DoLR - IIT Bombay

Collaboration summary

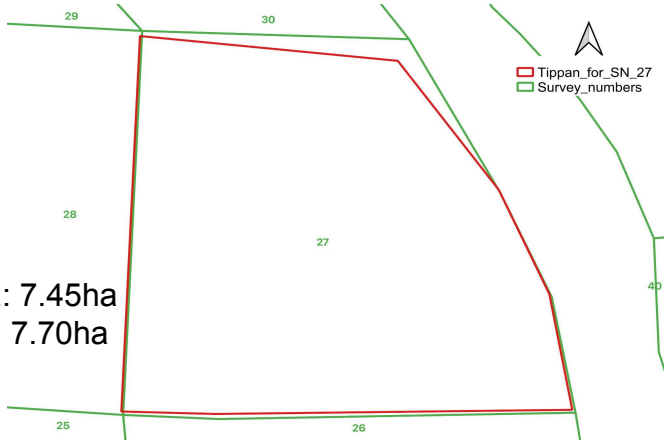
14 February 2023

Why should IIT Bombay help DoLR?

- Land disputes amount to 66% of civil court cases in India
  - according to NITI Ayog, in Land Titling Act '20
- Highly relevant and equally hard problem
- Maharashtra land records appear in 4-5 different forms
  - Tippans (Marathwada)
  - Bandobast (Vidarbh)
  - Konkan region has its own format
- Digitization and geo-reference of existing maps is not enough
  - Where on Earth is my land parcel?
  - Is it precise as per my entitlement (RoR)?

Why should IIT Bombay help DoLR?

- How to reconcile land records with story on the ground?
- IIT Bombay offers professional grade expertise in GIS, computer science, remote sensing, and validation based on rigorous field work



Tippan area: 7.09ha
Survey number area: 7.45ha
ROR area (gat 126): 7.70ha

DoLR state of the art

- Digitization of village maps
- Digitization / solving of tippans into non-georeferenced shapefiles
- Significant manual drudgery
  - High-res satellite / drone raster image to vector possession boundary
  - Paper based village map to geo-referenced survey number vector map
  - Comparison of tippan and possession boundary with visual inspection
- Eyeball based validation - not sound, not repeatable

Current Strategy: work with individual parcels

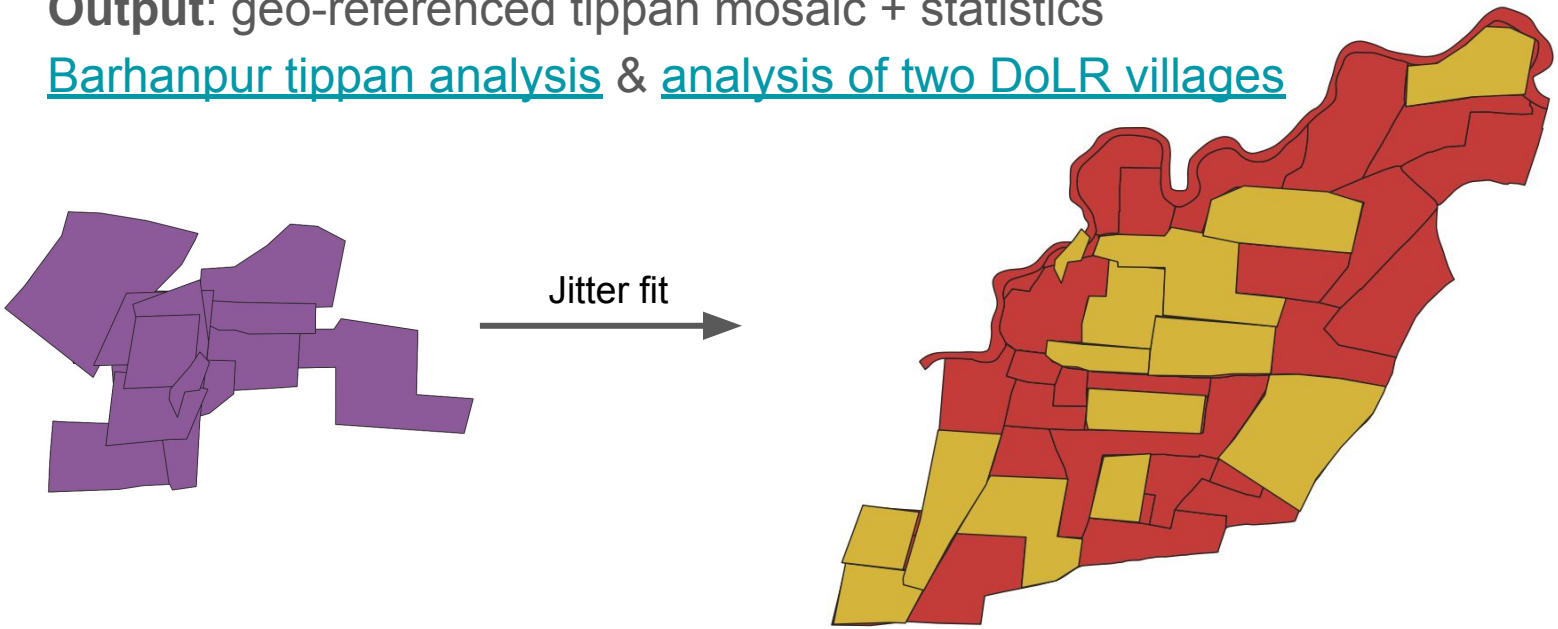
- Construct possession boundaries
- Match them with tippans / bandobast and give them “star” ranking

