

Kelin Wang¹, Yuemin Yue², Martin Brandt³, Xiaowei Tong³

KARST ECOSYSTEM OBSERVATION AND ASSESSMENT AT LOCAL AND REGIONAL SCALES

ABSTRACT

The highly sensitive and vulnerable karst ecosystem in Southwest China is one of the largest exposed carbonate rock areas (more than 0.54 million km²) in the world, hosting 220 million people. Rocky desertification is the most serious eco-environmental problems in China karst. For the ecological restoration and sustainable development of karst ecosystem, Huanjiang Observation and Research Station was established at 2 000 for the observation of ecosystem structures, processes and functions in China karst. With the long-term continuous observation, remote sensing and ecosystem models, we identified the changes of ecosystem spatial pattern, progresses and functions under the coupled impacts of climatic and human disturbances. The results showed that ecological restoration projects had positive effects on China karst restoration, especially at local and regional scales. The ecosystem structure and functions had been improved with the implementation of ecological restoration projects, despite a decline in rainfall and soil moisture in China karst. The vegetation greenness and carbon stock increased with conservation projects. China karst was one of the globally largest increases in vegetation cover and biomass. However, the water and soil conservation and biodiversity functions maybe increase slowly. It is needed for the comprehensive assessment for understanding of conservation projects' functional and biodiversity effects. The other intervention that have the potential to enhance or generate wider positive effects of ecological restoration projects.

KEYWORDS: ecosystem assessment, long-term observation, remote sensing, ecosystem functions, China karst

INTRODUCTION

The South China Karst ecosystem is one of the largest exposed carbonate rock areas in the world, hosting more than 200 million people and covering 8 provinces [Yuan et al., 2016]. Accelerating land degradation has been reported caused by the increased exploitation of natural resources during the last half century [Jiang et al., 2014]. Due to high population pressure, farmlands increasingly expanded to sloping areas and as a result, large parts of the karst area were deforested thereby exposing the soil to erosion. Consequently, vast karst areas (~0.13 million km²) previously covered by shrubs and trees were gradually converted to bare soils (State Forestry Administration of China. Bulletin of China's Rocky Desertification, 2012). The loss of soil and vegetation cover was detrimental from both an ecological and economical point of view: the karst area is an important water reservoir, but the reduction in vegetation cover resulted in surface run-off and decreased infiltration rates. Moreover, local livelihoods depending on agriculture lost their source of income which resulted in aggravated rate of poverty.

To combat this severe form of land degradation and to relieve poverty, more than 130 billion yuan (~19 billion USD) has been invested in mitigation initiatives since the end of the 1990s. The

¹ Institute of Subtropical Agriculture, Chinese Academy of Sciences, No.644 Yuanda Road (Sec.), Furong District, 410125, Changsha, China, *e-mail*: kelin@isa.ac.cn (KL Wang), ymyue@isa.ac.cn (YM Yue)

² Huanjiang Observation and Research Station for Karst Ecosystem, Chinese Academy of Science, Huanjiang, 714900, Guangxi, China

³ Department of Geosciences and Natural Resource Management, University of Copenhagen, Copenhagen, Denmark, *e-mail*: martin.brandt@mailbox.org, tongxiaowei1996@gmail.com

costs of mega-engineering as a climate change mitigation measure are however only justified if ecosystem properties can be affected at large scales. Only a few studies have assessed the direct impact of forestry and conservation projects on vegetation cover at large spatial scales [Tong et al., 2017; Fang et al., 2014; Xiao, 2014]. Therefore, it is crucial for the comprehensive assessment of China karst.

MATERIALS AND METHODS OF RESEARCH

Multiple and independent long-term data sets by Huanjiang Observation and Research Station for Karst Ecosystem, Chinese Academy of Sciences were analyzed to monitor the impact of conservation projects on karst ecosystem structure, processes, and function changes. These data included the observation and analysis of meteorological and atmospheric environment, soil physical and chemical analysis and profile description, observation and analysis of water environment, observation and analysis of terrestrial biocommunities. The long-term remotely sensed vegetation NDVI, LAI, and biomass were also analyzed.

