Identifying Pathways to Mitigate the Impact of Urbanization on Croplands

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The Problem

Prior to establishment of global supply chains and modern transport systems, large cities were provisioned with food from surrounding farmland.

For this reason, many world's cities were established in locations with good soils and adequate rainfall or irrigation to ensure food supply.

As urban population grew, surrounding highly productive croplands producing staple food crops were converted to urban uses as well as for production of high-value vegetable and specialty crops.

With rapid urban growth rates during the past 30 years, urbanization has appropriated millions of hectares of cropland, and this trend will persist as cities continue to expand

As the best farmland is already being used for crop production, it is likely that cropland will need to expand into less-productive environments, typically at the expense of a larger environmental impact.

Conversion of double/triple rice systems for residential & industrial purposes in West Java, Indonesia
(Photo: Nurwulan Agustiani, BB Padi)

Upland rice grown in marginal land after land clearing in West Nusa Tenggara, Indonesia
(Photo: P Grassini)

Limitations of previous studies

- Aggregated production of different crop types using calories equivalents.
- Assessed land-use change based on two points in time and/or without considering transitional stages.
- Compared productivity between converted and new cropland based on current crop yields.
- Ignored the role of crop intensification as a pathway to buffer against production losses due to cropland conversion for urban uses and to reduce need for cropland expansion.
- Ignored potential impact of land reclamation in rural areas due to rural-urban migration.

What is missing?

There is an urgent need to understand trends in converted and new cropland for key staple crops, and compare their associated productivity and resource demand, to predict the future impact of urbanization on land-use change, crop production, and environmental footprint under different scenarios of crop intensification and climate change.

Objectives

Overall objective: to identify pathways to reconcile urban growth with crop production while minimizing negative environmental impact.

Specific objectives:

1. Quantify long-term trends in converted and new cropland for key staple crops in U.S. and China.
2. Estimate potential productivity, yield gaps, and environmental footprint associated with converted and new cropland for each crop.
3. Explore future scenarios of land-use change, crop production, and environmental impact for different trajectories of urbanization, intensification, and climate change.

The approach

Combination of top-down and bottom-up approaches:

- Remote sensing and machine learning techniques to quantify areas where cropland is being converted for urban purposes and for areas where cropland is expanding
- Crop modeling based on high quality weather, soil, and management data collected for specific sites, complemented with interpolation techniques, to estimate yield potential at a high level of spatial resolution

Expected Outcomes

- An assessment of changes from 2000 to 2022 in new and converted cropland over time and space for the entire planted area for each of the target crops in U.S. and China.
- Crop-specific information about yield potential, yield stability, and environmental footprint for converted and new cropland and generate historical trends showing how the ratio between yield potential in new versus converted cropland has changed over time.
- Projections of crop production, cropland conversion, and environmental footprint for different combinations of urbanization and intensification scenarios by year 2050 to inform land-use policy and orient ARD programs over the next 30 years.
- Maps showing where the largest yield gaps exist, which represent opportunities for increasing current yields with improved agronomic management
- Maps showing where highly-productive cropland near urban areas should be prevented from conversion via better land-use planning and policy

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