Ongoing work with Maharashtra DoLR (pro-bono)

- Data received from DoLR
  - Two villages with geo-referenced survey number map and solved tippans
  - Four villages with MRSAC cadastres and solved tippans
- IIT Bombay automation
  - Tippan mosaic generation using survey number map
  - Automatic rectification of survey number map
  - Automatic generation of possession boundaries based on Google Anthrokrishi

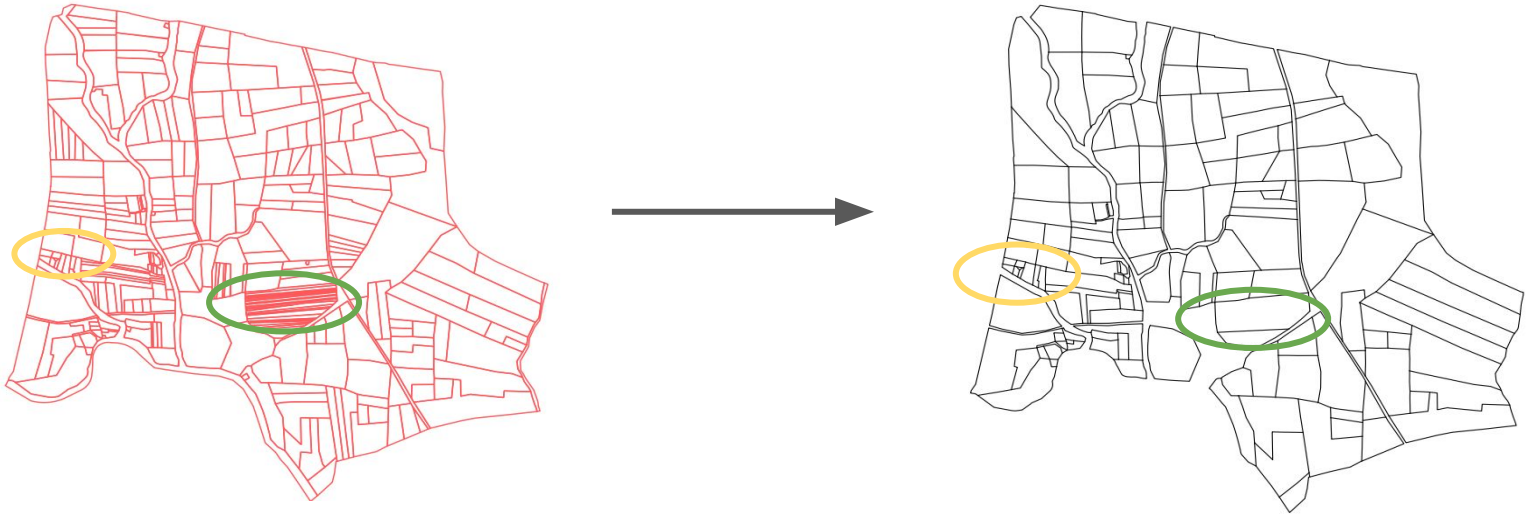
Solved tippans → tippan mosaic

- **Input**: solved tippans + geo-referenced survey number map
- **Output**: geo-referenced tippan mosaic + statistics
- Barhanpur tippan analysis & analysis of two DoLR villages



