SPATIO-TEMPORAL ANALYSIS OF URBAN ECOSYSTEM SERVICES WITH SENTINEL-2A MSI DATA

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INTRODUCTION

The objectives of this study are to evaluate the contribution of Sentinal-2A multispectral imager (MSI) data for urban ecosystem service mapping and to evaluate spatio-temporal characteristics of ecosystem service provisional patches through landscape metrics as an extension of the ecosystem service concept. Changes in service patterns over a 10-year time frame are mapped in the megacity of Beijing, China using Landsat TM data from 2005 and Sentinel-2A MSI data from 2015. Landscape metrics are generated based on the classification results to evaluate the changes of urban ecosystem service provision bundles.

STUDY AREA AND DATA

The study area is in Beijing, China's capital, where ecosystem services play an important role for many urban residents and visitors. High density built-up areas are characterized by the traditional Hutong areas and modern, high-rise complexes with commercial and residential function. Low density built-up areas exist as well in form of newly built low-rise homes with gardens. Other land use/cover classes include urban green spaces, golf courses, agricultural fields, forest and water bodies that represent the major ecosystem service provisioning classes. Figure 1 shows Sentinel - 2A MSI image acquired on 2015-09-13. A spectral subset of the Sentinel-2A image was chosen excluding the three bands at 60m resolution. For the analysis of ecosystem services change, Landsat 5 TM image acquired on 2005-07-09.

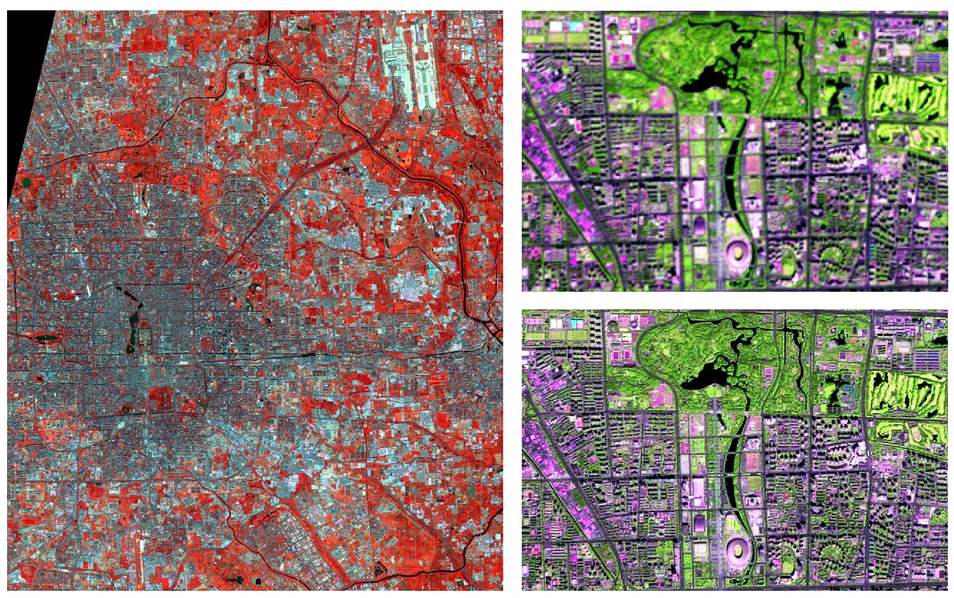

Figure 1. FCC Sentinel-2A image Beijing (left) and sub-scene before (upper right) and after pan-sharpening using band 8 (lower right).

METHODOLOGY

The methodology displayed in Figure 2 covers all major analytical stages of the analysis including image pre-processing, image segmentation and classification, accuracy assessment, post-classification aggregations, landscape metric and proximity analysis, quantification of spatial influences on ecosystem service provision and observation of changes from 2005 to 2015.

