

Contributions of Mountain Terraced Landscapes to Cultural Heritages and Nature-Human Welfares

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Research Center for Eco-environmental Sciences

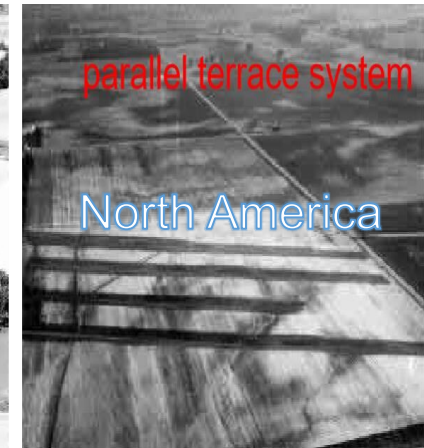
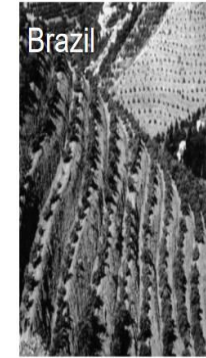
Chinese Academy of Sciences, Beijing, China



Global terraced landscapes: long history, worldwide distribution and cultural diversity

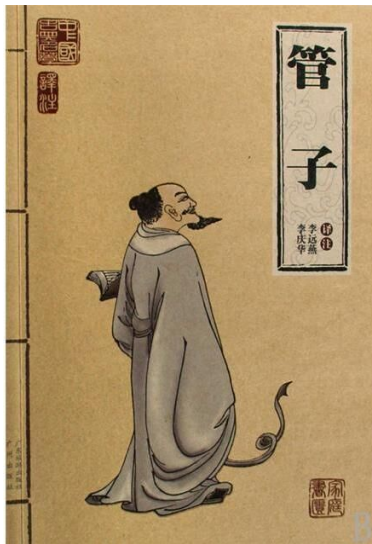


Palestine—
dryland terraces



World-wide terracing: From ancient history and arts to modern science

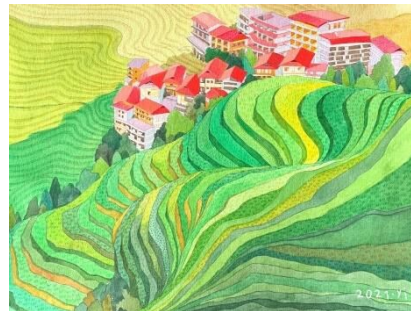
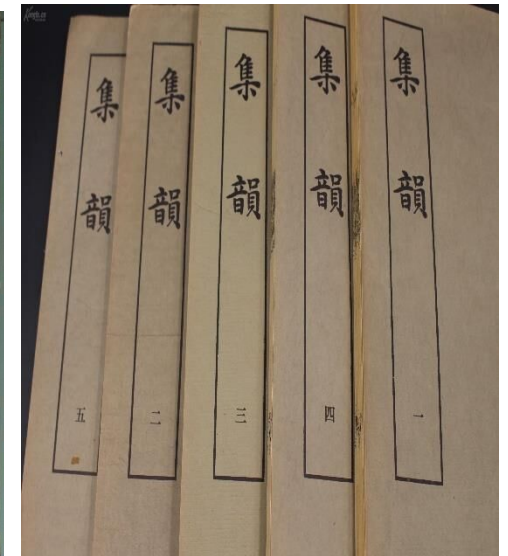
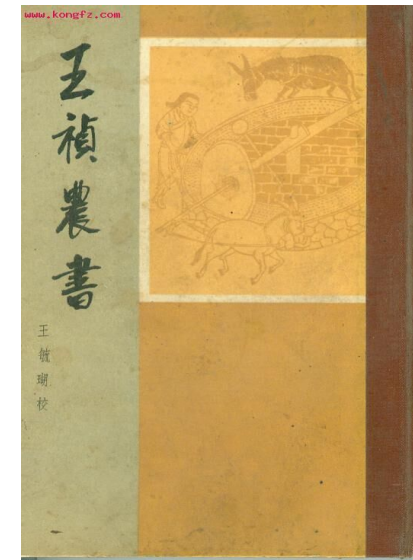
Many ancient Chinese books have recorded terraces in different names and ways at least over 3500 years ago.