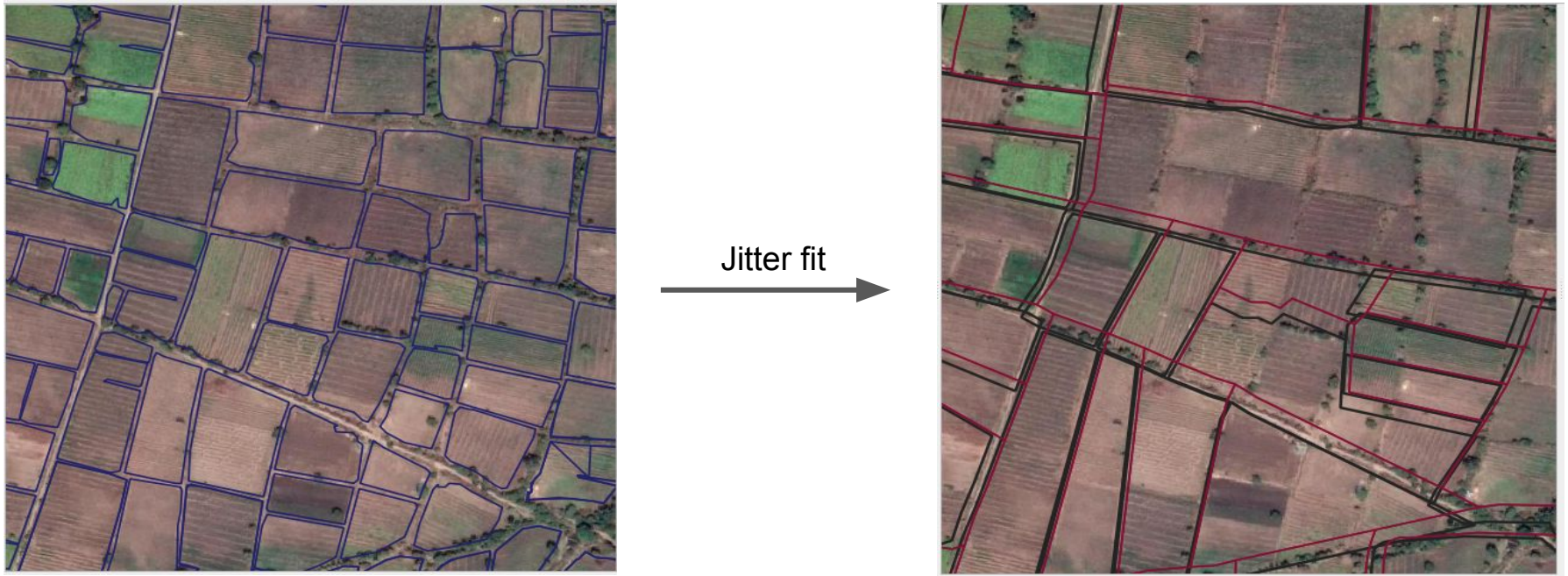
MRSAC cadastrals → Survey numbers

- Cadastral simplification to compensate unavailability of geo-referenced survey number map
- **Input**: MRSAC cadastrals + incorrectly scaled survey number map
- **Output**: rectified survey number map + jitter fitted tippan mosaic



Google farmplots → possession boundaries

- **Input**: farmplots from Google Research project Anthrokrishi
- **Output**: area partition that matches possession boundaries on ground

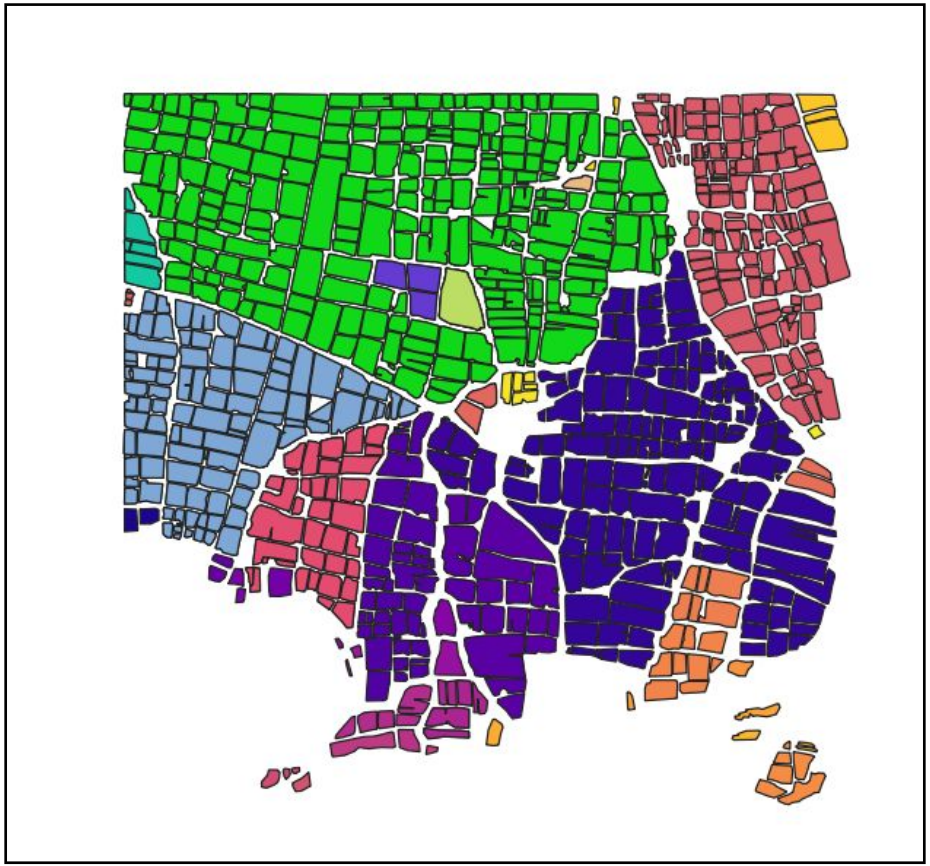


Google farmplots → possession boundaries

Metric for considered cadastrals	**Before**	**% of considered area**	**After**	**% of considered area**
Excess area with farmplots(in ha)	22.2	5.9	12.0	3.2
Overlap area with other cadastrals(in ha)	0.0	0.0	4.4	1.2
Total	**22.2**	**5.9**	**16.3**	**4.3**

