



Universiteit  
Leiden  
The Netherlands

## Going global to local: achieving agri-food sustainability from a spatially explicit input-output analysis perspective

Sun, Z.

### Citation

Sun, Z. (2021, June 1). *Going global to local: achieving agri-food sustainability from a spatially explicit input-output analysis perspective*. Retrieved from <https://hdl.handle.net/1887/3180744>

Version: Publisher's Version

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/3180744>

**Note:** To cite this publication please use the final published version (if applicable).

Cover Page



Universiteit Leiden



The handle <https://hdl.handle.net/1887/3180744> holds various files of this Leiden University dissertation.

**Author:** Sun, Z.

**Title:** Going global to local: achieving agri-food sustainability from a spatially explicit input-output analysis perspective

**Issue Date:** 2021-06-01

**Going global to local: achieving agri-food sustainability from a spatially explicit input-output analysis perspective**

**Zhongxiao Sun**

孙中孝

© Zhongxiao Sun – 2021

Going global to local: achieving agri-food sustainability from a spatially explicit input-output analysis perspective

PhD Thesis Leiden University, The Netherlands

Cover design:

Cover icons:

Printing:

ISBN:

Cai Huang

[www.nounproject.com](http://www.nounproject.com)

[www.proefschriften.nl](http://www.proefschriften.nl)

978-90-5191-999-8

# **Going global to local: achieving agri-food sustainability from a spatially explicit input-output analysis perspective**

Proefschrift

ter verkrijging van

de graad van doctor aan de Universiteit Leiden,

op gezag van rector magnificus prof.dr.ir. H. Bijl,

volgens besluit van het college voor promoties

te verdedigen op dinsdag 1 juni 2021

klokke 10.00 uur

door

Zhongxiao Sun

geboren te Zaozhuang city, Shandong province, China

in 1991

**Promotor:** Prof. dr. A. Tukker (Universiteit Leiden)

**Copromotor:** Dr. P.A. Behrens (Universiteit Leiden)

Dr. L.A. Scherer (Universiteit Leiden)

**Promotiecommissie:** Prof.dr.ir. P.M. van Bodegom (Universiteit Leiden)

Prof.dr.ing. J.W. Erisman (Universiteit Leiden)

Prof. dr. R. Wood (Norwegian University of Science and Technology)

Prof. dr. M. Huijbregts (Radboud UMC Nijmegen)

Dr. N.A. Soudzilovskaia (Universiteit Leiden)

Dr. J.M. Mogollón (Universiteit Leiden)



## Table of Contents

Going global to local: achieving agri-food sustainability from a spatially explicit input-output analysis perspective.....	1
Going global to local: achieving agri-food sustainability from a spatially explicit input-output analysis perspective.....	3
Abbreviations .....	7
1 General Introduction .....	9
1.1 Background .....	9
1.2 The heterogeneity of social and environmental impacts, especially in food systems.....	11
1.3 Global spatially-explicit multi-regional input-output analysis.....	12
1.4 Priorities in sustainable development – a focus on agriculture .....	13
1.5 Aims and research questions .....	13
1.6 Outline of this thesis.....	14
2 Going global to local: connecting top-down accounting and local impacts, a methodological review of spatially explicit input-output approaches .....	16
2.1 Introduction .....	16
2.2 An expanding field .....	18
2.3 Methodological and spatial categories .....	19
2.4 Options for enhancing spatial and sectoral resolution.....	25
2.5 Addressing uncertainties .....	31
2.6 Integration with other environmental .....	32
2.7 Outlook.....	33
2.8 Acknowledgements .....	33
2.9 Supporting Information Available .....	33
3 Linking Global Crop and Livestock Consumption to Local Production Hotspots .....	34
3.1 Introduction .....	34
3.2 Materials and Methods .....	36
3.3 Results .....	39
3.4 Discussion .....	43
3.5 Data statement.....	45
4 Land use in key biodiversity areas disproportionately threatens global biodiversity .....	46
4.1 Introduction .....	46
4.2 Results .....	47
4.3 Discussion .....	55
4.4 Conclusion.....	57