《the Book of Songs》

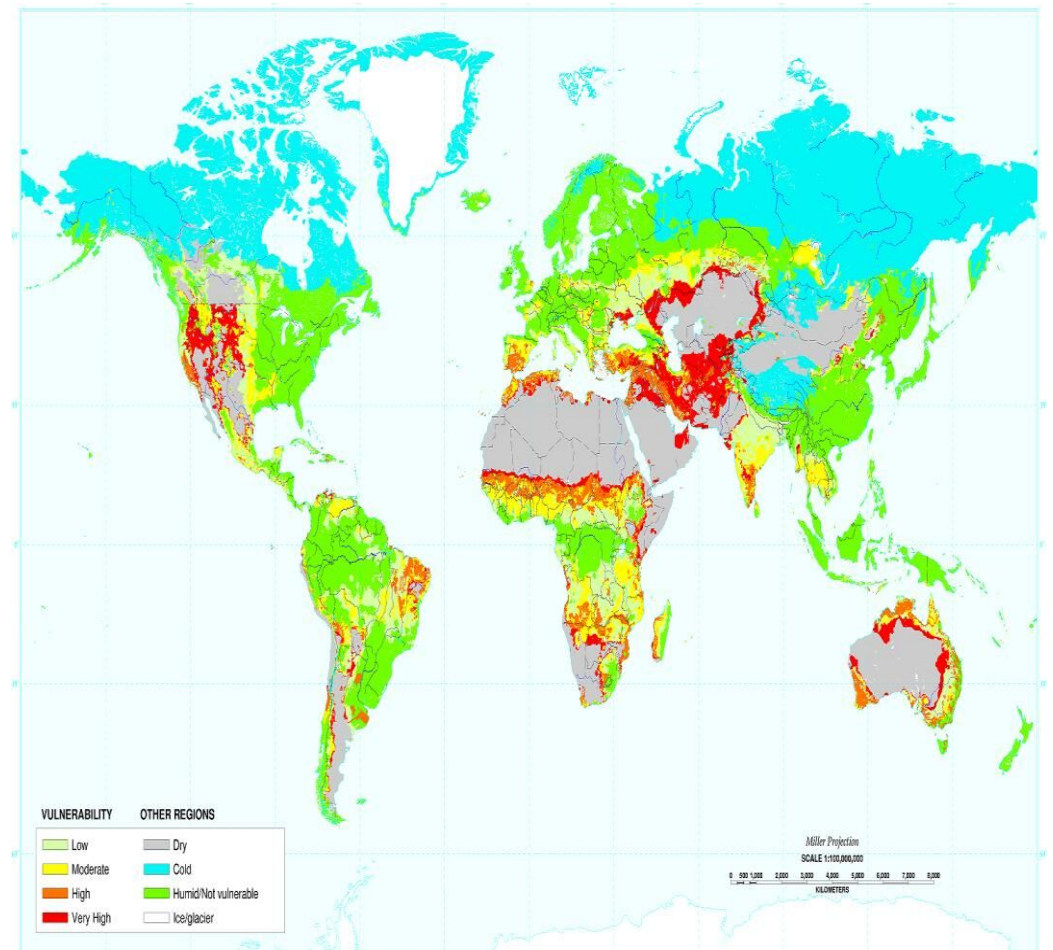
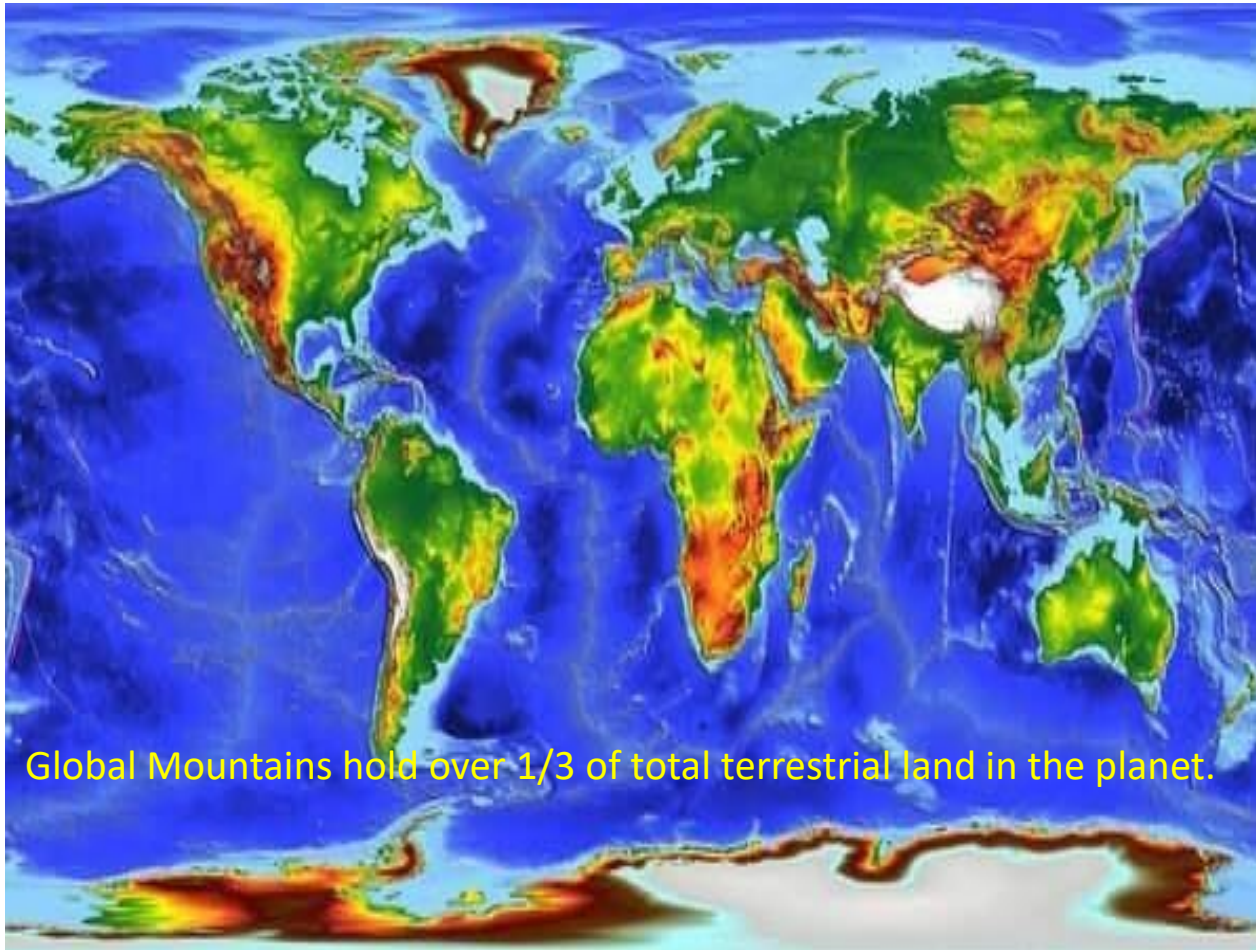