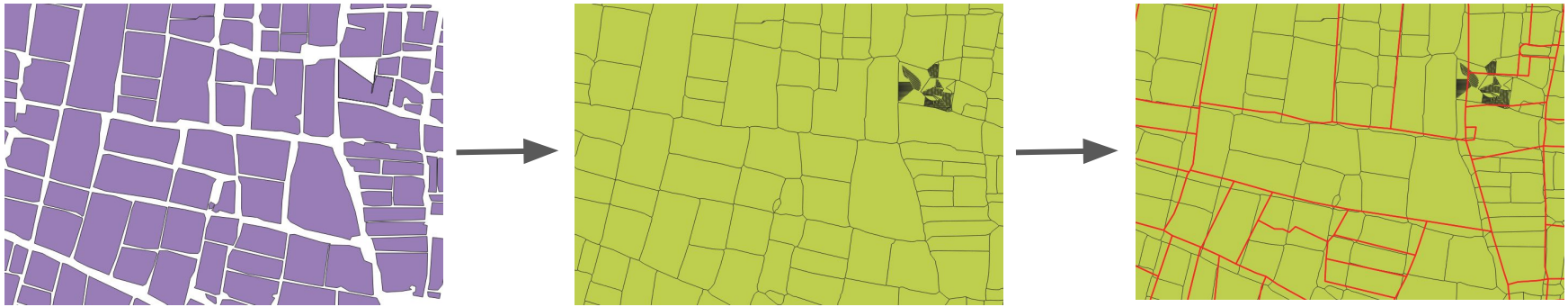
Distance Based Partitioning

- Matches with geographic features
- Points to regions of encroachment
- Prevents overflow of errors



Google farmplots → possession boundaries

Voronoi polygon construction



Conclusion

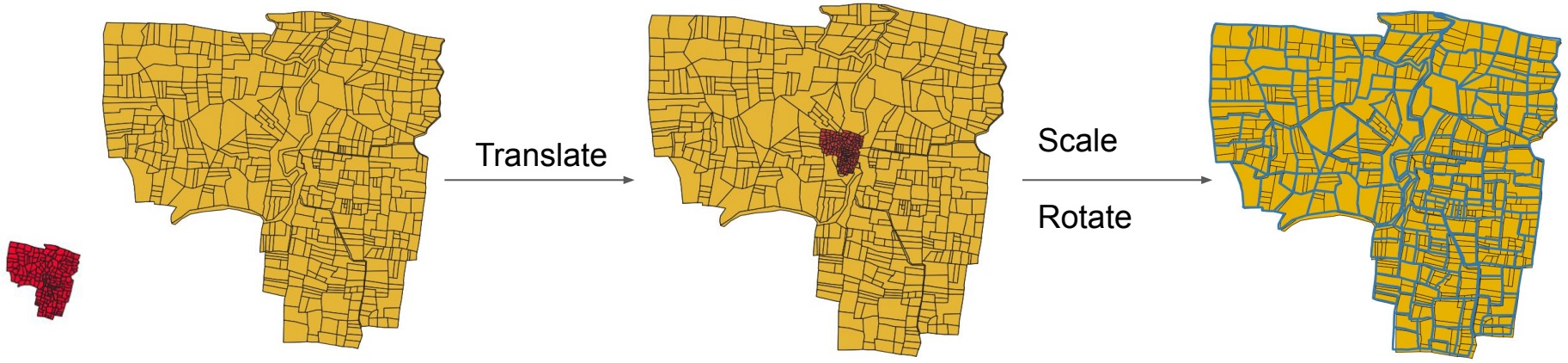
- Automation of existing DoLR workflow is possible
- DoLR can get actionable inputs
  - Worst tippans in village
  - Regions within village exhibiting significant possession mismatch (e.g. encroachment)
- Better to analyze all parcels in a village than ranking individual parcels
- Paid engagement with IIT Bombay → reliable, provable, repeatable land records analysis

Key Steps

1. **Georeferencing Survey plots.**
2. **Importing farm plots and first jitter-fit**
3. **Partitioning the problem**
4. **Deciding goodness of fit and Running Face-BFS**
5. **Fixing issues**

