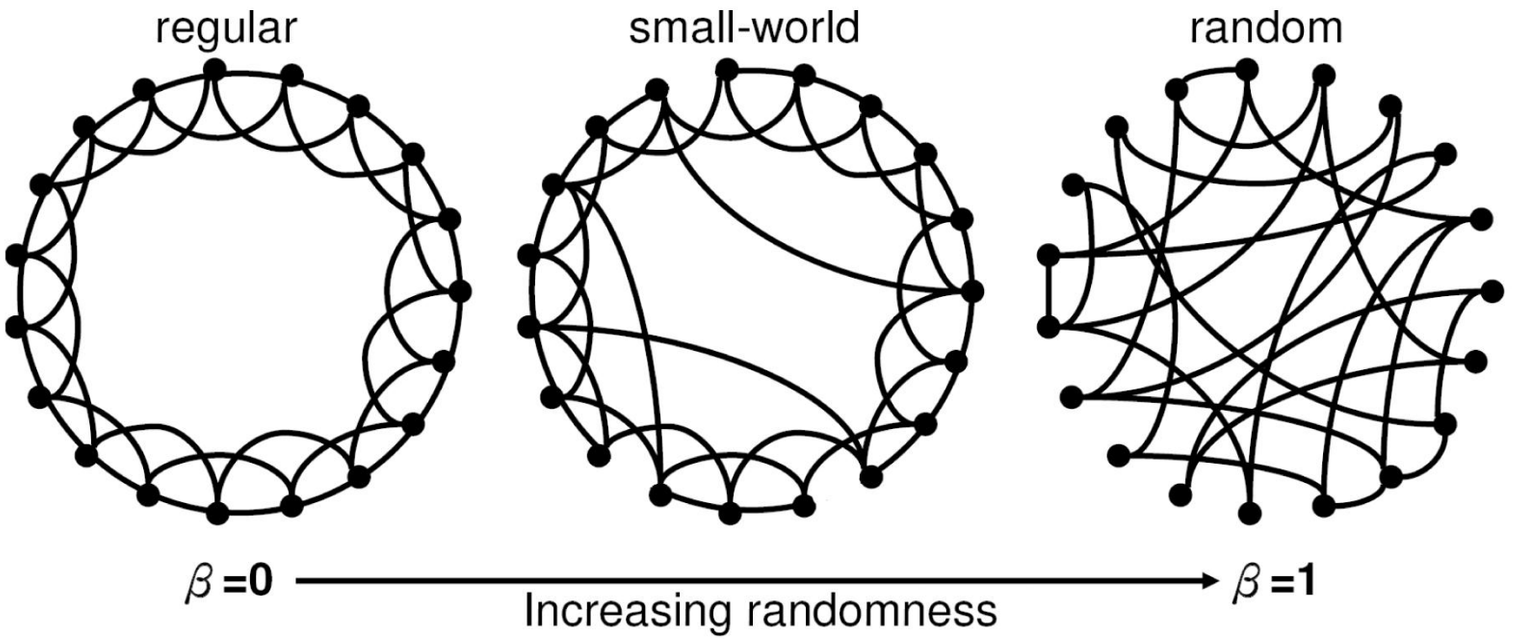
Unknowns

- Locations of farms & households
- Flock size at farms & households
- Flock size at markets

Knowns

- Representative areas
  Source: livestock surveys
- Household weights
  Source: livestock surveys
- Commercial farm size information
  Source: literature
- Network of farms and households contributing to markets

Small World Networks



Watts, Duncan J., and Steven H. Strogatz. Collective dynamics of 'small-world' networks, Nature 393.6684 (1998): 440

Goals & Methods

- Ground Metaflu simulations in reality
  - Country-wide poultry sector information collection
  - Spatial data processing
    - Probability surface development and spatial sampling for households and farms
    - Assignment of 'farm size' based on extensive/intensive production rasters

- Apply Small World Network principles to Random Spatial Networks
  - Generate network representations of spatial data
  - Define how each actor is connected to the others
  - Parametrize network to allow for testing of intensification and connectivity

- Identify limitations of existing data, and generate models and questions to share with FAO theme leaders

