Change Detection: How has Urban Expansion in Buenos Aires Metropolitan Region Affected Croplands

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Abstract

Cropland is one of the essential elements of our ecological systems for producing agricultural products.
Argentina is an extremely agricultural intense developing country affected by land cover land use (LCLU) change, and Buenos Aires province is a top agricultural production site and has been urbanizing during the last 30 years. This lead to detrimental consequences which has considerable effects on the social-ecological systems when croplands are lost.
Thus studying and analyzing the metropolitan area of this province will contribute to our understanding of the relationship between urban expansion and its effect on croplands. So far, no research has used measurable quantitative methodologies on the Buenos Aires metropolitan region (BAMR) to reveal the relationship between urbanization and cropland.

Introduction

Urbanization at difference scales has been the study area for many researchers due to its profound effects on the environment. For this research, urban expansion is defined as an increase in more city-like areas or features. It can appear in the form of newly formed housing, roads, buildings or industrial designated areas (Figure 1 and 2).

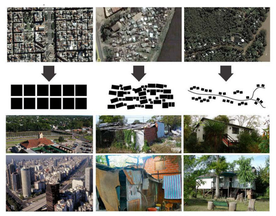

Figure 1. Urban land patterns in BAMR area (housing). *Left: urban centers of provincial departments; Middle: slums or informal settlements; Right: disperse housing. Modified from "Natural territory, urban growth and climate change in the Parana River Delta and Rio de la Plata estuarine system, Verónica M.E. Zagare, 2011".*

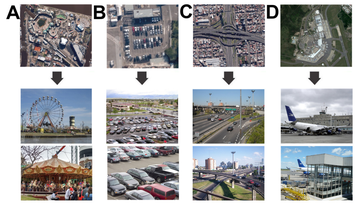

Figure 2. Other urban land features in BAMR area. *(A) Amusement parks (Parque de la Costa). (B) Parking lots. (C) Roads and bridges. (D) Airports (Ezeiza International Airport). Pictures acquired from google earth.*

Since urban population have been growing more rapidly than rural population especially in developing countries like Argentina, urbanization is the most important driver in cropland loss (Ramankutty, Foley, & Olejniczak, 2002; United Nations, 2014). This paper focuses on the Buenos Aires metropolitan region, to investigate the impact of urbanization on cropland from 1985 to 2015 (Figure 3).

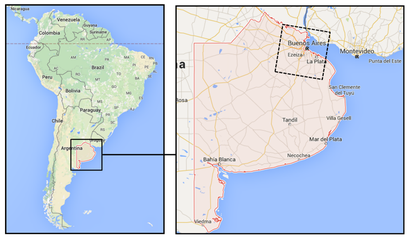

Figure 3. Location of Buenos Aires Metropolitan Region. *Left box: Buenos Aires Province. Right dashed box: Buenos Aires Metropolitan Region (BAMR).*

Limited research has been done towards urban expansion in Buenos Aires metropolitan region, Argentina and its effect on cropland especially using remote sensing techniques. ***This research aims to reveal how much has urban lands increased and how much of that comes from existing croplands***.

By using time series remote sensing data, this study is able to quantify cropland loss and better understand the relationship between urban expansion and cropland change.

Data and Methodology

Data for this research are Landsat images (path 225 row 084) for June 1985 and July 2015 from USGS Glovis (U.S. Department of the Interior, 2016). Winter season in Argentina include June, July and August. Both images are from winter season to keep consistency. It is also a good time for image classification because plant growth is generally very slow so the urban structures will be especially visible and clear.
For this research, classified maps using decision tree method is used after overlaying images from 1985 and 2015, which is also the most representative analyzing method currently. Classified maps can produce pixel counts, which can quantify landscape changes by calculating how many pixels are in each categorized land types.
This research used random sampling as accuracy assessment. Random sampling is a method of selecting *n* units (a sample of the population data, *N*) such that "every one of the ${}_{N}C_{n}$ distinct samples has an equal chance of being drawn" (Cochran, 1953).

Results

By using 30-meter resolution Landsat images of June 1985 and July 2015, this study finds urban land has expanded from 937.16 km^2 to 1835.47 km^2, and 30.28% of the new urban lands comes from existing croplands.