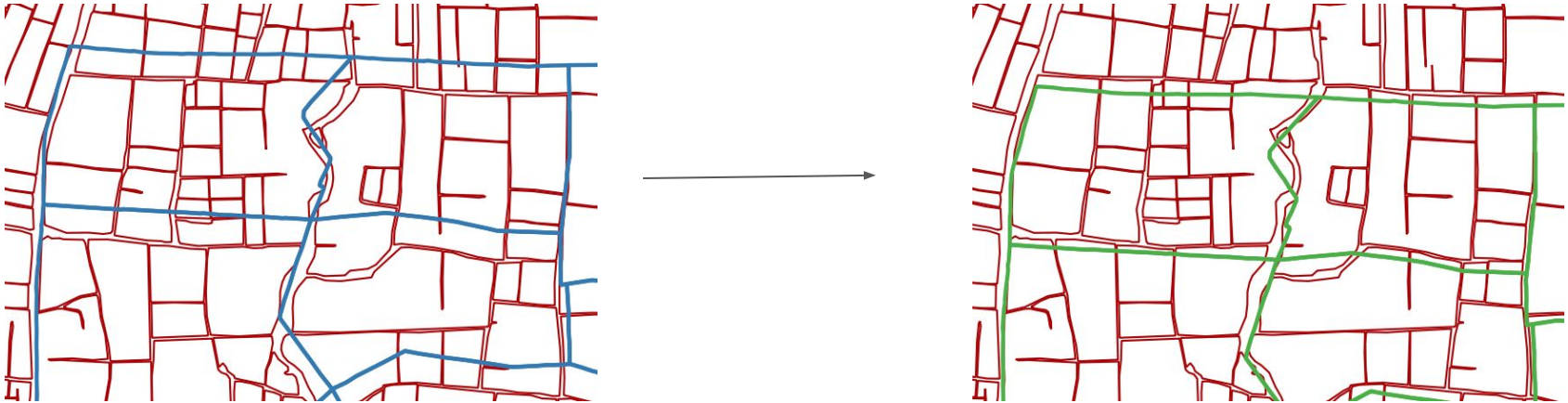
Survey plot geo-referencing: Matching with cadastrals

Translate, scale and rotate survey plots to match cadastrals.



Yellow: cadastrals Red: initial survey plots Blue: Final survey plots

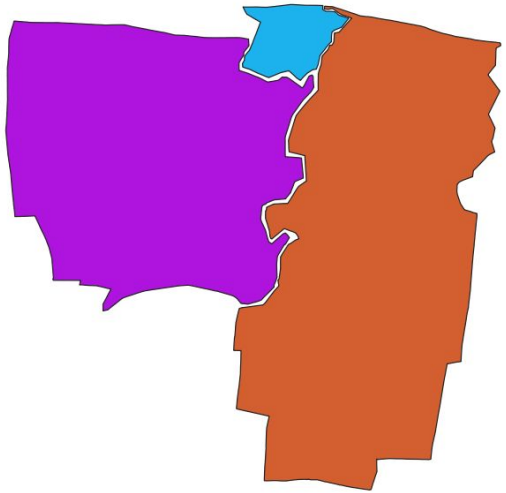
Jitter fit whole village with farm plots