Livestock Survey Data

- Primary data source: Country-level Livestock Survey data aggregated by FAO

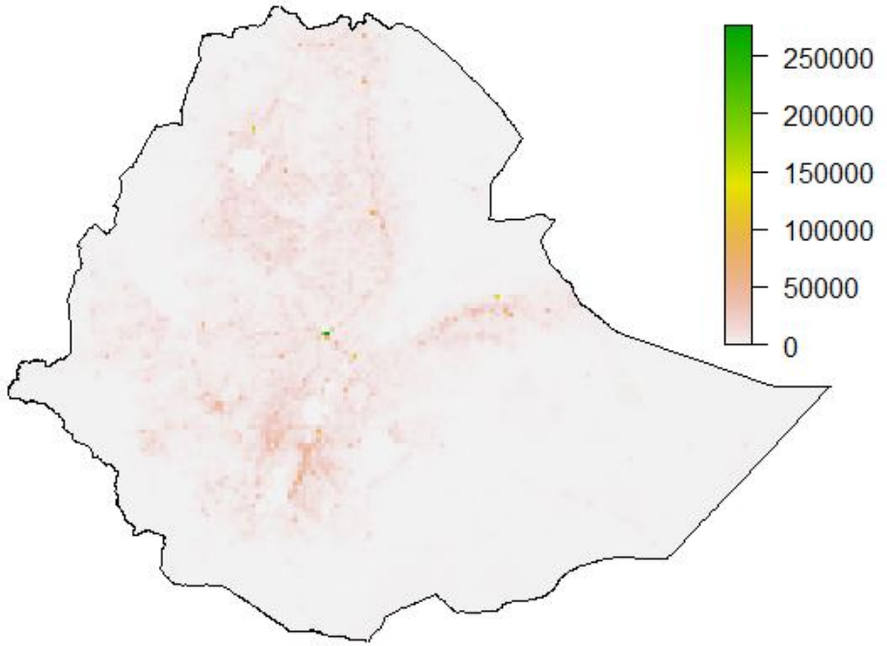
```
##    HHID    EAID Latitude Longitude Household.Weight Chickens
## 1 87095 1912049    9.324    38.592              3971        8
## 2 86375 1270896   10.394    38.225              4752        2
## 3 84926 1391416   15.392    39.212              3230        4
```

- Surveys provide approximate location information

- Representative households are actually spread out across survey enumeration areas