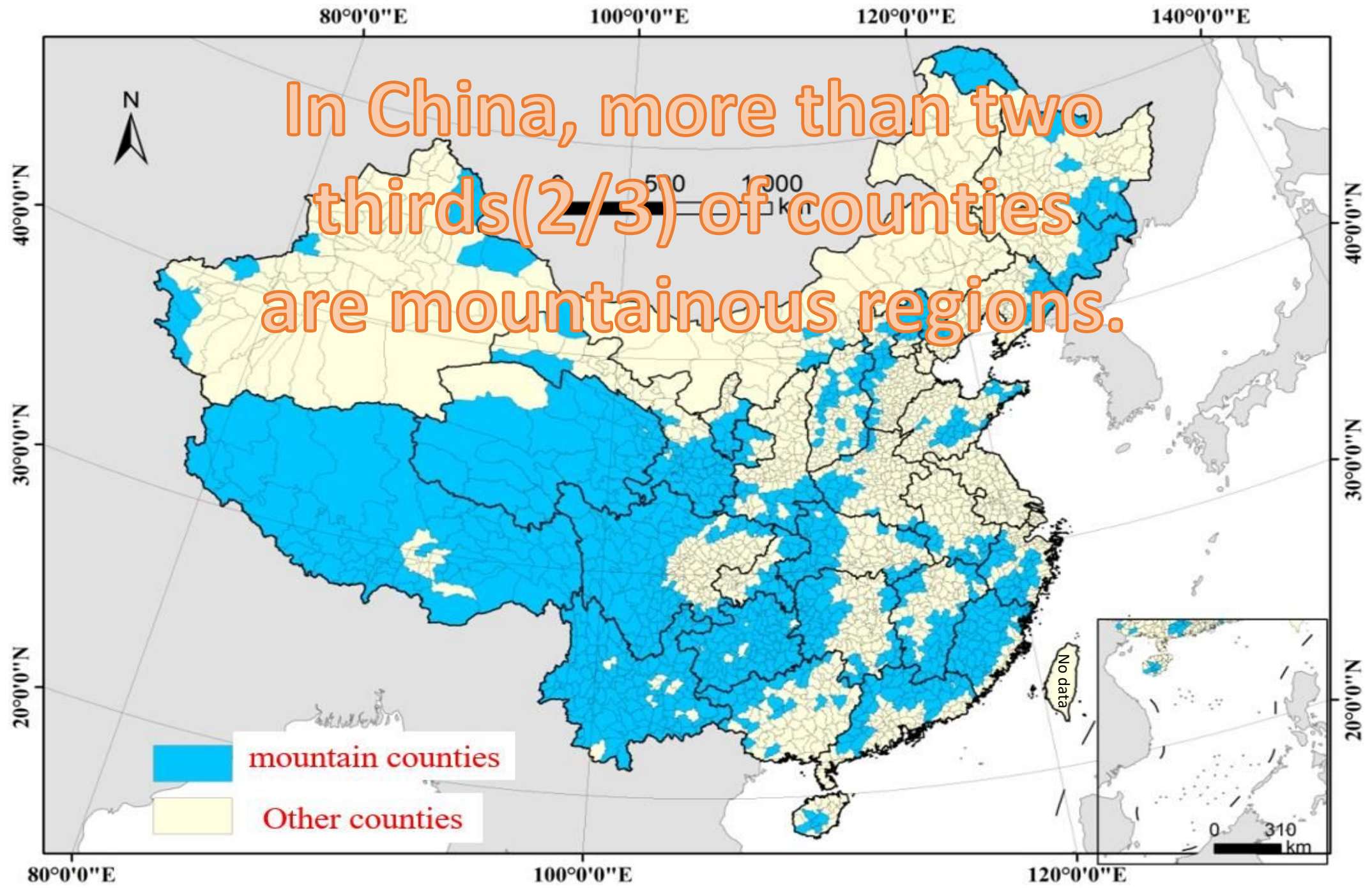
《Essential Techniques for the Welfare of the People》



So, Why world-wide terracing?

