Mapping Land Cover Change in The People's Republic of China

Luke Brogna, Rory Dickinson, and Tanner Honnef

Introduction

In the 1990s, the Chinese Government determined that there could not be a net loss of agricultural land in China in order to feed its ever-urbanizing population. To deal with this issue the "New Land Administration Law" was enacted in 1999. This legislation was an attempt to address the expanding urban population and growth in China and the way in which that expansion comes into conflict with the surrounding agricultural land. China is the largest producer of agricultural goods in the world, so it is paramount that it maintains its level of output capability in order to feed its population of over one billion and to maintain its massive export economy.

This project will explore how successfully this legislation has been in helping to protect agricultural land in China. It focuses on three main search areas. These include Shanghai, Beijing, and Chongqing. We chose these locations because they are three of the most important cities in China. Shanghai is the largest city in China, Beijing is the capital of China and Chongqing has served as a historical capital. These three cities also act as provinces in themselves and are three of the four municipalities under direct administration of the central government. We also chose these cities because they represent three distinct regions of China, those being coastal (Shanghai), northern (Beijing) and central (Chongqing). These being three of the most important cities in China, it is logical to assume that they would be featured heavily in the goals of this policy.

Objective and Research Question

The objective of this project is to analyze how successful the 1999 New Land Administration Law has been in preserving agricultural land in different parts of China.

The research question we aim to answer is: How successfully has the 1999 New Land Administration Law preserved agricultural land in China?

Data Description and Sources

The Landsat 7 and 8 data used has been exported from the Earth Explorer from the USGS (United States Geological Survey). The time points of 1999, 2000, and 2001 will use data from Landsat 7 while data from 2019 and 2020 will use data from Landsat 8. Chongqing and Shanghai are covered by 2 Landsat scenes while Beijing is covered by 1 Landsat scene. The CONCAT module in Terrset was used to combine the separate Landsat scenes for Chongqing and Shanghai. For the sake of processing time and available resources, not all of each of the provinces are going to be covered in the data that we are using. A large part of each of the provinces is going to be covered to give a realistic representation of how the amount of agriculture in the provinces has changed over time.

Methods

To answer the research question, urban and agricultural areas had to be identified in each area of interest at both points in time. This was done by using the Landsat bands to classify the image into spectral clusters, or areas with similar spectral signatures across all bands. The low resolution of the Landsat imagery makes discerning between features on a color composite with the naked eye difficult, so an unsupervised method of classification was used to avoid the possible human error that could arise during the digitization of training sites. Terrset's IsoClust module was chosen for unsupervised classification, set to 3 iterations and 15 clusters. Beijing was the simplest as it contained only one image.

We were able to do the IsoClust classification with all seven of the Landsat bands for both years for the Beijing maps. For the Shanghai maps, we were only able to get the first five bands for the 2000 image while we were able to get all seven bands for the 2020 image. Band 6 and 7 were unusable though, and the classification would not work, so we stuck with the first five bands for the 2020 Shanghai image as well. The Chongqing images turned out to contain too much distortion, so we decided to not use them. A mask was used to mask out any water in the Shanghai 2020 image as there were clusters that contained significant amount of land and water that made them unusable without the mask. The mask was created by using Terrset's reclass tool to make DN values of less than 10,000 in band 5 a mask. This mask made the landcover map for 2020 far more accurate. Following the successful completion of the module's multiple processes, the output images were displayed. The IsoClust processing took an average of around one hour each for each map.

By analyzing these new images, we determined which informational class to assign to each of the 15 clusters. We did this by comparing the classified spectral classes to the true color composites of the original images, along with the higher resolution imagery from Google Earth. The same process was undergone with the Shanghai images, though that extent was composed of two Landsat images, which had to be mosaiced using the CONCAT module as previously mentioned.

With two images of informational classes for each location, Terrset's AREA module was used and the net gains/losses in each category over the temporal extent could be discerned.