RESULTS OF RESEARCH AND DISCUSSION

1. Structural changes in field and satellite time series coincide with conservation project implementation

Vegetation cover and climate were analyzed at the regional scale for the provinces Guangxi, Guizhou and Yunnan in Southwest China (1982–2015). Structural (abrupt) changes in Normalized Difference Vegetation Index (NDVI) time series were identified at pixel level and the timing of the observed shifts (i.e. breakpoints) in vegetation cover were analyzed. The number of pixels with breakpoints for NDVI increased from 1. The biggest Chinese conservation program, the Grain to Green project, was launched in 2000/2001 in Southwest China and most conservation areas were fully implemented in 2002–2004 coinciding with of the highest numbers of detected breakpoints. Another largescale ERP named Karst Mountain Desertification Restoration Project was launched in 2008 corresponding with the 3rd highest a mount of breakpoints detected. The year 2 000 was thus used to divide the period in prior and post conservation periods.

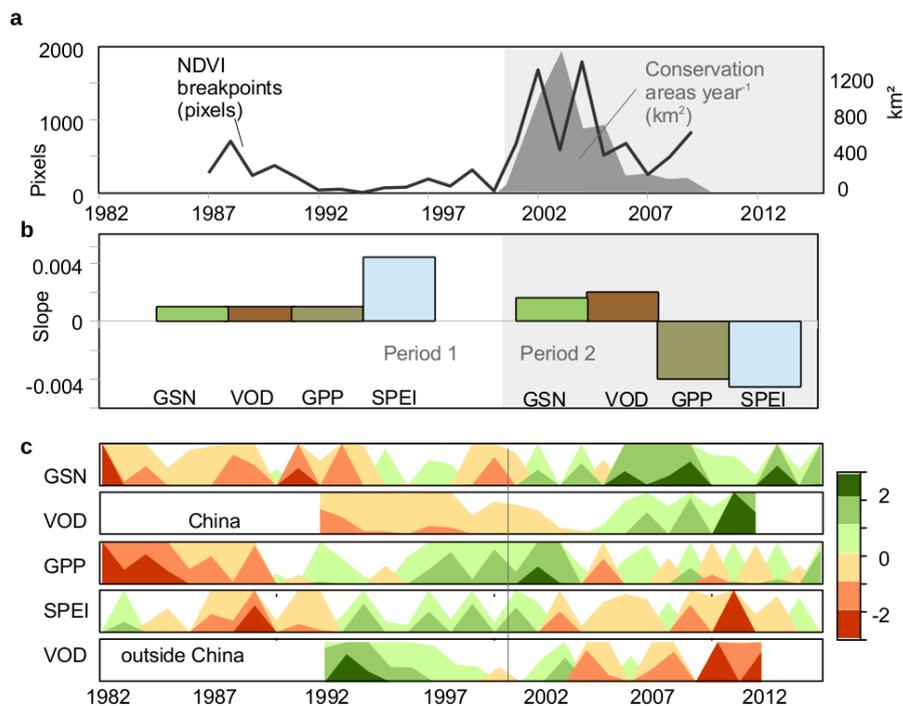


Fig. 1. The comparison of ecosystem changes between before and after conservation projects

2. Changes in karst ecosystem structure and function before and after the conservation projects at local and regional scales

We chose a typical county for analyzing the changes in ecosystem structure and functions. The results showed that the SPEI was decreased (0.006/a) during 2001–2015, indicating a decline in rainfall and soil moisture. The vegetation cover increased significantly during 1982–2015. Rocky desertification decreased 38.5 % during the past ten years, especially the most serious rocky desertification. Forest ecosystem increased 210 km², occupied 5 % of the total areas of Huanjiang county. For the ecosystem functions, the ecosystem productivity, carbon sink, water and soil conservation functions all increased with the implementation of ecological restoration projects. But compared with other ecosystem functions and biodiversity, water conservation did not recover simultaneously.