4.5 Materials and Methods .....	57
5 A double carbon dividend from dietary change in high-income nations .....	61
5.1 Introduction .....	61
5.2 Carbon sequestration and emission reduction potentials from dietary change .....	62
5.3 The role of animal products in the carbon cycle .....	65
5.4 Carbon mitigation potentials for items not included in the EAT-Lancet diet.....	66
5.5 Implications for natural climate solutions .....	68
5.6 Methods.....	70
6 General Discussion.....	74
6.1 Answers to the research questions .....	74
6.2 Limitations and future research – ways forward for SMRIO.....	76
6.3 Policy implications .....	79
7 References .....	81
8 Appendix .....	111
8.1 Supporting information to chapter 2 .....	111
8.2 Supporting information to chapter 3 .....	122
8.3 Supporting information to chapter 4 .....	143
8.4 Supporting information to chapter 5 .....	148
Summary .....	156
Samenvatting.....	159
Acknowledgements .....	163
List of publications.....	164
Curriculum vitae.....	165

## Abbreviations

AGBC	Above Ground Biomass Carbon
AIDA	Italian company information and business intelligence
AIM/CGE	Asia-Pacific Integrated Model/Computable General Equilibrium
AMNE	Analytical Activity of Multinational Enterprises
BGBC	Below Ground Biomass Carbon
CDR	Carbon Dioxide Removal
CES	Consumer Expenditure Surveys
CFs	Characterization Factors
CO <sub>2</sub> e	Carbon Dioxide equivalent
COICOP	Classification of Individual Consumption by Purpose
cSAR	countryside Species–Area Relationship
DEHM	Danish Eulerian Hemispheric Model
EDGAR	European Commission’s in-house Emissions Database for Global Atmospheric Research
EEIO	Environmentally Extended Input-Output
ESA CCI-LC	European Space Agency Climate Change Initiative-Land Cover
FABIO	Food and Agriculture Biomass Input-Output
FAO	Food and Agriculture Organization
FAOSTAT	Food and Agriculture Organization Corporate Statistical Database
GCAD	Global Cropland Area Database
GCAM	Global Change Analysis Model
GEOS	Goddard Earth Observing System
GGCMI	Global Gridded Crop Model Intercomparison
GHG	Greenhouse Gas
GISMO	Global Integrated Sustainability Model
GLOBIO	GLOBAL Biodiversity model for policy support
GLOFRIS	Global Flood Risk with IMAGE Scenarios
GMRIO	Global Multi-Regional Input-Output
GRIP	Global Roads Inventory Project
GTAP	Global Trade Analysis Project
HYDE	History Database of the Global Environment
IAMs	Integrated Assessment Models
ICIO	Inter-Country Input-Output
IELab	Industrial Ecology virtual Laboratory
IFA	International Fertilizer Association
IMAGE	Integrated Model to Assess the Global Environment
IoT	Internet of Things
IPBES	Intergovernmental Science–Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change

ISA	Integrated Sustainability Analysis
KBAs	Key Biodiversity Areas
LPJmL	Lund-Potsdam-Jena managed Land
LQs	Location Quotients
LULCC	Land Use Land Cover Change
MESSAGE	Model for Energy Supply System Alternatives and their General Environmental Impacts
Mha	Million Hectares
MODIS	Moderate Resolution Imaging Spectroradiometer
MRIO	Multi-Regional Input-Output
NRMSD	Normalized Root Mean Square Deviation
OECD	Organisation for Economic Co-operation and Development
PNV	Potential Natural Vegetation
POPs	Persistent Organic Pollutants
PREDICTS	Projecting Responses of Ecological Diversity In Changing Terrestrial Systems
REIM	Regional Econometric Input-output Model
REMIND	REgional Model of Investment and Development
SABI	Survey data from enterprises
SAR	Species-Area Relationship
SCA	Smeared Concentration Approximation
SDGs	Sustainable Development Goals
SIO	Spatially explicit Input-Output
SMRIO	Spatially explicit Multi-Regional Input-Output
SOC	Soil Organic Carbon
SPAM	Spatial Production Allocation Model
TEC	Trade by Enterprise Characteristics
UNEP	United Nations Environmental Program
WIOD	World Input-Output Database
ZCTAs	Zip Code Tabulation Areas