Approach: Households

Household/Backyard chicken production density from Marius et al, 2015

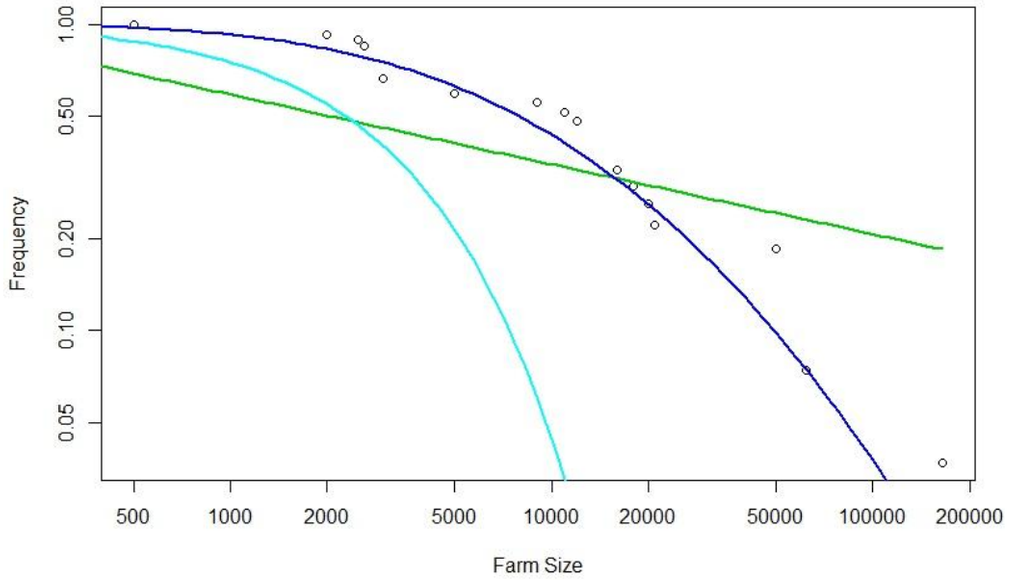


Use this as probability surface to distribute households within country

Approach: Commercial Farms

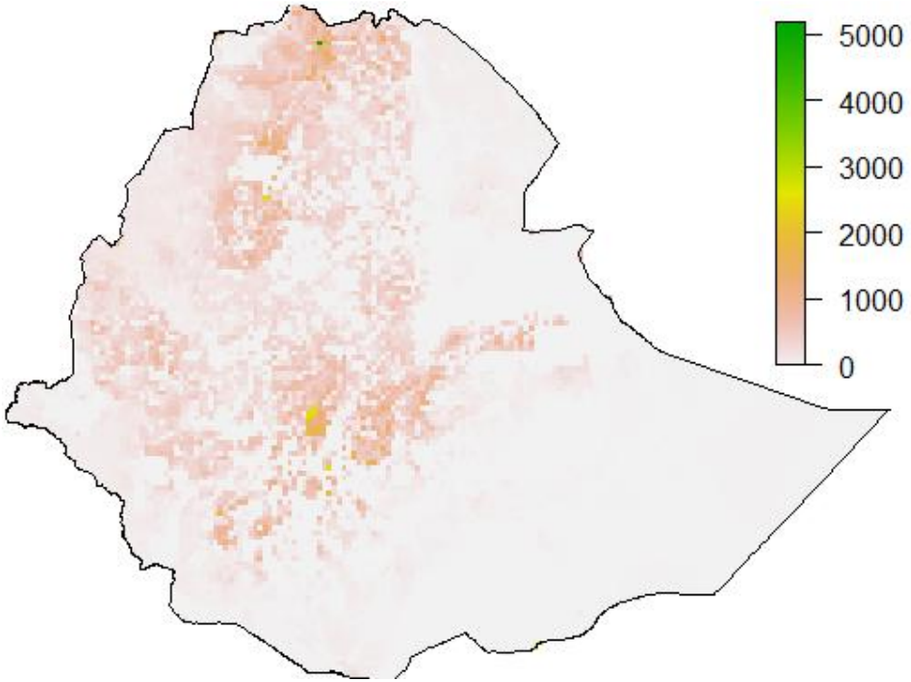
Get number and sizes of commercial farms from literature, poultry sector reports (Ethiopia, Kenya, Uganda), or scraped from OIE & FAO EMPRES-I outbreak data

Fit lognormal model to farm size, sample randomly from distribution until value adds up to total estimated intensive chicken population



Aproach: Commercial Farms

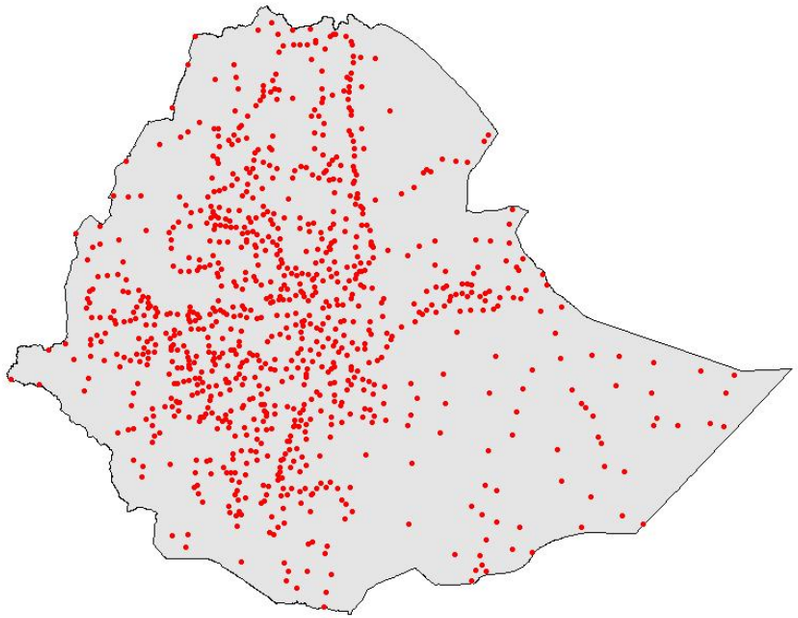
Distribute points based on intensive poultry production raster