Global DEM map





In China, more than two thirds (2/3) of counties are mountainous regions.

Why terrace?

Land and Environmental Degradation induced by Slope Deforestation and Steep Cultivation



World-wide terrace: From ancient history to modern science



More than 100 yrs ago, scientists have already caution about the role of terraces and tree plantings on erosion control from economic geographical aspects.

Soil Erosion and Its Remedy by Terracing and Tree Planting

Author(s): J. Russell Smith

Source: *Science*, New Series, Vol. 39, No. 1015 (Jun. 12, 1914), pp. 858-862

Published by: American Association for the Advancement of Science

Stable URL: <http://www.jstor.org/stable/1638924>

Accessed: 24-07-2017 04:57 UTC

美国地理学者
American Geographer
J. Russell Smith (1874–1966)



J. Russell Smith, US conservationist
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Caption: Joseph Russell Smith (1874–1966), US conservationist, geographer and economist, examining a plant. Smith was Professor of Geography at the University of Pennsylvania, USA. He published numerous textbooks and wrote widely on conservation issues. His works included 'Tree Crops: A Permanent Agriculture' (1929) that spoke out against the soil erosion and destruction caused by the technique of tilling land and hillsides to grow crops. His work 'North America' (1924), on the geography and economic resources of the continent, went through many editions. Smith was President of the Association of American Geographers from 1941 to 1942.

Release details: Model release not available. Property release not required.

Keywords: 1900s, 20th century, a permanent agriculture, adult, agriculturalist, agriculture, american, association of american geographers, black-and-white, caucasian, conservation, conservationist, ecological, ecology, economics, economist, environmental destruction, environmental science, environmentalist, farming, geographer, geographical, geography, historical, history, human, j. russell smith, joseph r. smith, joseph russell smith, joseph smith, male, man, monochrome, north america, north american, one person, outdoors, outside, people, person, plant, portrait, professor of geography, scientist, soil erosion, tilling, tree, tree crops, united states, university of pennsylvania, us, usa

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World-wide terrace: From ancient history to modern science

COMMENT

19 MARCH 2015 | VOL 519 | NATURE | 283

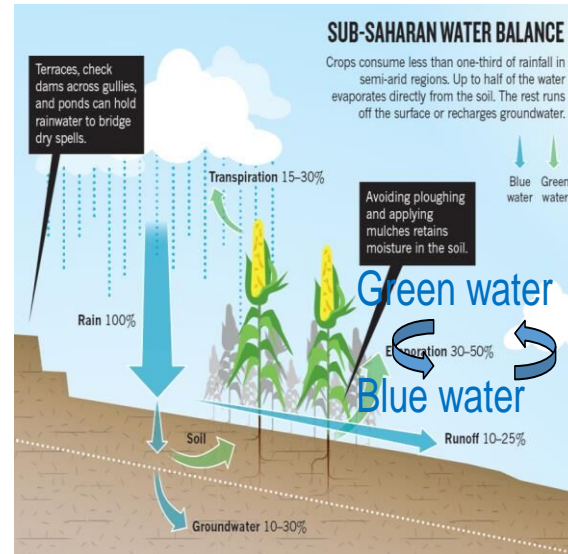


Increase water harvesting in Africa

Meeting global food needs requires strategies for storing rainwater and retaining soil moisture to bridge dry spells, urge **Johan Rockström** and **Malin Falkenmark**.



Terraced fields in the Simien Mountains, Ethiopia, help to conserve soil moisture.



ENGLISH FRANÇAIS ESPAÑOL



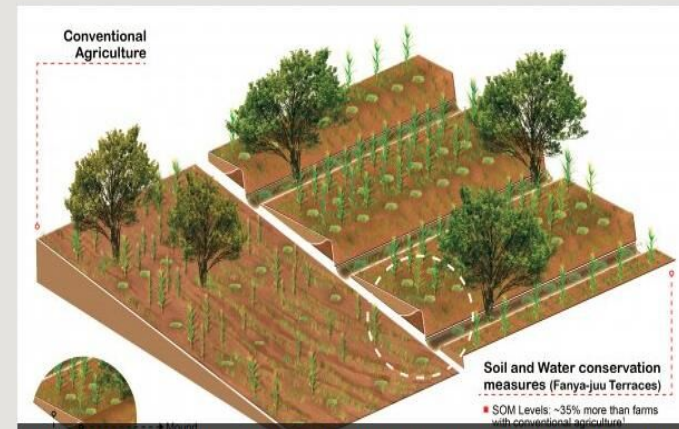
RESEARCH PROGRAM ON
Climate Change,
Agriculture and
Food Security