Blue: scaled,rotated survey plots

Green: jitter fitted survey plots

Regional jitter fit



Divide the village into regions based on river boundaries

Jitter fit each region independently

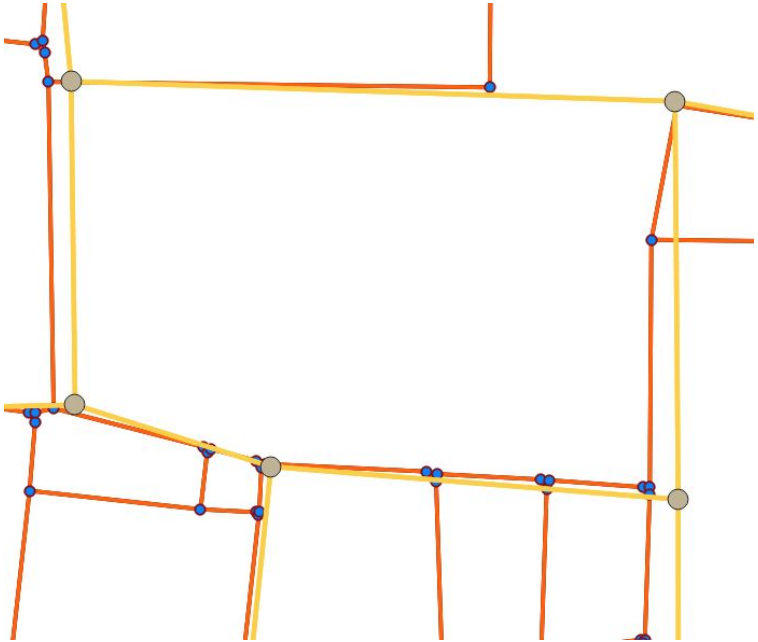
Green: region wise jitter fit

Creating a farm graph: nodes and straight edges

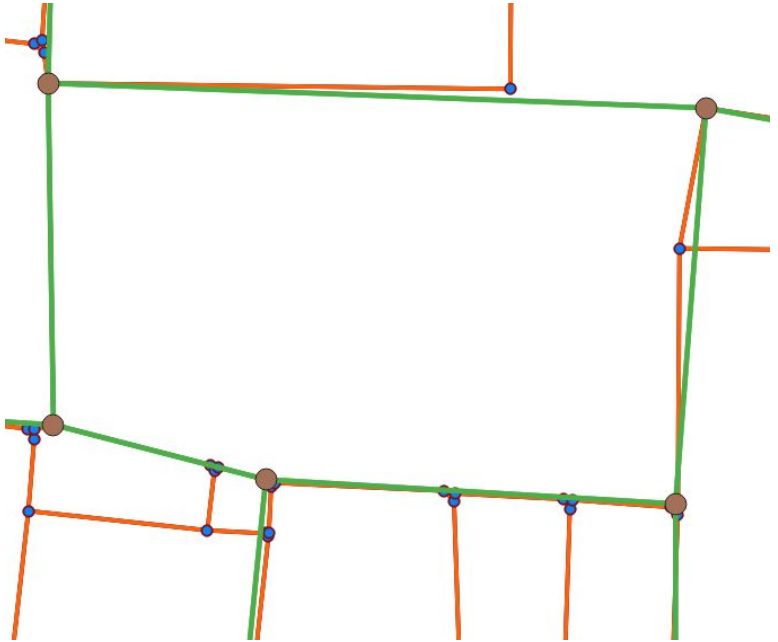
Google farm plots

Farm Voronoi graph

Snapping jitter-fitted polygons to farm graph

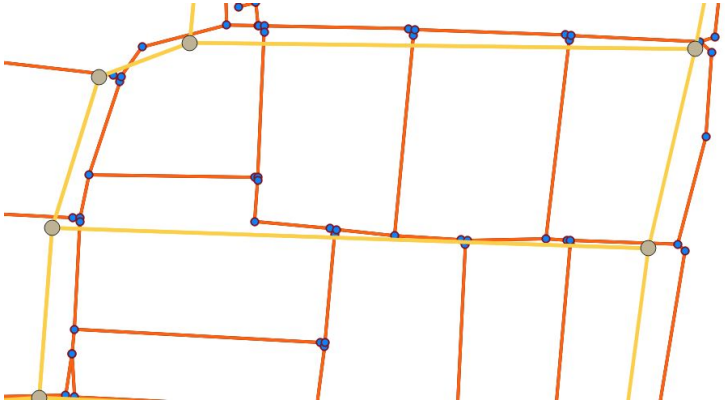


A jitter-fitted survey polygon (yellow) overlaid on the farm graph (red)



A possession polygon (green) with vertices shown (brown)

Snapping jitter-fitted polygons to farm graph



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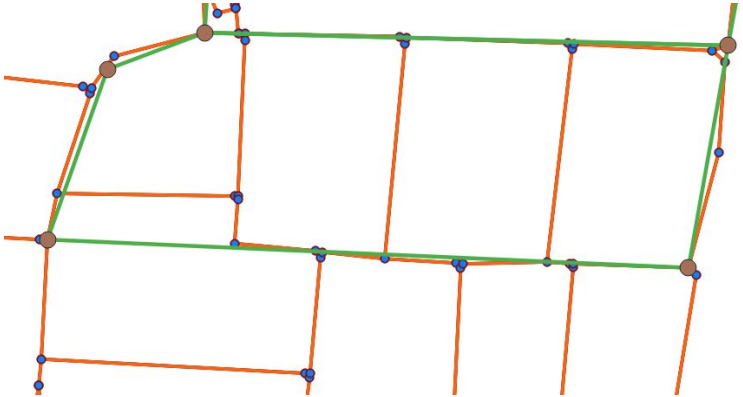
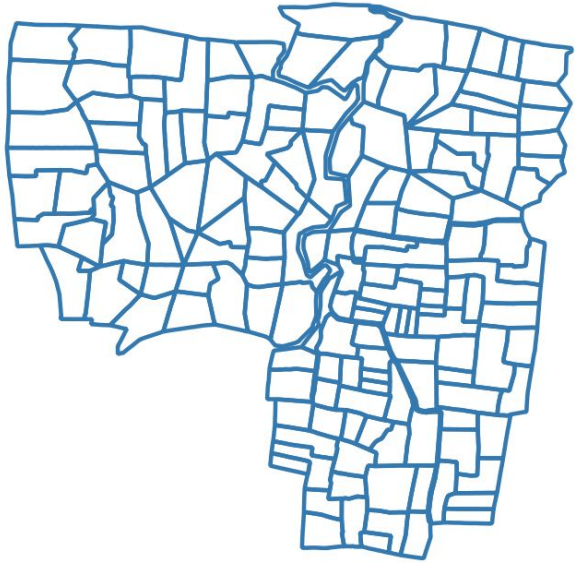
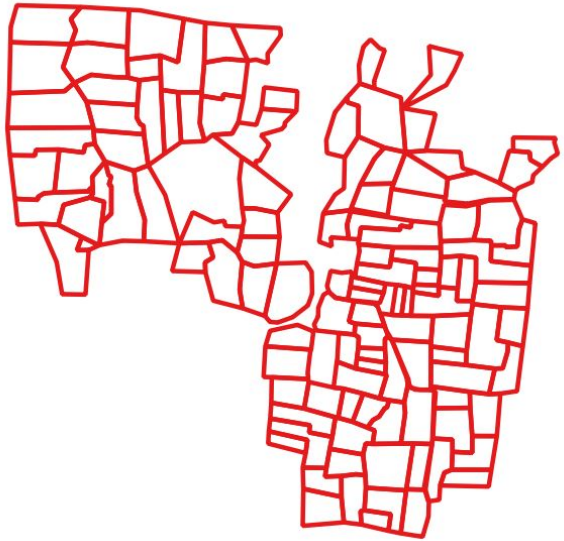


