Land use change and livelihood responses to large investments for high-value agriculture: managing risks in the era of the Green Morocco Plan

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Climate change poses risks to livelihoods in Northern Africa

- Precipitation declines of 10-20%
- Temperature rises of 2-3 °C by 2050

“Climate change will likely have the strongest effect on Morocco [among North African countries, as…] the agricultural sector is of high importance for the country’s economy and particularly for poor people.”

Schilling et al. 2012 “Climate change, vulnerability and adaptation in North Africa with focus on Morocco”

- Employing labors 38% nationally and 75% in rural areas
Examining risk for high value crops: focus on Morocco

- Green Morocco Plan: $10bn from 2008-2020 towards modernizing agriculture, including support for
  - Irrigation
  - High-value crops (e.g., convert cereals to olives)

- But high capital investment implies high risk exposure for adoption

- Current ag. insurance focuses on cereal crops

  Could a responsible indexed product (e.g., insurance, drought relief) be created for high value crops such as olives, with or without irrigation?
How do remote-sensing products help inform design of financial instruments to manage risk in climate constrained countries?

**Examine environmental changes & conditions**
- Detect land conversion, olives, & irrigation
- Assess water stress & meteorological conditions

**Examine social coping & risks**
- Use AtlasAI data + experts for survey stratification
- Conduct stratified surveys
- Assess correlation of economic activities & coping strategies

**Evaluate**
- Evaluate linkages of enviro. & social stressors
- Evaluate projected risks

**Synthesize opportunities:**
(a) if/how remote sensing indicators reflect local economic stress
(b) if/how financial tools can help manage risk
Study Area
Research Team

Zhenong Jin (PI)
Stanford → AtlasAI → UMN
Crop mapping & yield prediction, especially for smallholders in Africa

Elinor Benami (Co-I)
Stanford → UC Davis → VT
Socioeconomic consequences of high value crop cultivation
Agricultural insurance/risk management

David Mulla (UMN)
Pioneer in precision agriculture
Consultant to MCC projects that planted 8 million olive trees on 80,000 ha in Morocco

Travis Lybbert (UC Davis)
Economist working on poverty dynamics
20+ years project experience in Morocco, much with olives

Rachid Bouabid (NSAM)
Local expert in soil fertility and crop management
Works very closely with olive growers
Preliminary Results on detecting LCLUC
Mapping olive tree groves: currently we’re investigating the performance of different data sources, training data sampling methods, & model choices.

Lin et al. (in prep)
Spatial features of old versus new groves

Legacy olives:
• Planted along contours
• Mostly in sub-humid region
• Large crown size

Newly planted by GMP:
• Planted after 2008
• Grow slowly
• Small crown size, hardly visible from PlanetScope
With single-date imagery, DG outperforms Planet in this region.

<table>
<thead>
<tr>
<th>Site</th>
<th>DG Basemap (0.5m)</th>
<th>PlanetScope (3m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Precision</td>
<td>Recall</td>
</tr>
<tr>
<td>1</td>
<td>0.883</td>
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<tr>
<td>2</td>
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<tr>
<td>Semi-arid</td>
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<tr>
<td>6</td>
<td>0.881</td>
<td>0.940</td>
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<tr>
<td>7</td>
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<tr>
<td>Sub-humid</td>
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<td></td>
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<tr>
<td>8</td>
<td>0.827</td>
<td>0.878</td>
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<tr>
<td></td>
<td>0.879</td>
<td>0.924</td>
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</tbody>
</table>
Using multi-temporal Planet data improves performance, especially in the subhumid area.

- Olives are evergreen thus have more stable features over time.
- Non-olives show some phenological changes.

<table>
<thead>
<tr>
<th>Site</th>
<th>Semi-arid</th>
<th>Sub-humid</th>
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<tr>
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<td>0.534</td>
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<tr>
<td>4</td>
<td>0.228</td>
<td>0.570</td>
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<tr>
<td>5</td>
<td>0.194</td>
<td>0.670</td>
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<tr>
<td>Overall</td>
<td>0.259</td>
<td>0.420</td>
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<table>
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<tr>
<th>Site</th>
<th>Multi-temporal LRCN</th>
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<td>0.313 0.172 0.222 0.726</td>
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<td>8</td>
<td>0.389 0.274 0.321 0.706</td>
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<tr>
<td>9</td>
<td>0.444 0.212 0.337 0.743</td>
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<tr>
<td>Overall</td>
<td>0.397 0.271 0.322 0.736</td>
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<th>Site</th>
<th>Single Time CNN</th>
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<td>8</td>
<td>0.595 0.653 0.612 0.661</td>
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<tr>
<td>9</td>
<td>0.689 0.727 0.708 0.756</td>
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<tr>
<td>Overall</td>
<td>0.650 0.637 0.643 0.735</td>
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</table>
Next Steps

- Land Cover Mapping
  - Collect ground truth at 20 sites from the two regions, e.g. almonds, stone fruit, argan, in addition to olives
  - Explore self-supervised clustering to reduce need for labels
  - Develop and examine performance of CNN-LSTM model, possibly with attention architecture, to distinguish key phenological stages
  - Detect adoption of irrigation systems

- Social Surveys on Key Risks and Livelihood Challenges
  - Stratify population to survey, based on areas identified with olives and irrigation as well as socioeconomic data from AtlasAI and admin. data
  - Design survey questions on livelihoods and risk management strategies to pilot launch either in person, COVID permitting, or remotely (via phone or SMS) in summer 2020
  - Examine linkages between observed environmental hazards and livelihood changes, with and without irrigation
Questions? Contact us at:

jinzn@umn.edu & elinor@vt.edu

Check out our new paper on related themes

Uniting remote sensing, crop modelling and economics for agricultural risk management

in Nature Reviews Earth & Environment

coming out in the next few weeks
If we have unlimited access to DG…

A simple UNet classifier achieved an overall accuracy of 97% for 200 images from the sub-humid region in Morocco.

An unexpectedly large count of trees in the West African Sahara and Sahel

Martin Brandt, Compton J. Tucker, Ankit Kariryaa, Kjeld Rasmussen, Christin Abel, Jennifer Small, Jerome Chave, Laura Vang Rasmussen, Pierre Hiernaux, Abdoul Aziz Diouf, Laurent Kergoat, Ole Mertz, Christian Igel, Fabian Gieseke, Johannes Schöning, Sizhuo Li, Katherine Melocik, Jesse Meyer, Scott Sinno, Eric Romero, Erin Glennie, Amandine Montagu, Morgane Dendoncker & Rasmus Fensholt

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