To visualize the changes in the urban and agricultural land cover types, a cross tabulation was performed using the two time points for each location. The images had to be windowed to the same extent, after which Terrset's CrossTab module was used to overlay the two images such that the differences could be visualized. These output images from CrossTab were then Reclassed to include only the interaction between, and persistence of, the agriculture and urban cover types.

Results *(relevant numbers and figures in Figures section)*

For the Beijing images we separated the spectral classes into five different information classes for both years' images. These classes were: *No Data* for the background of the image, *Urban* for built up areas and manmade structures, *Agriculture* for cultivated land, *Water* for lakes and rivers and *Forest* for wooded and nonagricultural vegetation. The 2020 image shows an increase in agricultural land (+ 541,048 sq. km) in comparison to the large expansion in urban (+406,682 sq. km) and built-up land. The Beijing images also had significantly different visual looks in their true color composite. This is because the 1999 image was collected in September, whereas the 2020 image was taken later in the fall. The changed colors of the leaves and increased number of fallow fields did not seem to influence the classification though as we could not see any confusion in the IsoClust result.

For the Shanghai images we ended up separating the spectral classes into five different information classes for the 2000 image and six information classes for the 2020 image. For the 2000 image these were: *No Data* for the background of the image, *Urban/Exposed Land* for the built-up area, but also included areas of bare soil and sand, *Agriculture* for both fallow and healthy agricultural fields, *Water* for the ocean, lakes, and rivers and finally, *Forest* for the wooded areas of the map. For the 2020 image these were: *No data* again for the background, *Urban/Exposed Land*, *Agriculture*, *Water*, *Forest* and lastly for this image, we assigned a miscellaneous category, (*Sand*) as we felt its inclusion created a more accurate depiction of the levels of agriculture and forest on the map. The miscellaneous class consists mostly of sand, non-forest, and non-agriculture vegetation as well as unclassifiable vegetation. The 2020 Shanghai image shows a significant decrease in agricultural land (-3,643,221,600 sq. km), although as we will explain in the next section, this is not as concrete a solution in comparison to the Beijing results.

Conclusion and Discussion

After analysis of the data from the two images, we consider the 1999 New Land Administration Act was successful in helping to preserve agricultural land as urban expansion continues. In Beijing, there is an increase in agricultural land, and the urban expansion is prominent, the act has been successful. We consider the Shanghai analysis to be a failure though because it shows an overall decrease in urban areas, which we know to be untrue, through cross analysis with satellite data. This decrease in built up land is likely due to the IsoClust not being able to differentiate between the pixels in the images, especially the 2020 image. As stated previously there is a cloud present in the 2000 Shanghai bands that came out classified as urban area. The IsoClust module also had difficulty discerning the differences between certain darker agricultural fields and darker forested areas. All this led to an inaccurate portrayal of land use in Shanghai Province in 2000 and 2020, rendering the results to be untrustworthy.

Once IsoClust had run on the imagery for Chongqing, it became apparent that the clusters were not going to be able to be separated into different information classes for the analysis to take place.

References

Lichtenberg, Erik, and Chengri Ding. "Assessing farmland protection policy in China." *Land use policy* 25.1 (2008): 59-68.