A possession polygon (green) with vertices shown (brown)

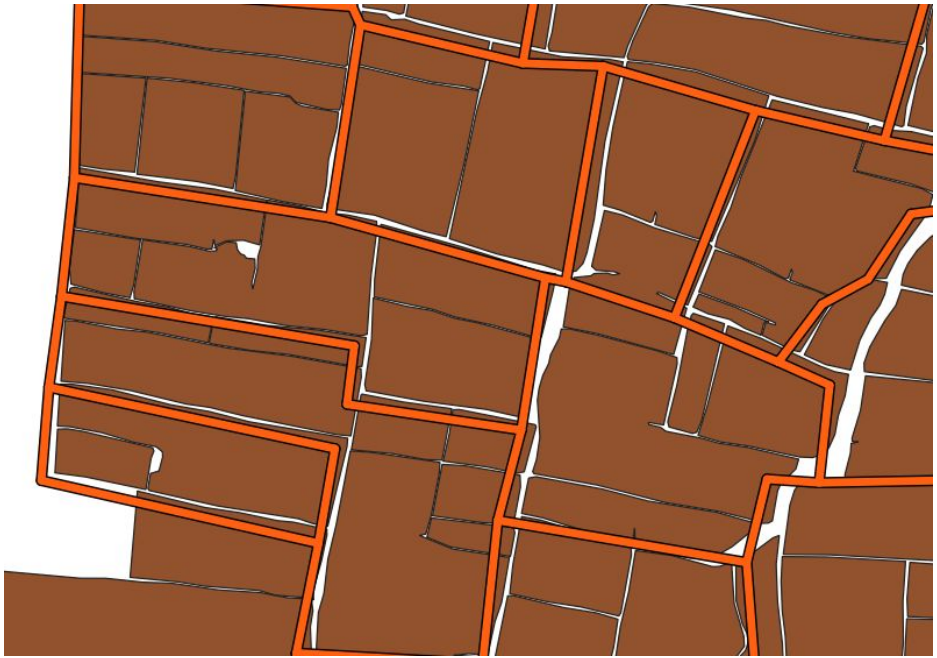
Sawangi: Creating possession boundaries





Survey plots	Possession
160	115
1010 Ha	714 Ha

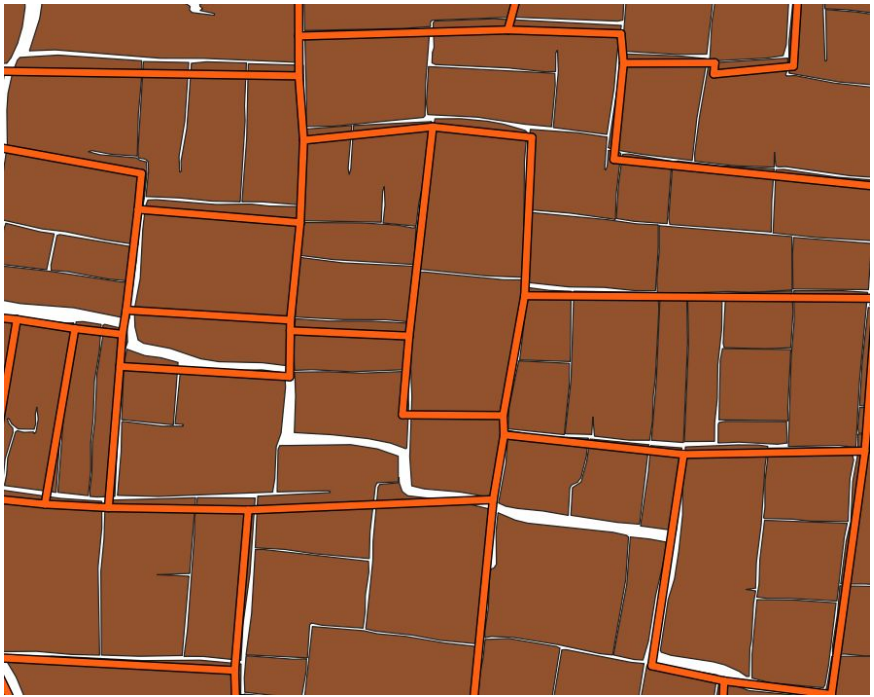
Sawangi: Possession boundaries



Jitter-fitted survey plots (orange) on Google farm plots (brown)