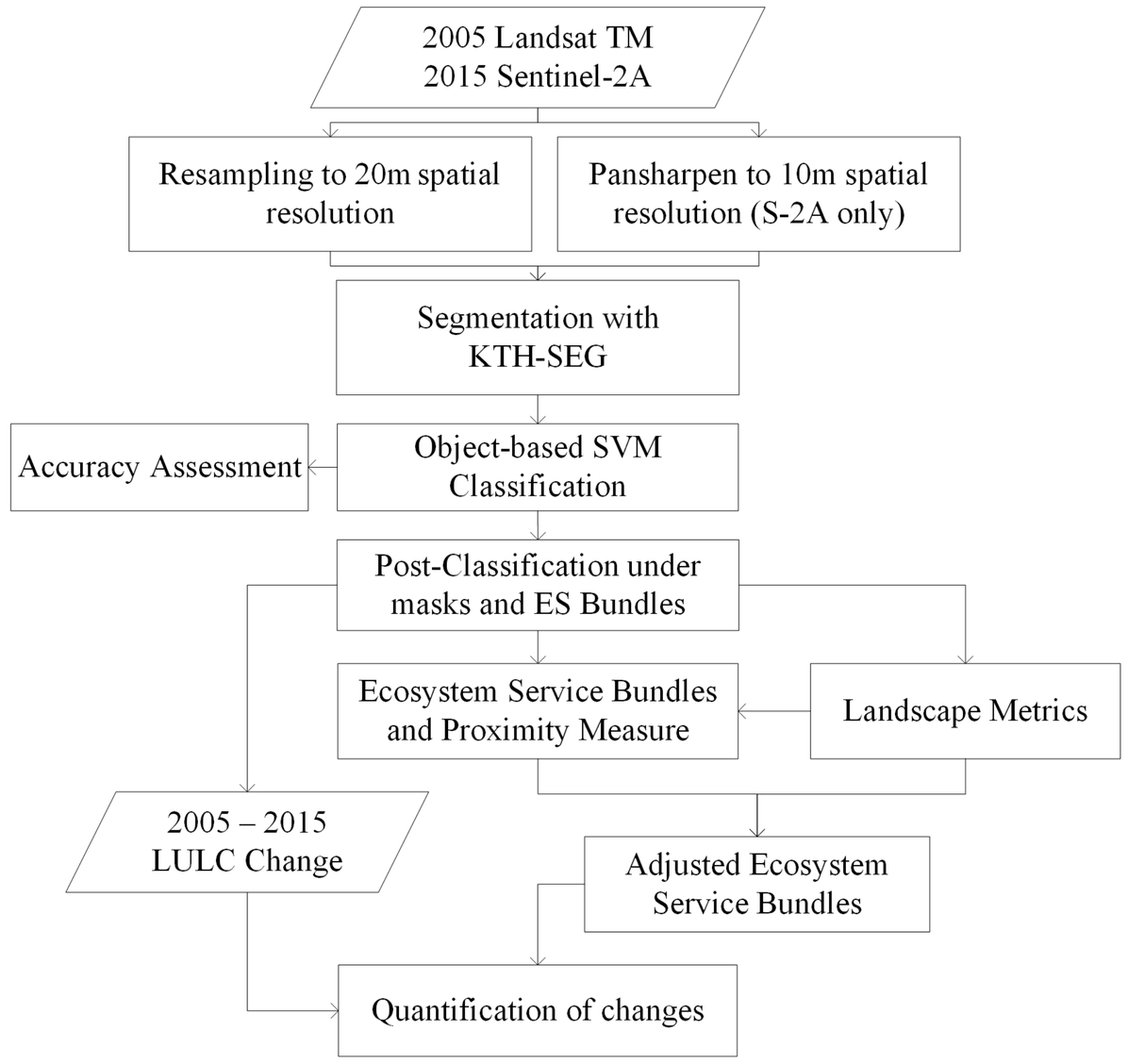

Figure 2. Methodology Flowchart

RESULTS AND DISCUSSION

With Sentinel-2A MSI data's higher spatial resolution, the 2015 classification accuracy at 90.2% (kappa 0.89) was higher than the 2005 one at 84.7% (kappa 0.82). Classification of the pan-sharpened Sentinel-2A MSI image at 10m resulted in classification accuracies of 77.8 % (kappa 0.75) but with two additional classes.

