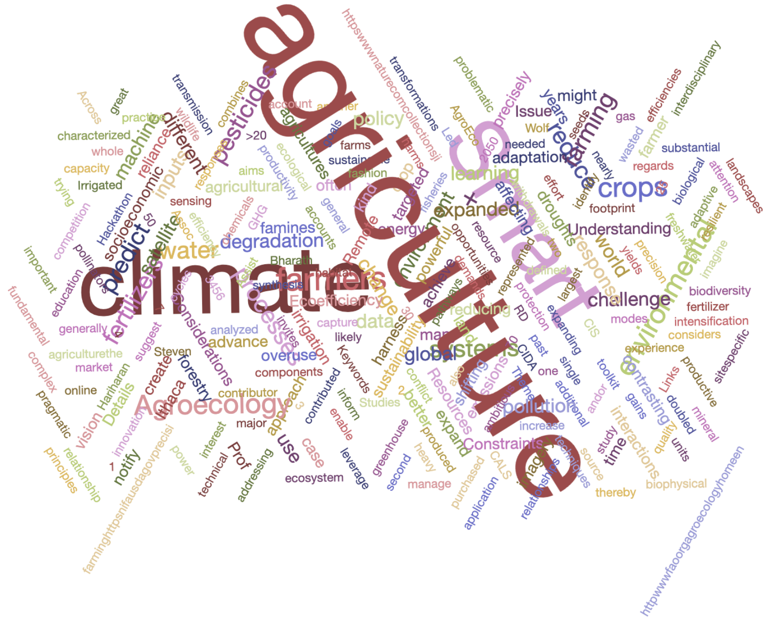
CIDA Hackathon: Theme 3

Climate-Smart Agriculture



Led by	*Bharath Hariharan (Assist. Prof.) - CIS, Ithaca* *Steven Wolf (Assoc. Prof.) - CALS, Ithaca*
Keywords	Environmental protection, agroecology, remote sensing, eco-efficiency
Links	[The Issue](#) [Details](#) [Considerations](#) [Constraints](#) [Resources](#)

The Issue

Agriculture and forestry account for >20% of global greenhouse gas emissions. Studies suggest that GHG emissions from agriculture, forestry and fisheries have nearly doubled over the past 50 years and could increase an additional 30% by 2050. Irrigated agriculture accounts for 70% of global freshwater withdrawals. In the U.S., agriculture is the single largest contributor to water quality degradation. Agriculture is also a major source of pollution and habitat degradation, which harms wildlife, pollinators, and biodiversity more generally.

Challenge 1: How might we reduce pollution produced by the overuse of pesticides, fertilizers, and/or reduce wasted irrigation?

Challenge 2: How might we leverage the expanding toolkit of satellite + machine learning techniques to inform adaptive policy and practice for agriculture/the environment?

Details

*We can identify **two contrasting responses** to agriculture's heavy environmental footprint.*

Eco-efficiency: An effort to expand yields and reduce inputs of land, energy and chemicals. Agricultural R&D, education of farmers, and market competition have contributed to substantial gains in resource productivity over time. There is great interest in trying to harness the power of data to expand efficiency of farming, as represented by 25 years of experience with precision farming(https://nifa.usda.gov/precision-agriculture-crop-production). While there are opportunities to further achieve efficiencies and advance sustainable intensification (https://www.nature.com/collections/jieihecica) it is likely that more ambitious modes of innovation is needed to achieve sustainability goals for agriculture https://www.politico.com/news/2020/02/19/usda-environmental-footprint-116063#:~:text=The%20Agriculture%20Department%20is%20preparing,on%20the%20plan%20told%20POLITICO.

Agroecology: The second general approach to addressing agriculture's problematic relationship with the environment is agroecology. Agroecology, defined online by AgroEco, "considers interactions of all important biophysical, technical and socioeconomic components of farming systems and regards these systems as the fundamental units of study, where mineral cycles, energy transformations, biological processes and socioeconomic relationships are analyzed as a whole in an interdisciplinary fashion."
Agroecology aims to harness ecological processes to create productive and resilient farming systems, thereby reducing reliance on purchased inputs such as seeds, fertilizer, and pesticides. This vision of agriculture demands expanded understanding of complex, site-specific interactions, which invites attention to data capture, transmission, synthesis and application (http://www.fao.org/agroecology/home/en/).

While these contrasting pathways are often characterized as being in conflict with one another, we can imagine a pragmatic approach that combines these principles. Across different crops, different farms, and different landscapes, expanded reliance on data will enable more targeted use of agricultural inputs and expanded capacity to manage ecosystem processes to advance the sustainability of farming systems.

Considerations

— Improved measurement/sensing to reduce waste and pollution — Agriculture in many parts of the world often involves overuse of pesticides, fertilizers and irrigation, which is both wasteful (in case of water) as well as polluting (in the case of fertilizers and pesticides). Farmers can precisely treat and water crops, reducing and ultimately eliminating the misuse of fertilizers + water. If farmers could precisely figure out exactly how much and what kind of irrigation/pesticides/fertilizers etc. are required, which in turn can be done if we can *measure* and *sense* the state of crops in the field: for example, by measuring what pests are ravaging the crops[1] or detecting any diseases in the crops[2].

— Remote sensing-based prediction and adaptation to a changing world — Around the world, environmental degradation and climate change are affecting agriculture, causing famines, and affecting the livelihood of farmers. Farmers must adapt and evolve, both in response to the environment, and in ways that are demonstrative of shifting environmental changes. Is there a way to notify or predict droughts, famines or catastrophic crop failures? How can governments mobilize relief faster and in a more targeted manner [4]? The vision includes the potential to predict droughts, predict famine, notify + predict crop failure, better government response to ag/environmental concerns, better prepare farmers or proactively create policy

Constraints

- **Solution cost:** While many solutions exist pointing in this direction, and it's a topic of increasing popularity [3,4,5,6], a key challenge is to keep production in a threshold available to *any* farmer; i.e.: #lowcost and #low-resource. Impact derived from widespread use + distribution for *any* farmer, no matter how stretched their finances, how small or large their farm, or the kind of crops they grow.
- **Combination of satellite imagery and machine learning:** A particularly powerful tool for predictive policy and response is satellite imagery coupled with powerful machine learning techniques[8,9,10]. Understanding and recording what crops are being planted [7] and shifting patterns of land use over time, would help us understand processes of global environmental change + support adaptation to climate change.

Recommended Resources

- https://www.wadhwaniai.org/work/cotton-farming/
- https://arxiv.org/abs/1908.02900
- https://www.nytimes.com/wirecutter/reviews/best-smart-sprinkler-controller/
- https://www.ers.usda.gov/amber-waves/2016/december/precision-agriculture-technologies-and-factors-affecting-their-adoption/
- https://www.walmartsustainabilityhub.com/project-gigaton/agriculture
- https://civileats.com/2019/07/11/can-indigo-ags-new-carbon-market-pay-off-for-farmers/
- https://wandb.ai/wandb/droughtwatch/benchmark
- https://openaccess.thecvf.com/content_CVPRW_2019/html/cv4gc/Rustowicz_Semantic_Segmentation_of_Crop_Type_in_Africa_A_Novel_Dataset_CVPRW_2019_paper.html
- https://www.microsoft.com/en-us/research/blog/predicting-the-holy-grail-of-climate-forecasting-a-new-model-and-a-new-public-dataset/
- https://www.nature.com/articles/s41467-020-16185-w