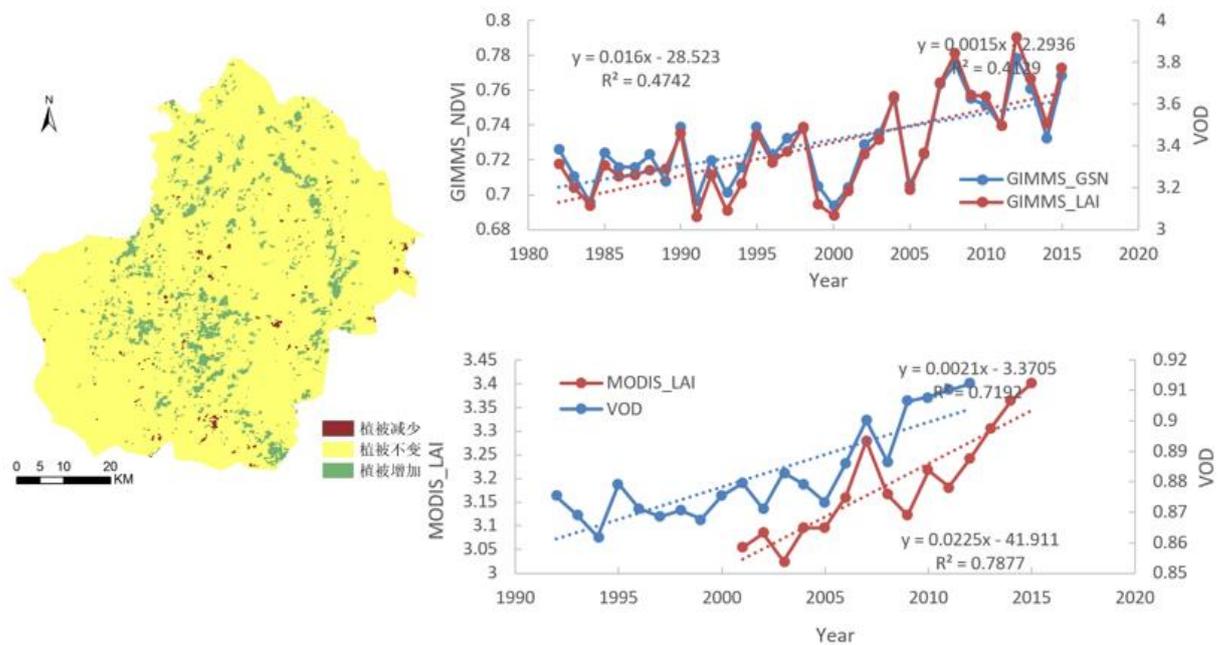


Fig. 2. The vegetation cover changes during 1982–2015 at local scales

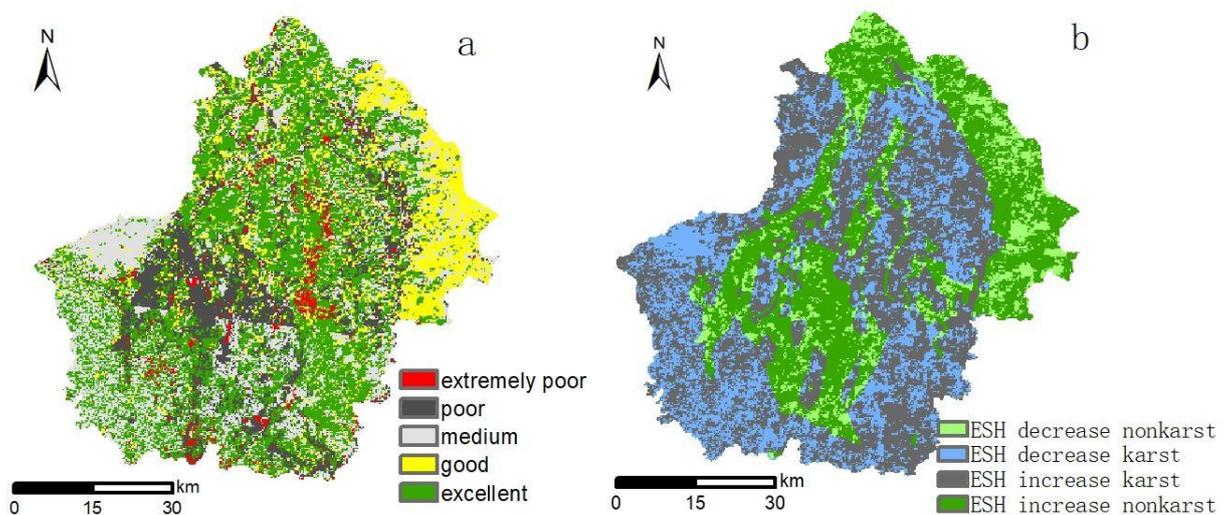


Fig. 3. Ecosystem conditions with the ecological projects

3. Global and regional changes in biomass 2010–2017

By using SMOS L-VOD as a proxy for aboveground biomass we mapped percent deviation from the mean from 2010 to 2017 at a 25 km spatial resolution. For this period, there was an overall slightly positive change in biomass at global scale ($+ 0.01 \% \pm 26$ for all pixels and $+ 4\% \pm 34$ if considering only significant pixels at $P < 0.05$). Areas with a significant ($p < 0.05$) positive biomass trend covered globally ~ 12 million km^2 , of which 7 % were located in the South China Karst region, making the study area one of the largest, spatially coherent, area of biomass increase. More specifically, 55 % of the study area showed a significant ($P < 0.05$) increase in biomass (on average $+ 48 \% \pm 21$ over ~ 0.8 million km^2 ; fig. 3 a), of which 0.3 km^2 were found in pure karst landscape (representing 64 % of the 0.5 million km^2 pure karst area). Biomass trends were exclusively positive over the study area and similar results were obtained when considering absolute values instead of relative values (fig. 3 b). Furthermore, 19 % of the major increases in global biomass (values above the 90th percentile) were located in the Chinese karst region.