Figures

Figure 1: Beijing Landcover at year 1999

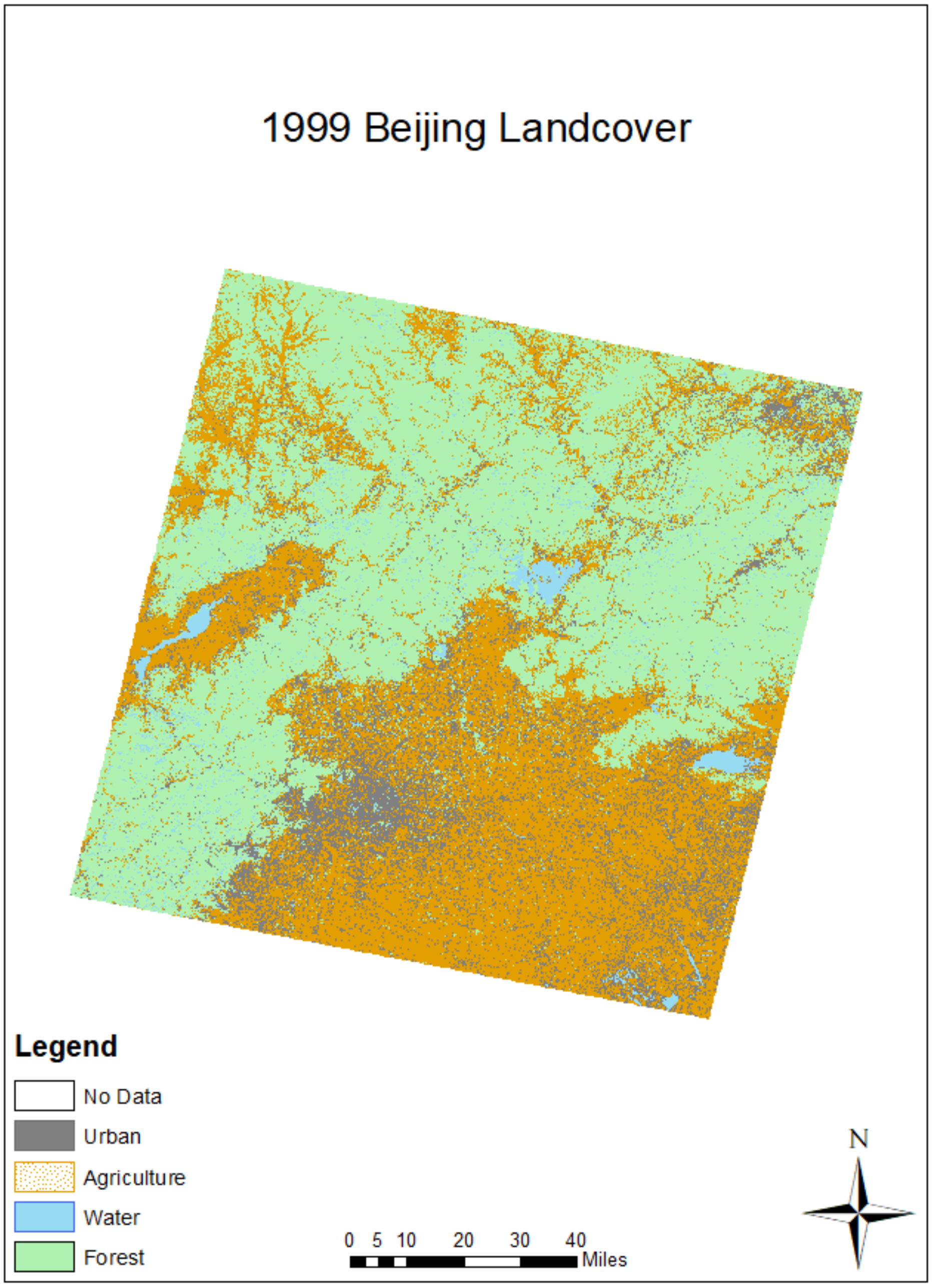

Figure 2: Beijing Landcover at year 2020

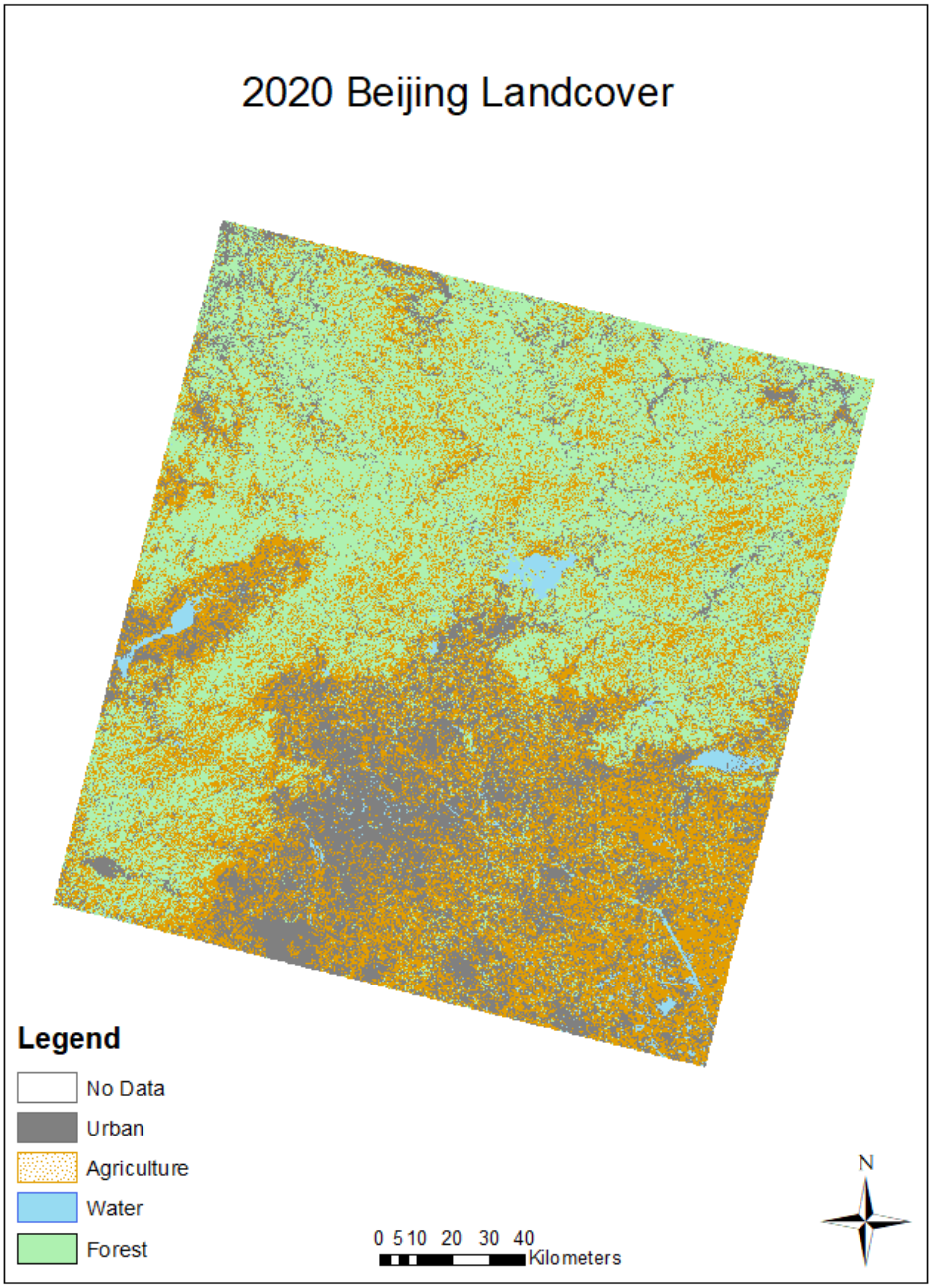

Figure 3: Shanghai Landcover at year 2000

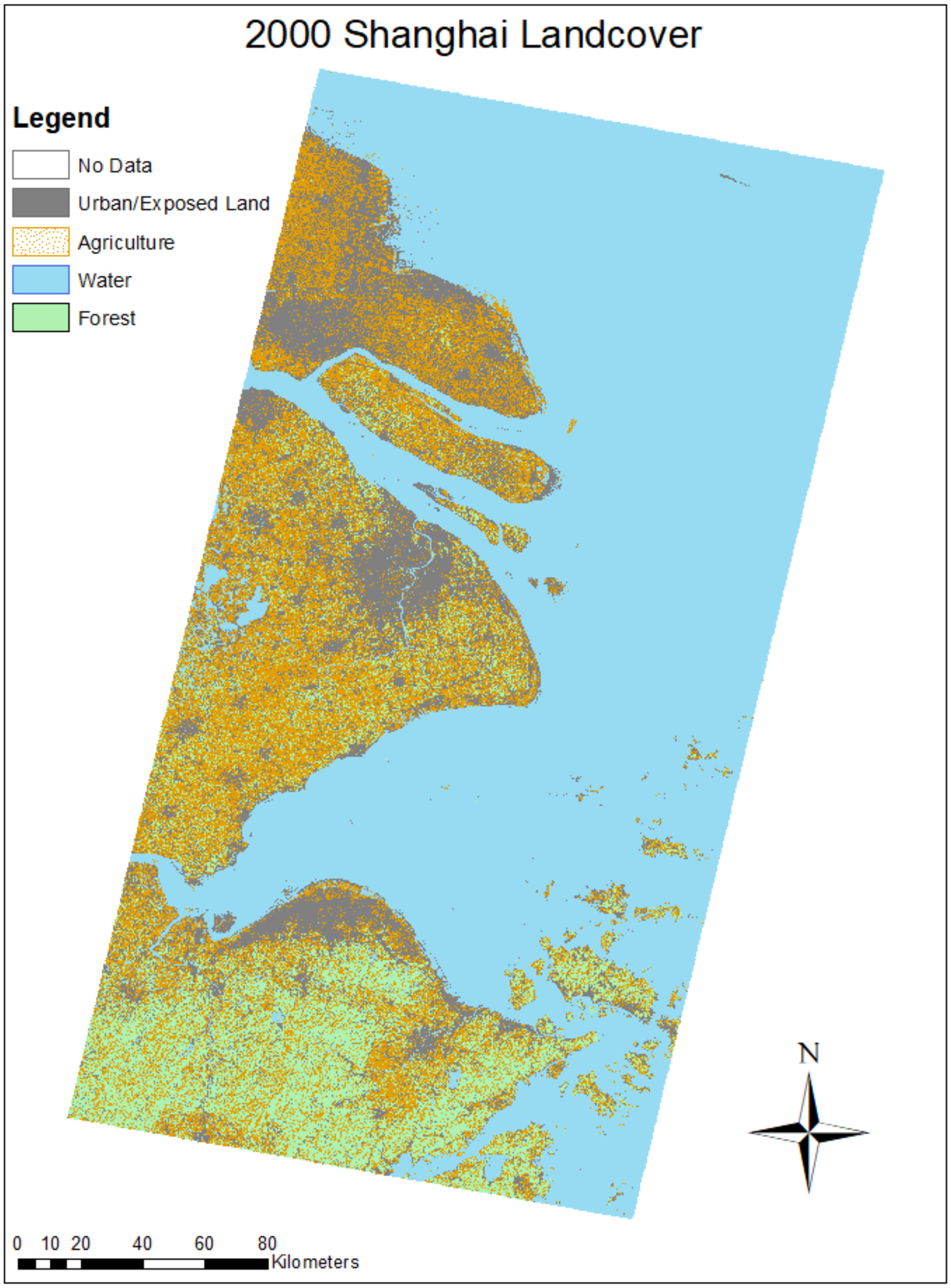

