Science of the Total Environment 646 (2019) 930–939

Contents lists available at ScienceDirect

Science of the Total Environment

journal homepage: www.elsevier.com/locate/scitotenv

Carbon emissions induced by land-use and land-cover change from 1970 to 2010 in Zhejiang, China

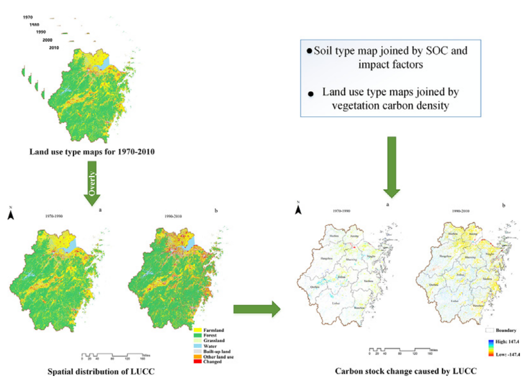
Enyan Zhu, Jingsong Deng *, Mengmeng Zhou, Muye Gan, Ruowei Jiang, Ke Wang, AmirReza Shahtahmassebi

College of Environmental and Resource Sciences, Zhejiang University, Hangzhou 310058, Zhejiang, China

HIGHLIGHTS

- Great changes of land-use and land-cover took place in Zhejiang during 1970 to 2010.
- Land-use and land-cover change played an important role in the carbon emissions.
- The carbon emission volume of 1990-2010 is nearly three times those of 1970-1990.
- It is essential to preserve lands with high soil organic carbon storage.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 19 April 2018
Received in revised form 30 June 2018
Accepted 23 July 2018
Available online 23 July 2018

Editor: R Ludwig

Keywords:
Global climate change
Carbon emission
LUCC
Vegetation carbon
SOC

ABSTRACT

Land-use and land-cover change (LUCC) is a crucial factor affecting carbon emissions. Zhejiang Province has witnessed unprecedented LUCC concomitant with rapid urbanization from 1970 to 2010. In this study, remote sensing, geographic information system (GIS) and the Intergovernmental Panel on Climate Change (IPCC) method were combined to quantify changes in both vegetation carbon storage and soil organic carbon (SOC) storage resulting from LUCC during 1970–1990 and 1990–2010. For both 1970–1990 and 1990–2010, the results showed successive decrease in farmlands (2.8×10^5 ha or −9.15% and 5.9×10^5 ha or −20.49%, respectively) and grasslands (3.4×10^4 ha or −10.73% and 1.5×10^5 ha or −54.1%, respectively), and continuous increase in forests (2.0×10^4 ha or 0.33% and 1.7×10^5 ha or 2.81%, respectively) and built-up lands (2.07×10^5 ha or 78.41% and 6.49×10^5 ha or 137.8%, respectively). From 1970 to 1990, approximately 8.3 Tg of the total carbon sink declined, including a 0.4 Tg reduction in vegetation carbon and a 7.9 Tg reduction in SOC. While from 1990 to 2010, approximately 17.5 Tg of carbon storage declined, comprising a 2.8 Tg of carbon accumulated by vegetation, and a 20.3 Tg reduction in SOC. Overall, LUCC has resulted in huge amount of carbon emissions in Zhejiang from 1970 to 2010. Efficient planning for LUCC and gradual mitigation of carbon emissions are indispensable for future urban development in China under increasing pressure from global warming.

1. Introduction

Global warming is an international challenge facing humanity in the 21st century (Wang et al., 2017). Since the last century, the average global surface temperature has risen by 0.74 °C (95% confidence

* Corresponding author.
E-mail addresses: eyzhu@zju.edu.cn (E. Zhu), jsong_deng@zju.edu.cn (J. Deng), mmzhou@zju.edu.cn (M. Zhou), ganmuye@zju.edu.cn (M. Gan), rwjiang@zju.edu.cn (R. Jiang), kwang@zju.edu.cn (K. Wang), amir511@zju.edu.cn (A. Shahtahmassebi).

https://doi.org/10.1016/j.scitotenv.2018.07.317
0048-9697/© 2018 Published by Elsevier B.V.