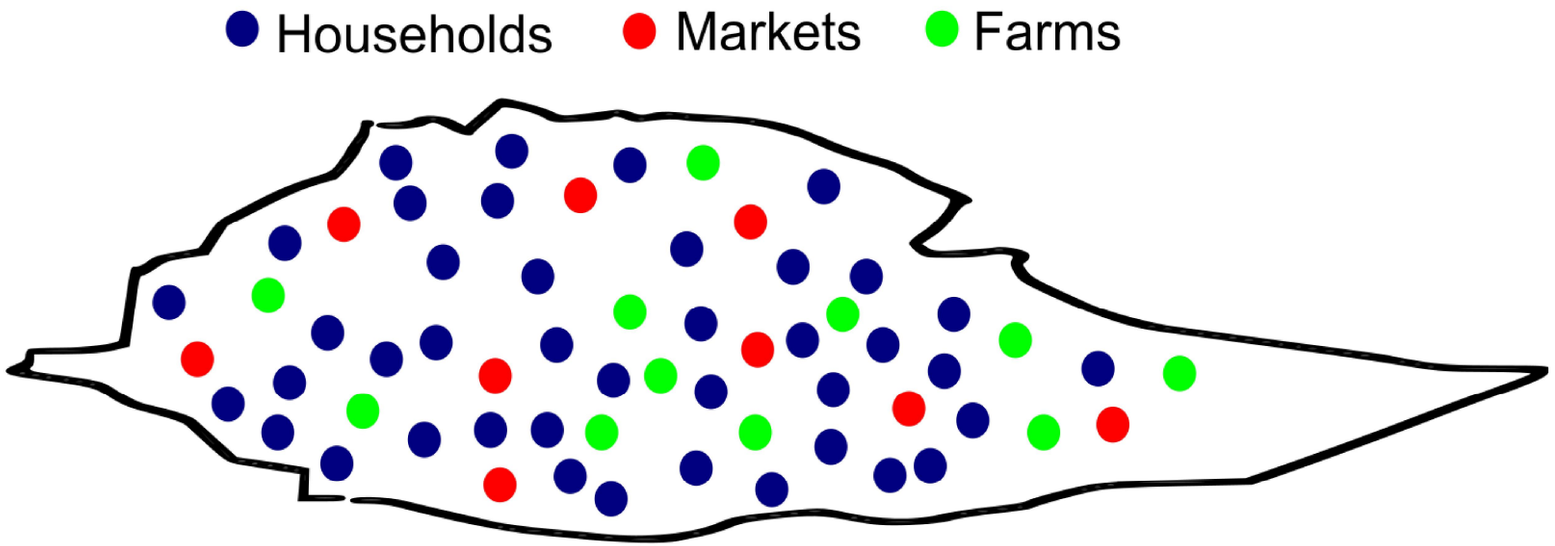
Approach: Markets

Ethiopia, Uganda, Kenya: Intergovernmental Authority on Development (IGAD)