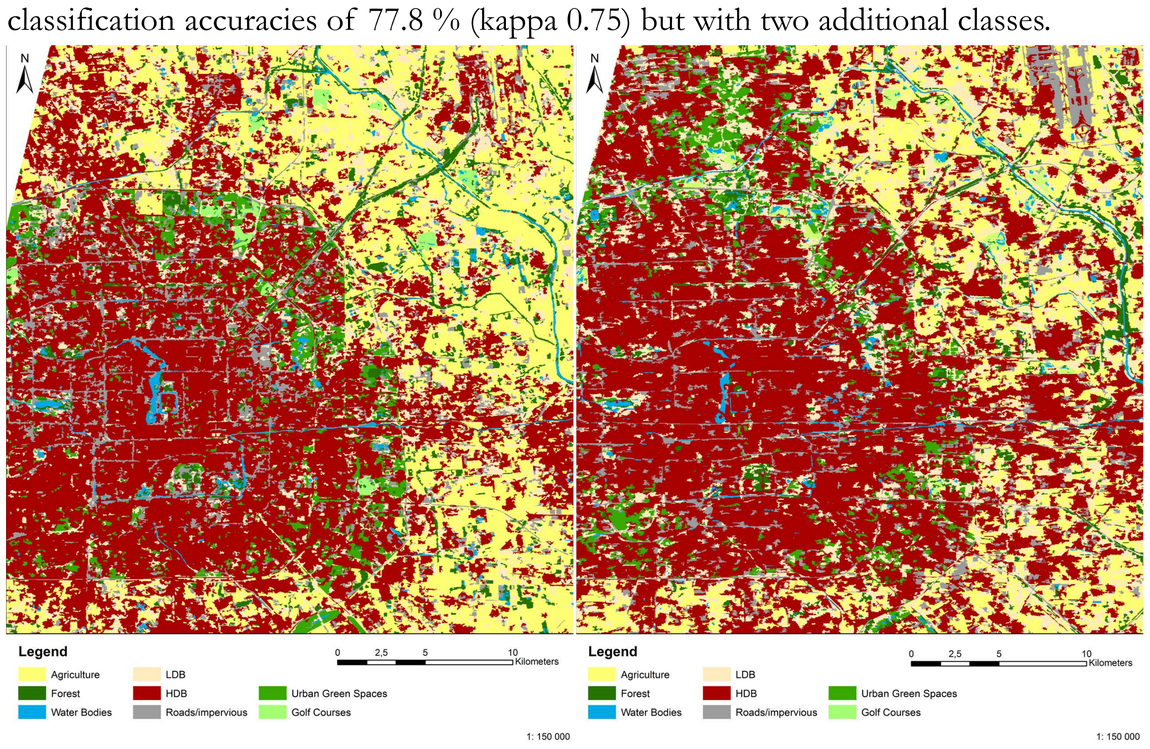

Figure 3. Classification result of Landsat TM data from 2005 (left) and Sentinel-2A MSI data from 2015 (right).

Ecosystem service bundles based on underlying land cover classes and similar spatial factors that influence service quality were derived for 2005 and 2015. Changes in landscape composition and configuration resulted in decreases of more than 30% in the bundles that represent food supply, noise reduction, waste treatment, global climate regulation. Temperature regulation/moderation of climate extremes, recreation/place values and social cohesion, aesthetic benefits/cognitive development and less affected by the observed land cover changes.

Beijing's urban development is characterized by a decrease in agricultural areas in the urban fringe in favour of new high and low density built-up areas, urban green space and golf courses. In total, high density and low-density urban areas have increased ca. 21%. Furthermore, the deconstruction of former high density low-rise suburban agglomerations into urban green space can be observed. The planar increase in urban areas is partly counteracted by the creation of managed urban green spaces.

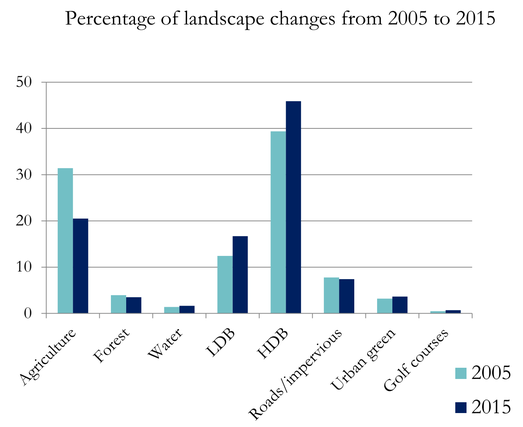

Figure 4. Ecosystem service bundle changes and share of spatial influence.

CONCLUSIONS

- High classification accuracies indicate the suitability of Sentinel-2A MSI data for urban land cover mapping and urban ecosystem service analyses.
- Using pan-sharpened S-2A data at 10m spatial resolutions yielded very promising classification results with two additional classes.
- The Sentintel-2A MSI red edge band was found effective in distinguishing urban green spaces.
- The approach developed in this study extends the ecosystem service concept to including the influence of spatio-temporal characteristics of ecosystem service provisional patches, thus resulting in a more realistic and comprehensive appraisal of ecosystem services than traditional monetary approaches in urban areas.

ACKNOWLEDGEMENT

This study is part of the project "Multitemporal multisensor analysis of urban agglomeration and climate impact in China for sustainable development" within the European Space Agency (ESA) and the Chinese Ministry of Science and Technology (MOST) Dragon III program. The authors would like to thank ESA for the provision of Sentinel-2A data.