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Terracing practice increases food security and mitigates climate change in East Africa



Farmers build fanya-juu terraces to increase yields. The resulting soil and water conservation also increases soil organic carbon. Image: Saiz et al. 2016 Geoderma. (view original)

May 11, 2016
by
Julianna White (Low Emissions Agriculture, CCAFS)

Flagships
Low Emissions Development

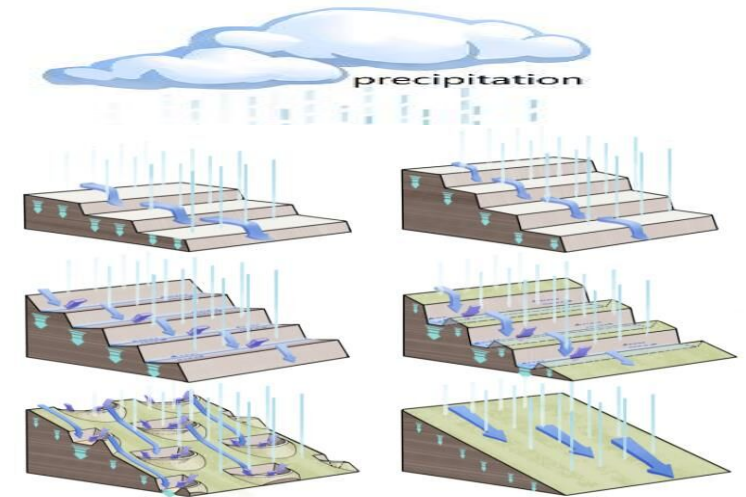
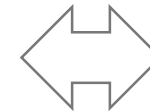
Regions
East Africa

Terracing as a key micro-landform reshaping technique to modify slope topography



Slope site

Terrace site



Diverse terracing techniques greatly alter microlandform and surface soil hydrology

ENVIRONMENTAL
Science & Technology

Microtopography Recreation Benefits Ecosystem Restoration

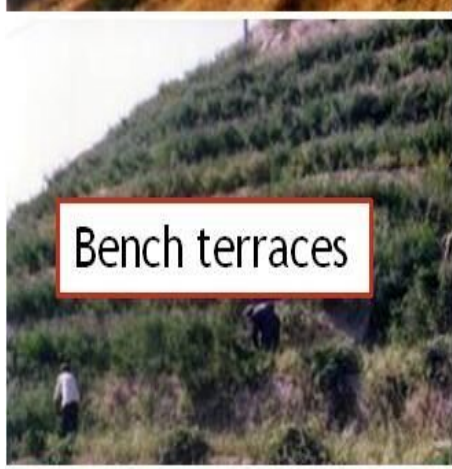
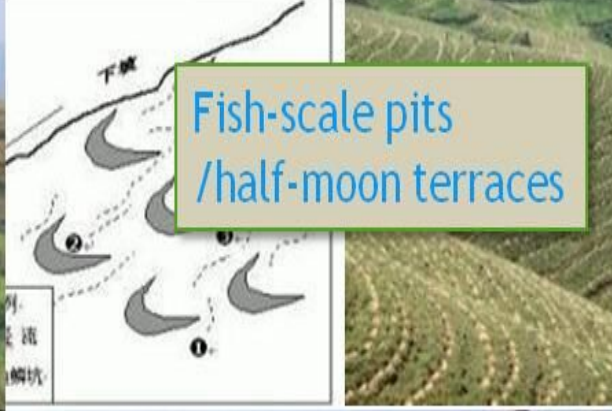
Wei Wei,^{*,†} Liding Chen,[†] Lei Yang,[†] F. Fred Samadani,[‡] and Ge Sun[§]

[†]State Key Laboratory of Urban and Regional Ecology, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

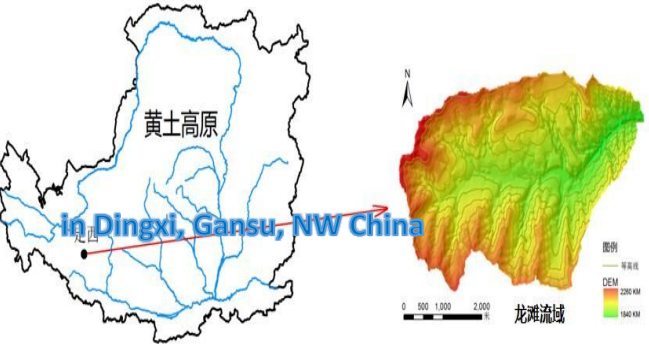
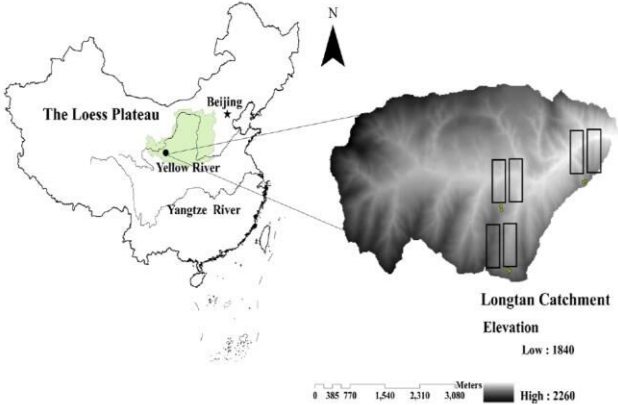
[‡]Environmental and Water Resources Management Consultant, Rockville, Maryland 20850, United States