Table 1. *Urban and non-urban area statistics (Calculated with Landsat image footprint)*

	1985	2015
Urban	937.16 km^2	1,835.47 km^2
Non-urban	3,1462.84 km^2	30564.53 km^2

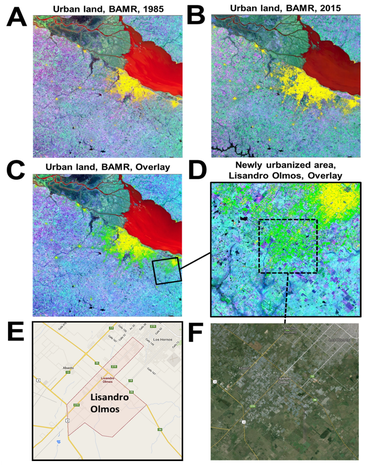

Figure 4. Urban land expansion in BAMR. *(A) Urban land classification of Landsat image (path 225 row 084, BAMR) for June 1985 from USGS Glovis. (B) Urban land classification of Landsat image (path 225 row 084, BAMR) for July 2015 from USGS Glovis. (C) Figure 4A merged with 4B. Yellow: 1985 urban land; Green: 2015 urban land. (D) Lisandro Olmos (dashed box) is a newly urbanized area in BAMR. (E) Google Map image showing the boundary of Lisandro Olmos. (F) Google Earth satellite image showing the urban extent of Lisandro Olmos in July 2015.*

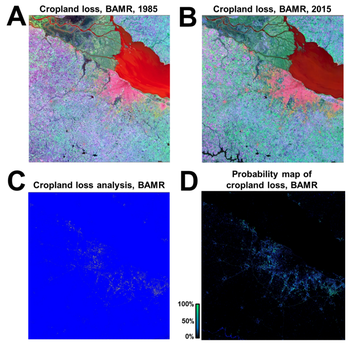

Figure 5. Cropland loss in BAMR. *(A) Cropland loss shown on 1985 Landsat image of BAMR. (B) Cropland loss shown on 2015 Landsat image of BAMR. (C) Cropland loss classification analysis. Yellow: lost area of cropland; Blue: non-change area of cropland. (D) Probability map of cropland loss results. Black: 0%; Blue: 50%; Green: 100%.*

Discussion and Analysis

For thousands of years, "cities have expanded into neighboring fields…as the population required more space for" residential, agricultural, industrial and cultural uses (Gardner, 1996). Rapid urbanization has occurred during the past two centuries in developed countries and accelerated significantly within the last few decades globally resulting in net cropland loss due to the limited availability of new land (Gardner, 1996). Same scenario could be placed on BAMR that the massive city expansion between 1985 and 2015 is at the cost of remarkable and potentially irreversible cropland loss.

Urbanization Pattern

The urbanization type of BAMR is concentric. The concentric zone model is first created by a sociologist named Ernest Burgess in 1925. It suggests the urban growth can be "best illustrated …by a series of concentric rings" (Burgess, 2008). The comparison between 1985 and 2015 shows that the city kept growing around the city center. It is a typical processes of the expansion of a city with "The Loop" (downtown), "zone in transition", "zone of workingmen's homes", "residential zone" and "commuters zone" (Park, Burgess, & McKenzie, 1984).

Drivers of Cropland Loss

Political decisions are the main cause of cropland loss. The best agricultural lands are often replaced by cities (Pimentel & Pimentel, 1980). New classical economic theory can be one of the reasons for cropland loss. According to this theory, land use change is the result of land managers to pursue the maximum profit (X. Liu, Wang, Liu, & Meng, 2005).

Social-ecological Resilience

Social ecology is related to land use and agricultural production, and the environmental impacts of human activities. It examines the past and present transitions, and projects the future of society–nature coevolution (Fischer-Kowalski, 2015). A resilient social-ecological systems incorporate "diverse mechanisms for living with", and learning from, "change and unexpected shocks" (Adger, Hughes, Folke, Carpenter, & Rockström, 2005).
Urbanization and its induced cropland loss is a test for social-ecological resilience. Although there is reduction of cropland, if the urban expansion can lead to higher income and better life quality the residents as well as out-weighting the cost of agricultural land loss, then this would be a positive change overall

Making Connections and Future Works

As global population keeps growing and urbanization continues to expand, the competition of the available land by cities and agricultural land will be more intensive in the future. Therefore, it is critical to assess trade-off of ecosystem services caused by the conversion of prime agricultural landscape to urban land. Particularly, the competition of different land use may causes severe ecological consequences (Raudsepp-Hearne, Peterson, & Bennett, 2010).

Conclusions

This research has investigated in a unique designated region, BAMR, that is significant and suitable for urban and cropland loss study. Although many researchers had studied multiple aspects of ecological systems, none had quantitative result using remote sensing techniques and GIS data to conduct the effect of urban land expansion on cropland. This study used supervised decision tree classification method to detect urban and non-urban land for satellite image from 1985 and 2015, then overlaying both images to detect cropland loss due to urban expansion. Results shows that the urban land area has nearly doubled from 937.16 km^2 to 1,835.47 km^2 during 1985 to 2015. Of the area that has expanded (1,835.47 km^2 - 937.16 km^2 = 898.31 km2), 272 km^2 comes from existing cropland which is 30.28%. An accuracy assessment test using random sampling was following to validate the result of the decision tree classifications. The accuracy of the result is 81% which proves the method is a significant and valid.

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