Figure 4: Shanghai Landcover at year 2020

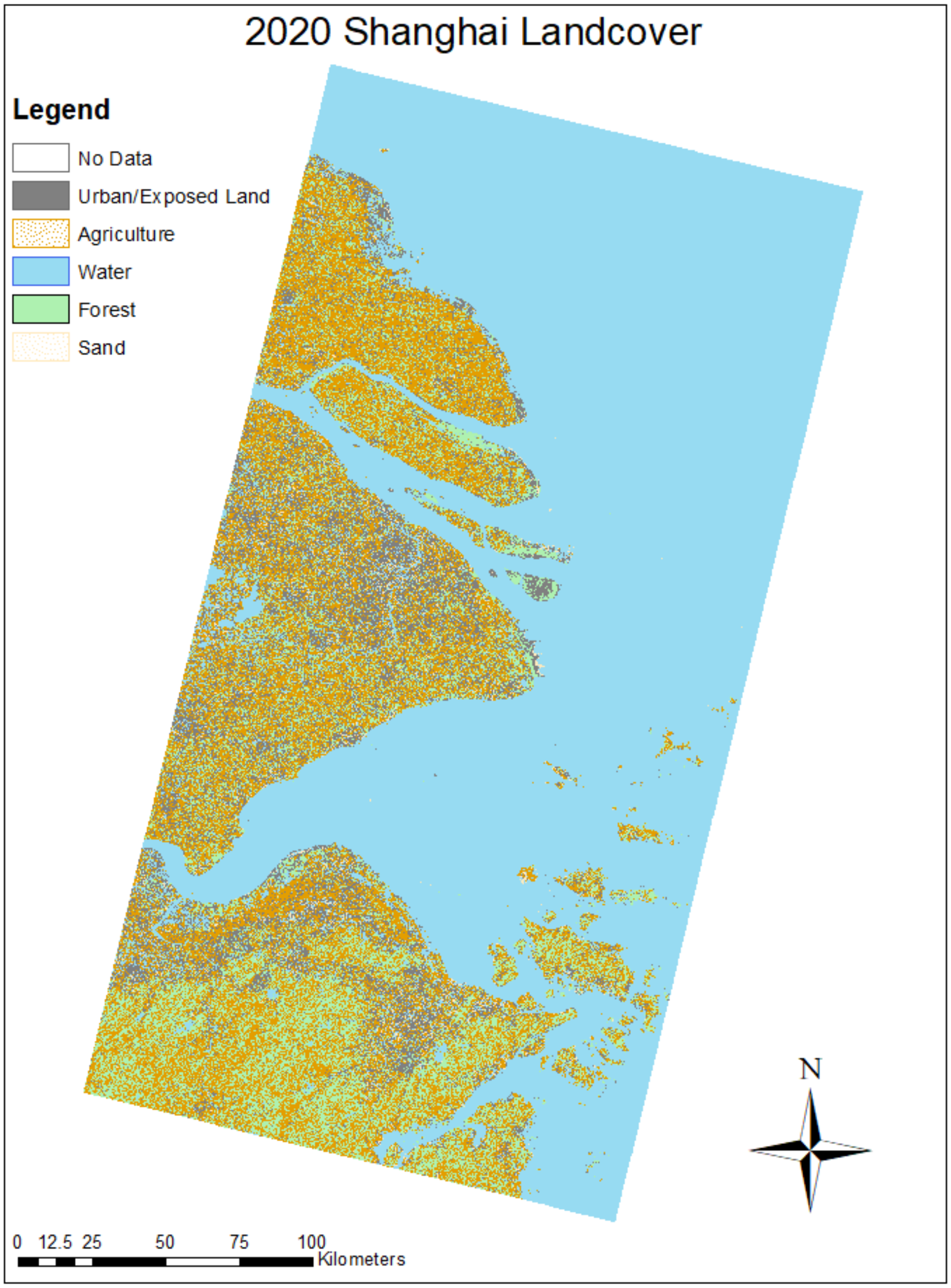

Figure 5: Urban/Agriculture Interaction Between 1999-2020 in Beijing

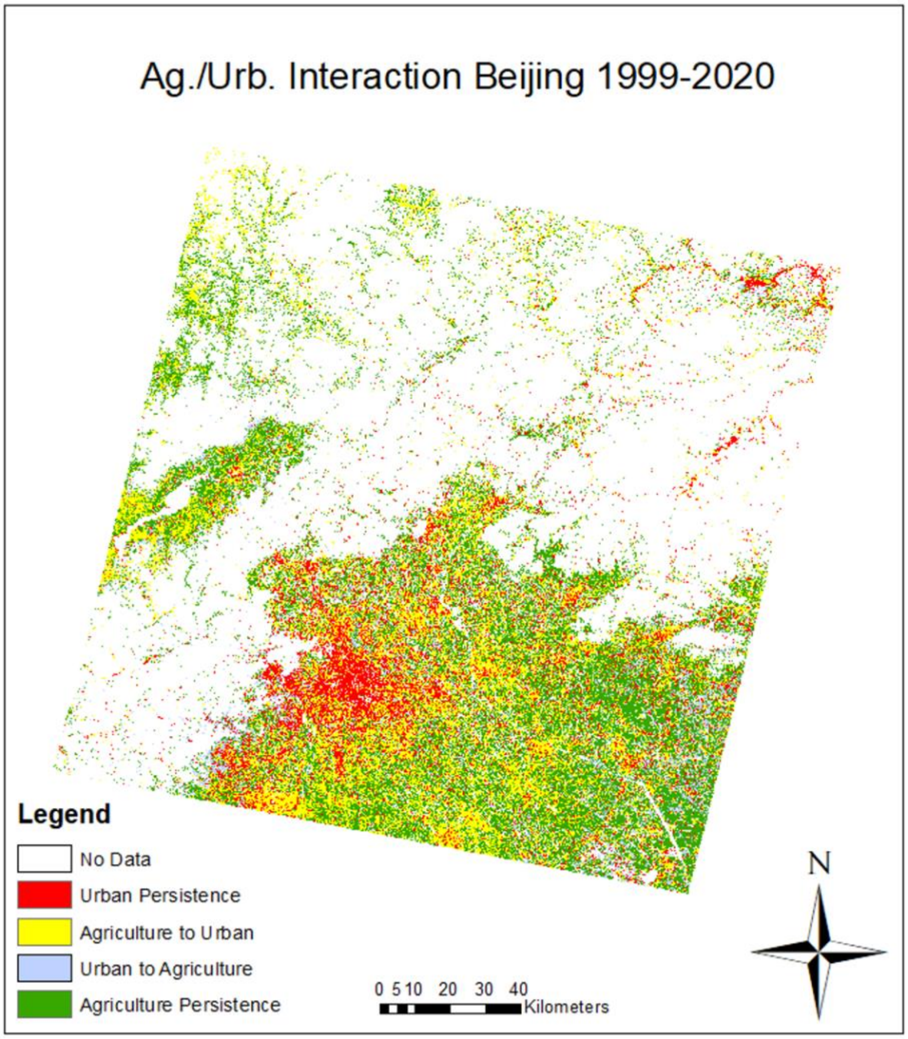

Figure 6: Beijing Cross Tabulated Land Cover Change Table, Simplified Categories (meters squared)

Category	Urban 2020	Agriculture 2020	Water 2020	Forest 2020	Total
Urban 1999	2364022	4880502	59880	829288	8133692
Agriculture 1999	1332923	5876399	44246	5032295	12285863
Water 1999	122623	106545	505034	61082	795284
Forest 1999	751409	1798287	564216	13169432	16283344
Total	4581472	12760459	1175980	19209357	37727268

Figure 7: Beijing Proportional Cross Tabulated Land Cover Change Table, All Categories (names in Results section)

Category	1	2	3	4	Total
0	0.0003	0.0026	0.0001	0.0031	0.0061
1	0.0627	0.1294	0.0016	0.0220	0.2156
2	0.0353	0.1558	0.0012	0.1334	0.3256
3	0.0033	0.0028	0.0134	0.0016	0.0211
4	0.0199	0.0477	0.0150	0.3491	0.4316
Total	0.1214	0.3382	0.0312	0.5092	1.0000