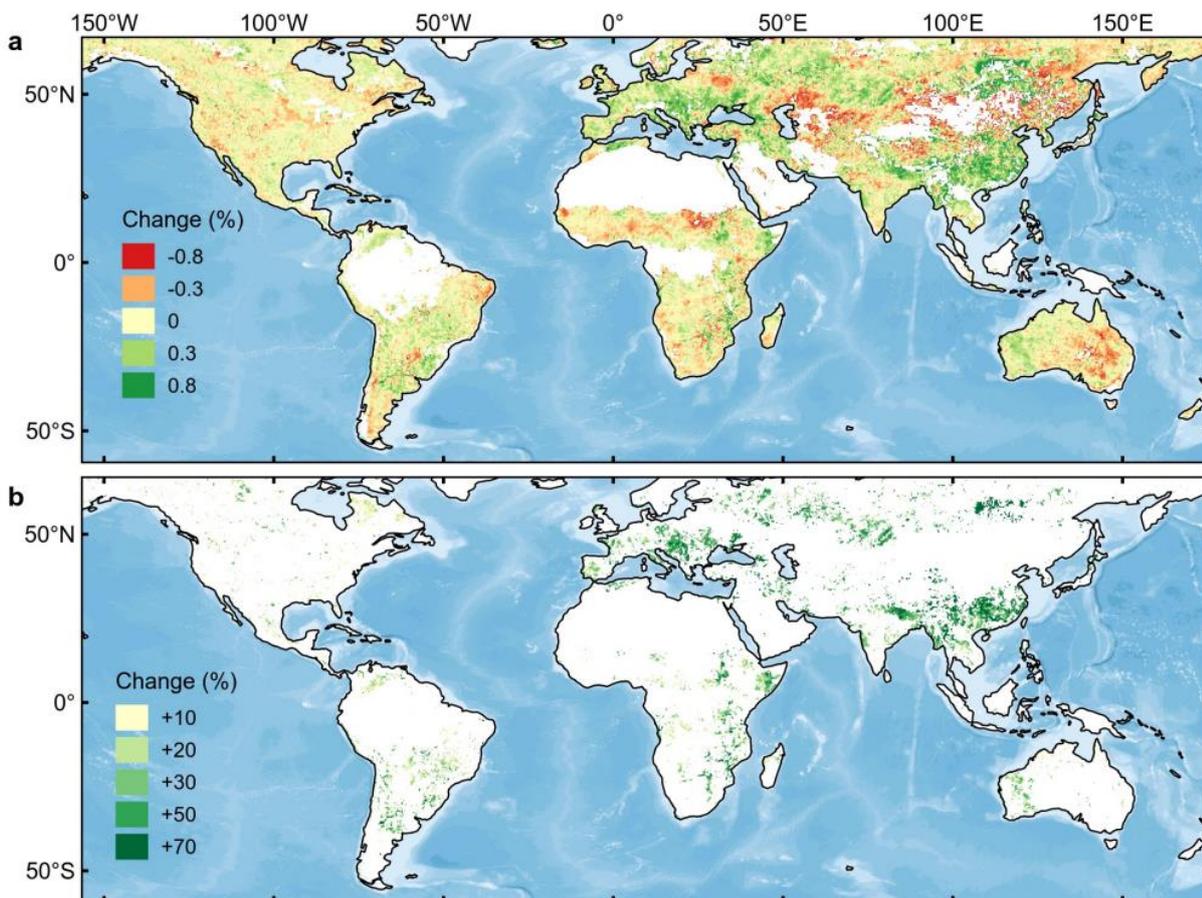


Fig. 4. Global maps of vegetation aboveground biomass significant ($P < 0.05$) increase/decrease

CONCLUSIONS

Our study indicate that the vegetation greenness and carbon stock increased with conservation projects. China karst was one of the globally largest increases in vegetation cover and biomass. However, the water and soil conservation and biodiversity functions maybe increase slowly. It is needed for the comprehensive assessment for understanding of conservation projects' functional and biodiversity effects. The other intervention that have the potential to enhance or generate wider positive effects of ecological restoration projects.

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