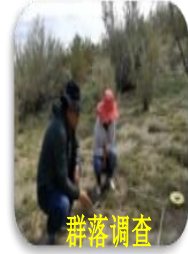
[§]Southern Research Station, USDA Forest Service, Raleigh, North Carolina 27606, United States

Terraces in the Loess Plateau of China



Great contributions of terracing: based on in situ measurements and large-scale evaluation





Multiple measurements in Dingxi



群落结构

凋落物与细根

地表特征

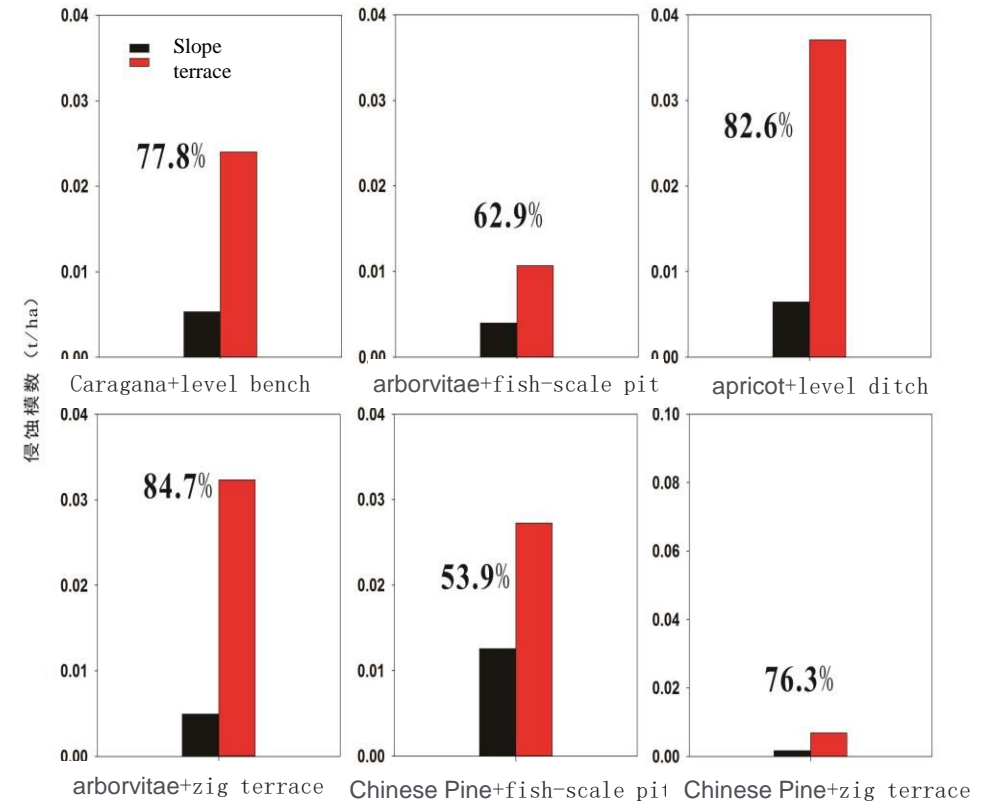
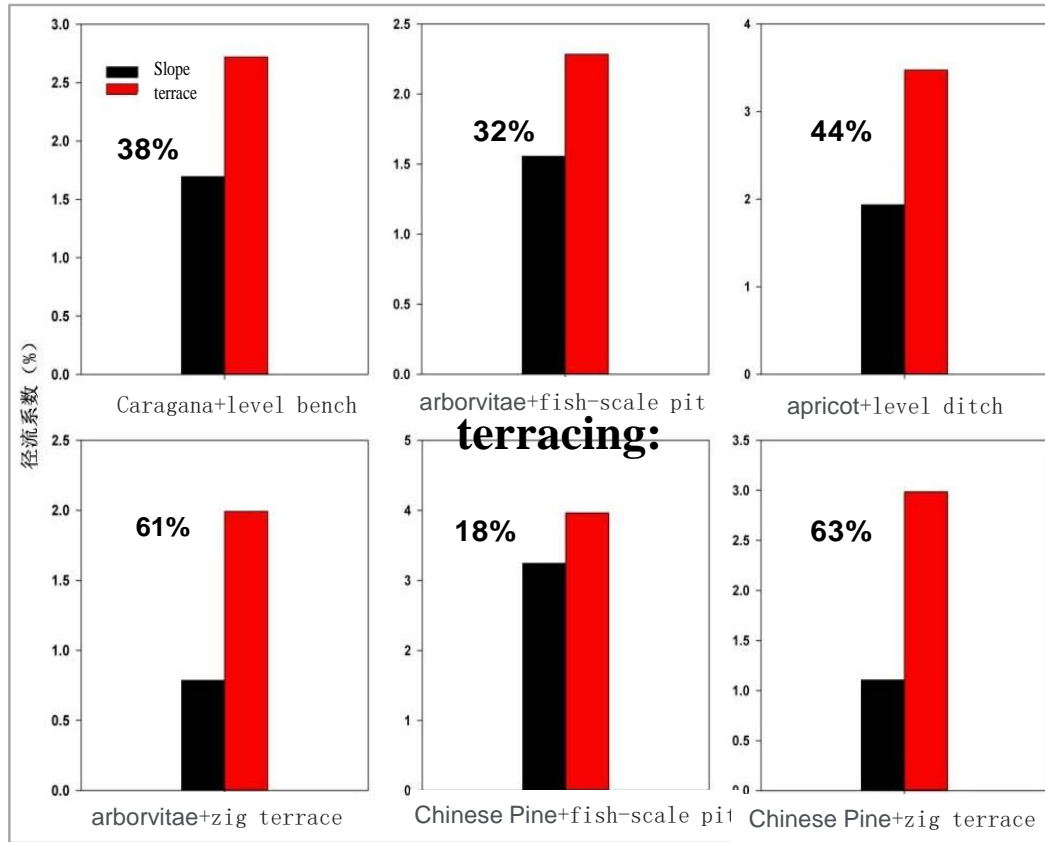
土壤理化性质