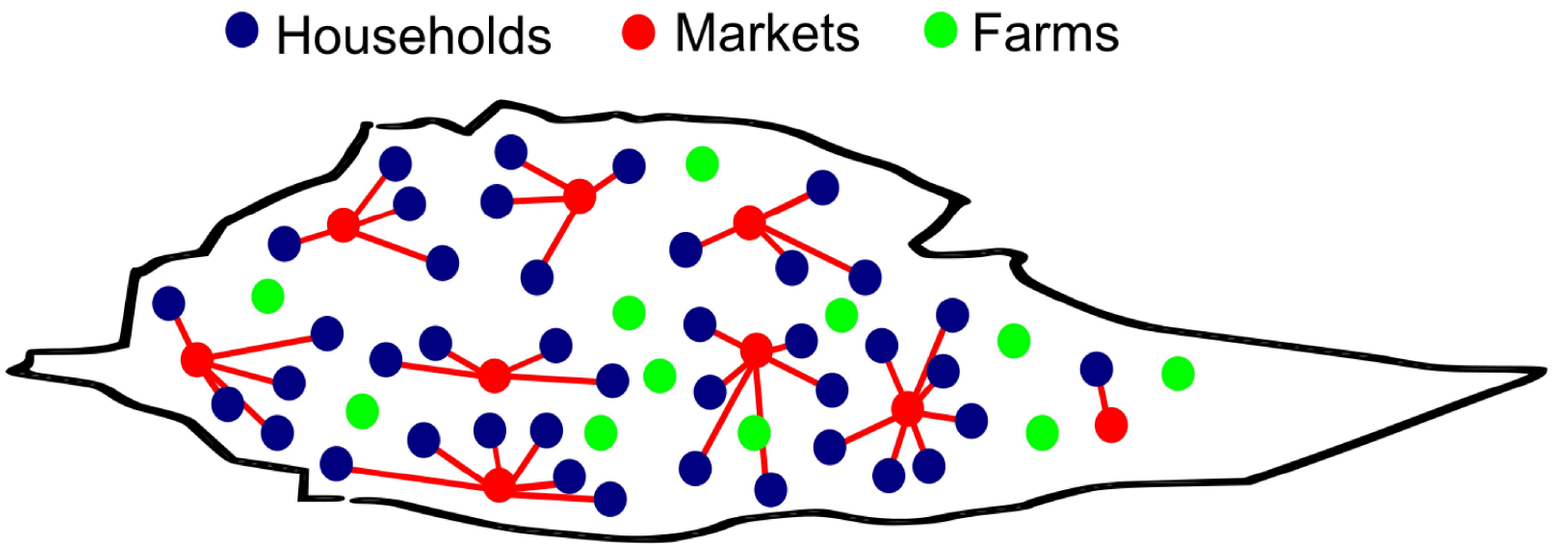
Burkina Faso, Egypt, Nigeria: Populated Places data from OpenStreetMap and SEDAC GRUMP