Possession plots (blue) on Google farm plots (brown)

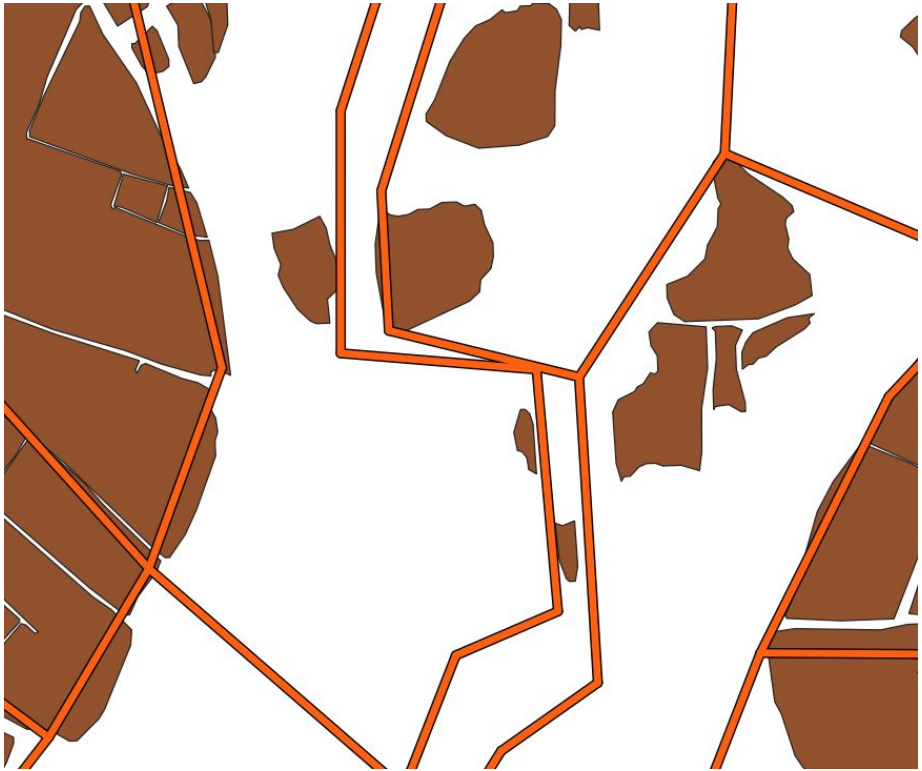
Sawangi: where our algorithm does well



Jitter-fitted survey plots (orange) on Google farm plots (brown)

Possession plots (blue) on Google farm plots (brown)

Issues: Rivers and Roads



Rivers and Roads: Google farm plots don’t help much

How to precisely map rivers? Hard problem…

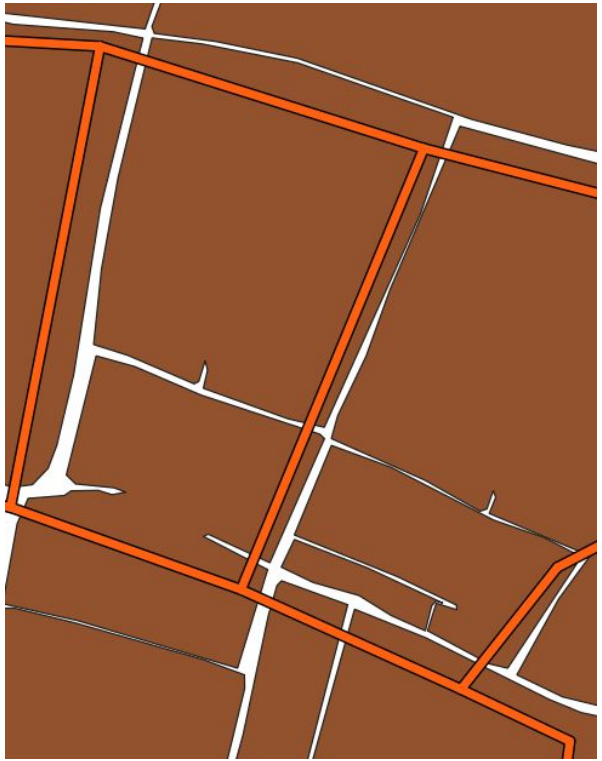
Issues: Water Bodies

Water bodies: can change positions over time. Bad survey plots -> how to keep track?

Issues: Water Bodies

Hence some bad survey plots: no good fit whatsoever

Issues?



Google farm plot’s fault?

Survey plot’s fault?

Voronoi points and GCPs