Figure 8: Urban/Agriculture Interaction Between 1999-2020 in Shanghai

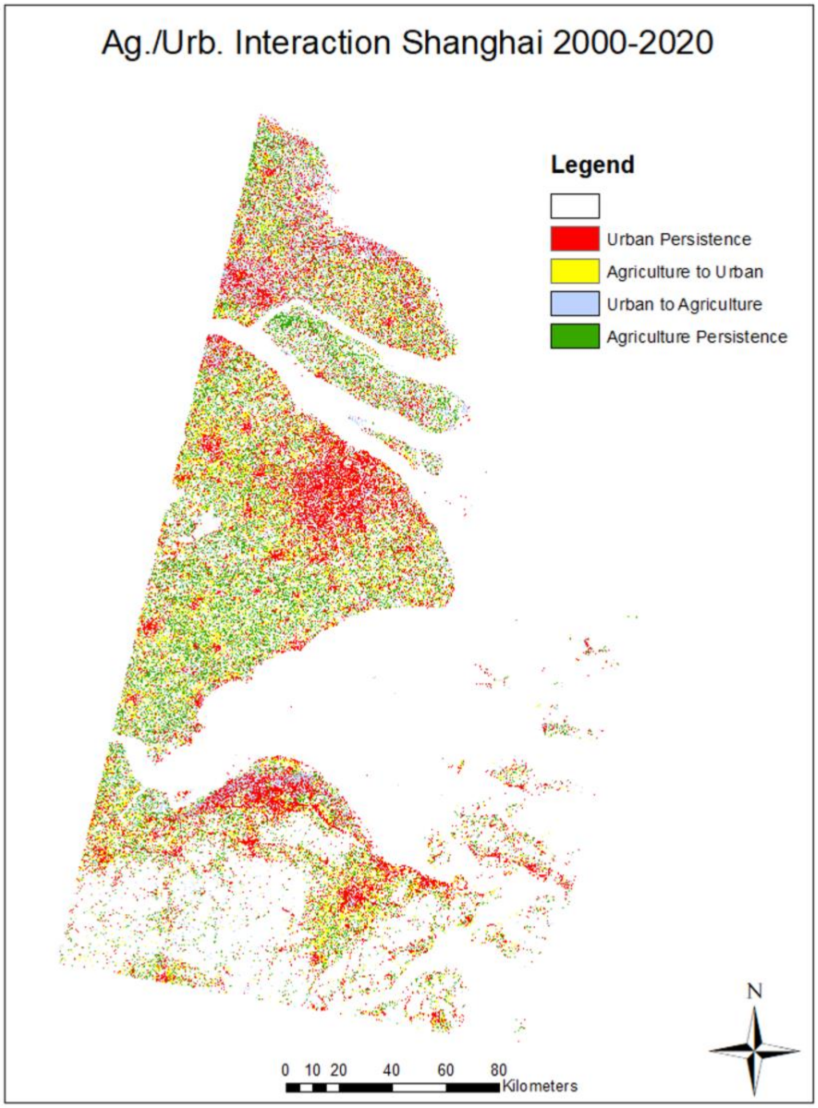

Figure 9: Shanghai Cross Tabulated Land Cover Change Table, Simplified Categories (meters squared)

Category	Urban 2020	Agriculture 2020	Water 2020	Forest 2020	Total
Urban 2000	4349580	3100127	923637	1153322	9526666
Agriculture 2000	2696901	3450141	457850	1757906	8362798
Water 2000	497656	519588	38787078	99420	39903742
Forest 2000	423767	2236076	137340	3506071	6303254
Total	9793647	12563330	41037038	7842950	71236965

Figure 10: Shanghai Proportional Cross Tabulated Land Cover Change Table, All Categories (names in Results section)

Category	1	2	3	4	Total
0	0.0052	0.0078	0.0028	0.0029	0.0186
1	0.0611	0.0435	0.0130	0.0162	0.1337
2	0.0379	0.0484	0.0064	0.0247	0.1174
3	0.0070	0.0073	0.5445	0.0014	0.5602
4	0.0059	0.0314	0.0019	0.0492	0.0885
5	0.0205	0.0380	0.0075	0.0157	0.0816
Total	0.1375	0.1764	0.5761	0.1101	1.0000