Rainfall simulation experiments



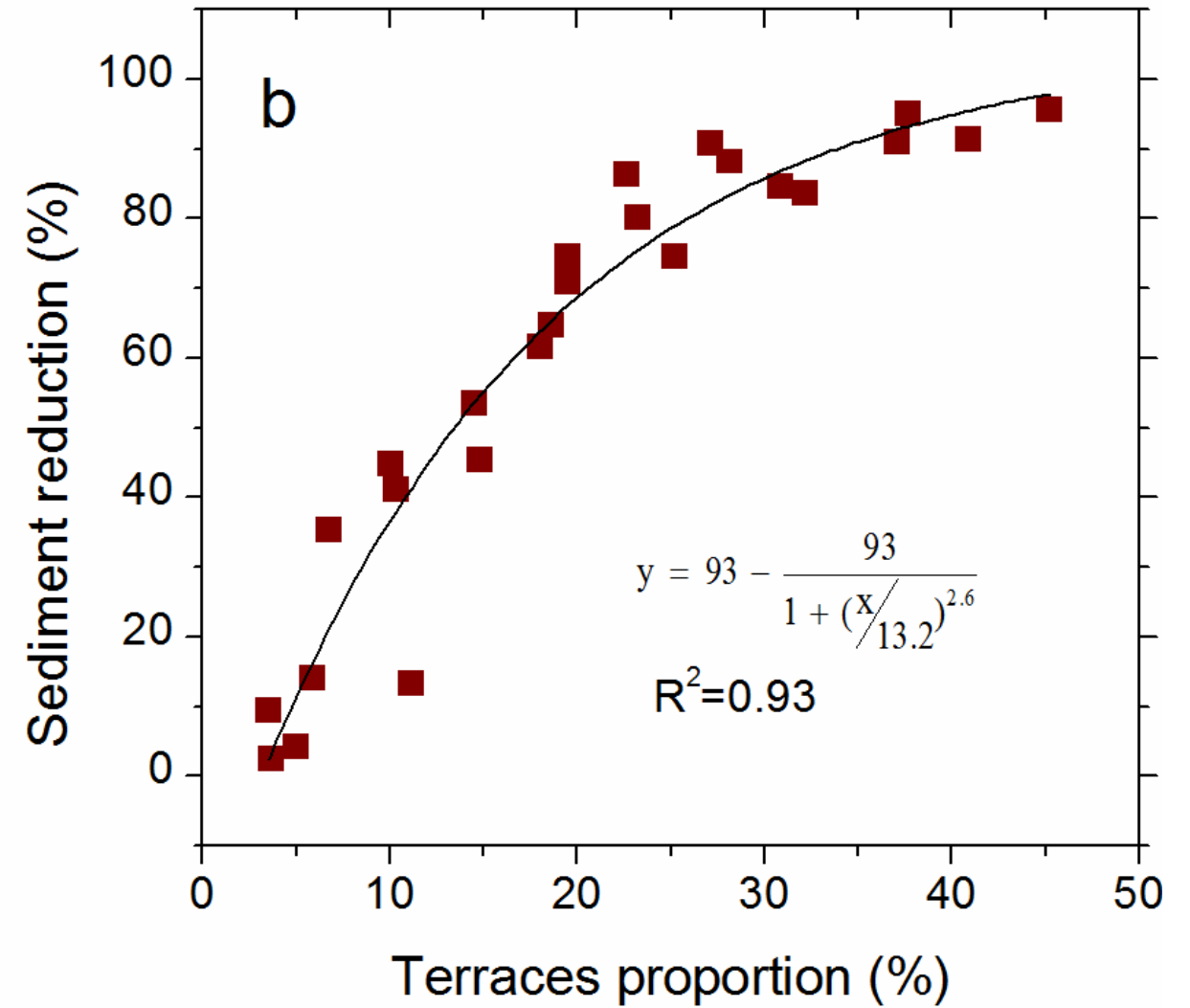
(1) terracing: runoff and erosion reductions