Combining Data

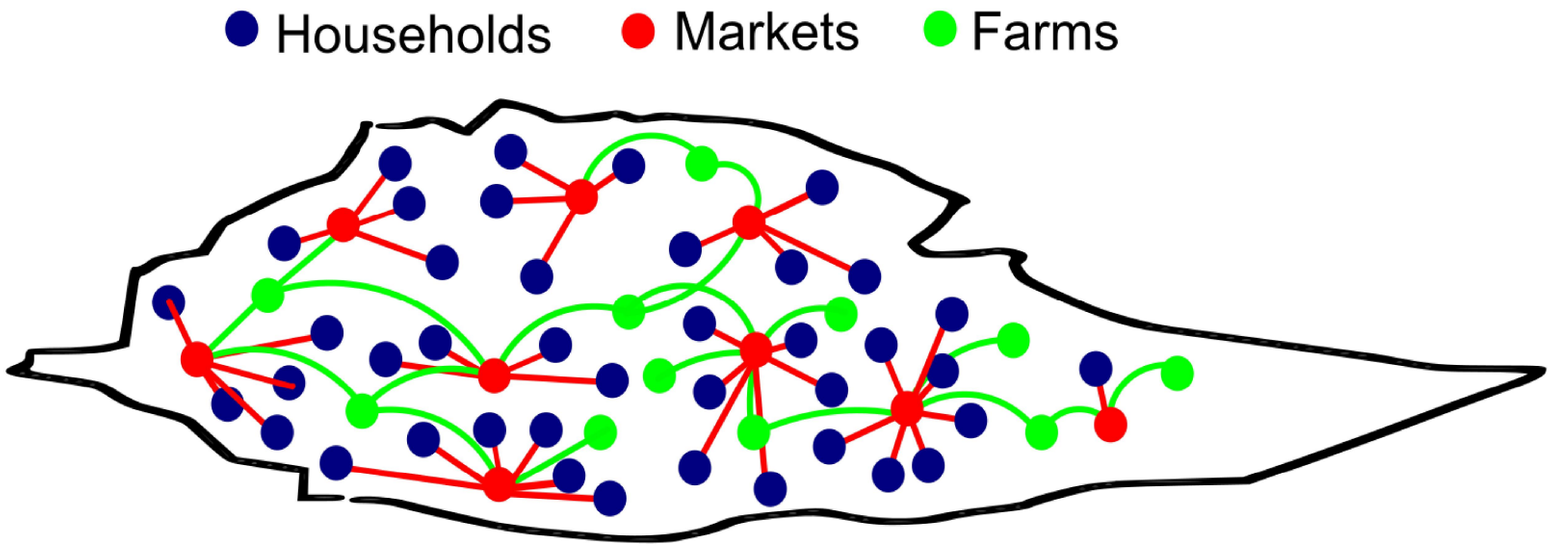


Parametrize connectivity



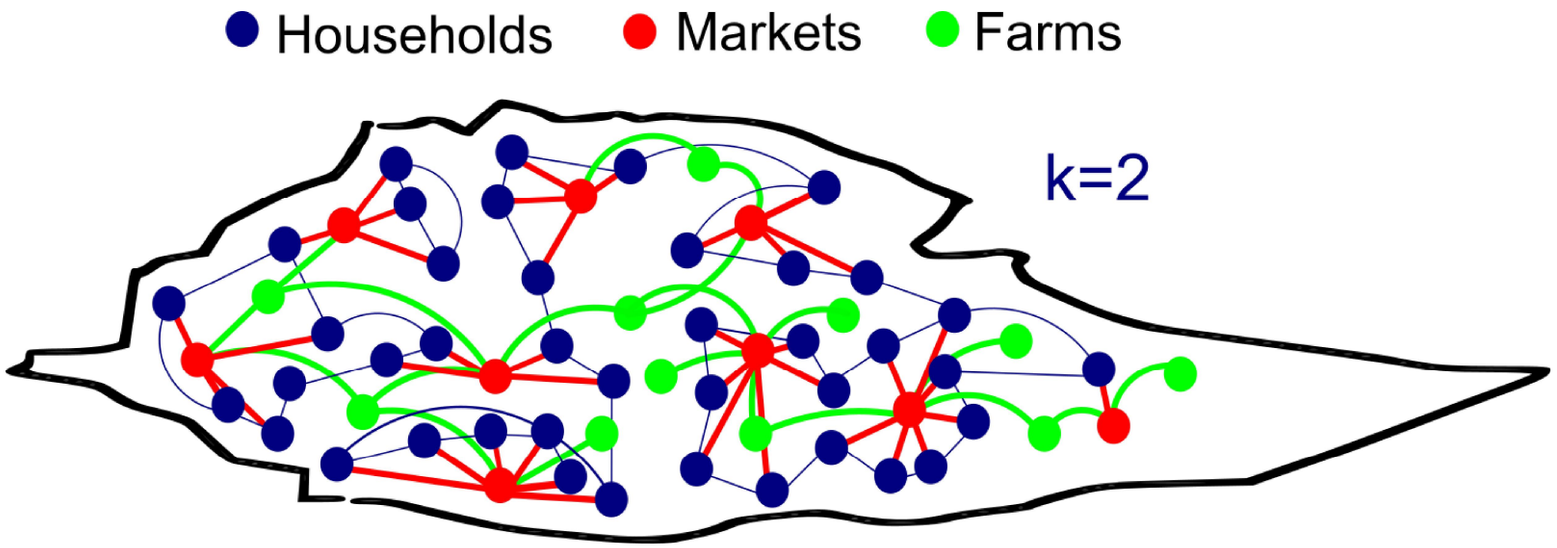
Each household is connected to nearest market