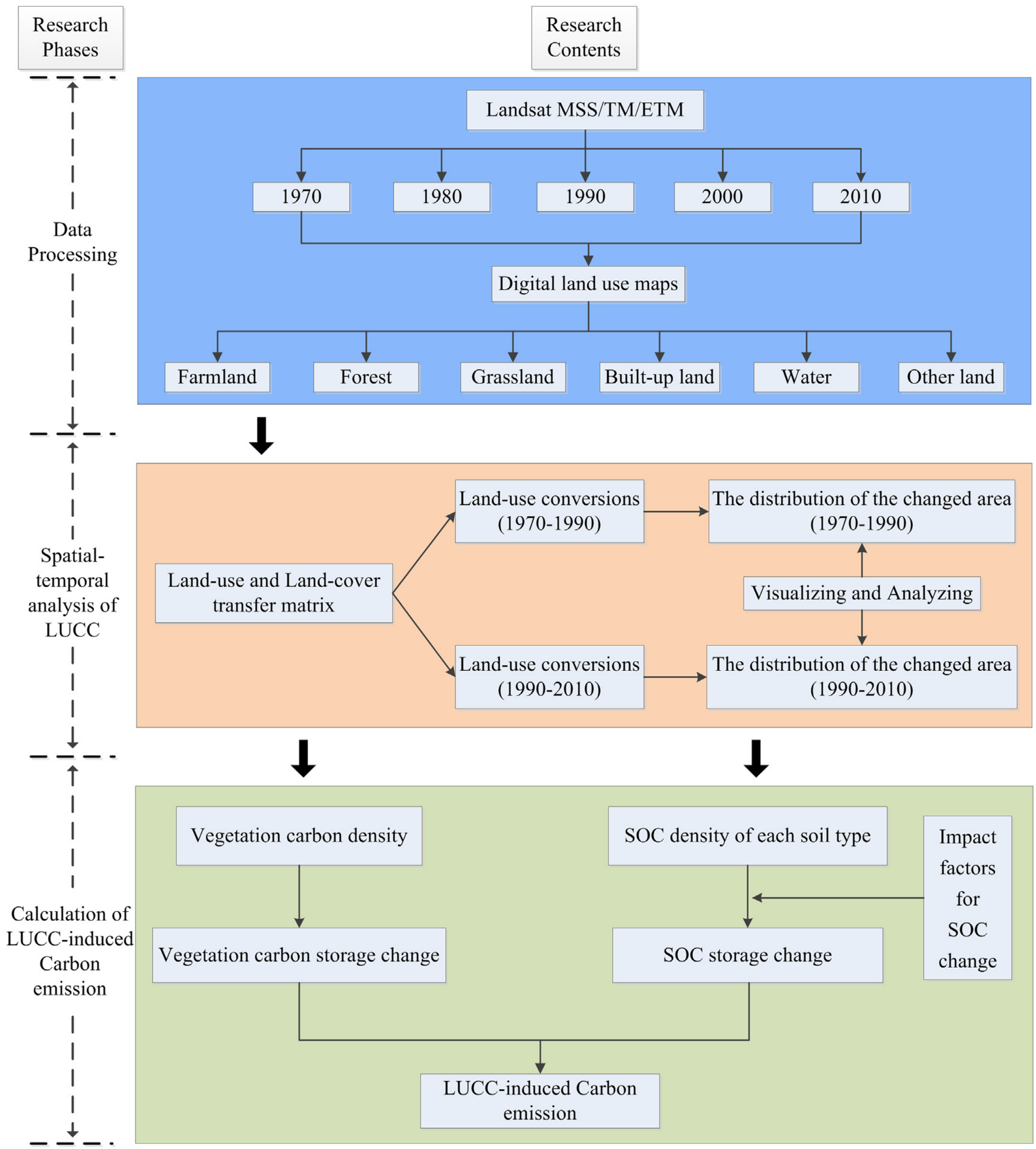


Fig. 1. Flow chart of approaches employed in this study.

interval: 0.56–0.92 °C) (Cubasch et al., 2013). At the end of 2015, 195 nations adopted the Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC), which focused on limiting the increase in the global temperature to less than 2 °C above pre-industrial temperatures (Talks, 2015). Climate models indicate that it is still possible to achieve, but efficient and sustainable policies relating to low carbon emissions are required (Talks, 2015).

Greenhouse gas emissions (GHG), especially carbon dioxide (CO_2) emissions, are considered to be the main drivers of global warming (Bamminger et al., 2018; Cubasch et al., 2013; Yu et al., 2017). And the increase in atmospheric CO_2 concentrations has reached 1.9 ppm per year (Wang et al., 2016), which has further exacerbated global warming. Land-use and land-cover change (LUCC) is a crucial source of carbon emissions (Intergovernmental Panel on Climate Change, 2006) and accounts for approximately one-third of the carbon emissions caused by human activities since the industrial revolution (Houghton et al., 2012). Due to the significant feedback of land systems to the atmosphere, an insightful evaluation of the interaction between LUCC and carbon emission is critical.

Many studies have concentrated on the mechanisms by which land-use changes affect the carbon balance (DeFries et al., 2002; Houghton, 2002; Leite et al., 2012). These studies can be divided into two major groups: national-scale studies (Fang et al., 2007; Pilli and Grassi, 2009), and regional-scale studies (Fahey et al., 2010; Pan et al., 2003; Zhang et al., 2011). Studies of both types have focused mainly on the carbon flux of a specific ecosystem (for instance, paddies, grasslands or forests), but comparisons of the interactions between different ecosystems are lacking. Several studies have employed bookkeeping models by tracking altered areas and carbon density to calculate carbon emissions during LUCC (Dixon et al., 1994; Houghton et al., 1999; Houghton and Nassikas, 2017). The bookkeeping approach has the advantage that carbon densities and carbon response functions describing the temporal evolution and fate of carbon after a LUCC disturbance can be based directly on observational evidence (Hansis et al., 2015; Houghton et al., 2012), but has to assume that local observations can be extrapolated to regions/countries or biomes, thus partly ignoring spatial heterogeneity of carbon stocks. In several other studies, processing models have been applied to analyze the dynamic of carbon