Parametrize connectivity



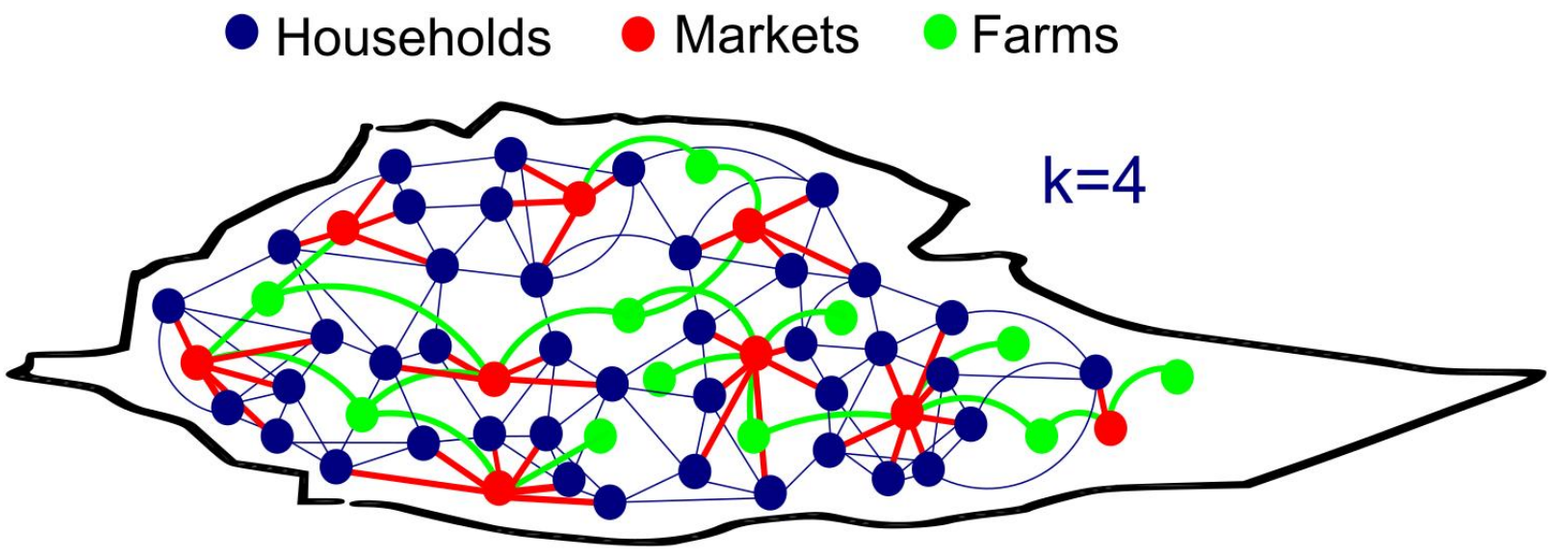
Each farm is connected to multiple markets

Parametrize connectivity: households



Each household is connected to two other households

Parametrize connectivity: households



Each household is connected to four other households

Connecting poultry sector actors

$$p_{u,v} = min\left(\kappa_u \kappa_v \frac{f(d_{uv})}{\rho\langle\kappa\rangle}, 1\right)$$

$u, v =$ two nodes (any of households, markets, farms)
$p =$ probability of connection between nodes u and v
$f(d_{uv}) =$ exponential decay kernel connecting nodes, defined by a distance (rate) at which 50% of nodes in country are connected
$\kappa =$ expected degree of connections per node (Poisson distributed across nodes)
$\langle\kappa\rangle =$ average degree of connections for all nodes
$\rho =$ density of nodes within country

Lang, John, et al. Random Spatial Networks: Small Worlds without Clustering, Traveling Waves, and Hop-and-Spread Disease Dynamics. arXiv:1702.01252 (2017).

Progress

- Identified data sources for all six countries, validation and review in progress
- Pipeline for analysis and input into Metaflu defined
- Experiments to test kappas and distances (rates) for reproducibility across countries

Next Steps

- Network generation for all ASL countries
- Break down network into modules for metaflu simulations
- Develop risk maps and outbreak probability analyses
- Writing and publication of results

Skills learned

- GIT!
- Parallel processing
- Network analysis in igraph
- Sparse matrices
- Geographically weighted principal components analysis (PCA)
- Raster stack manipulation and raster PCA
- Random forest models and boosted regression trees

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