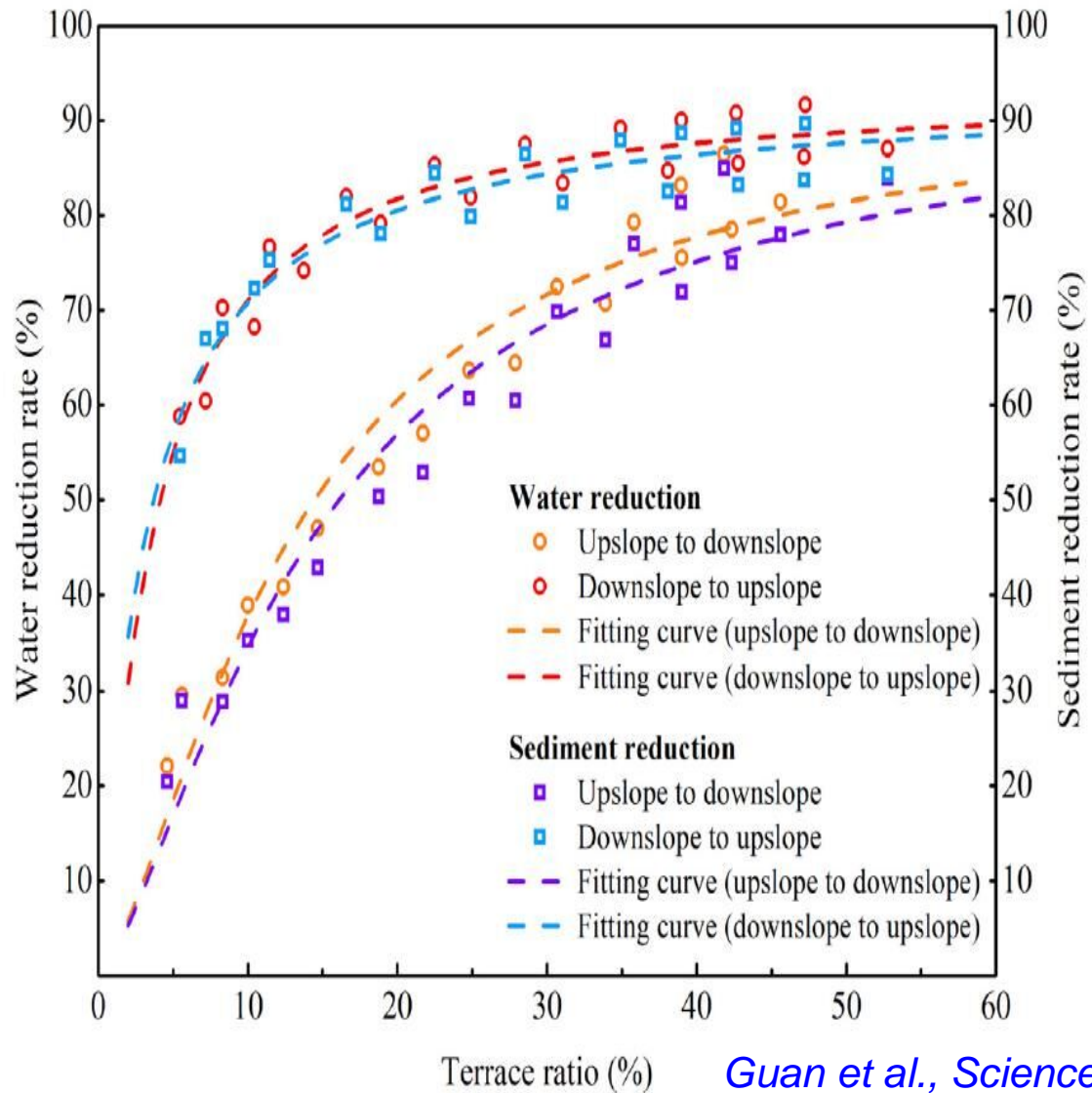


Terracing can greatly reduce soil and water loss, and the efficiency of erosion control is more powerful. Compared to slope, mean sediment reduction rate reaches 73%, while runoff reduction is 42%.

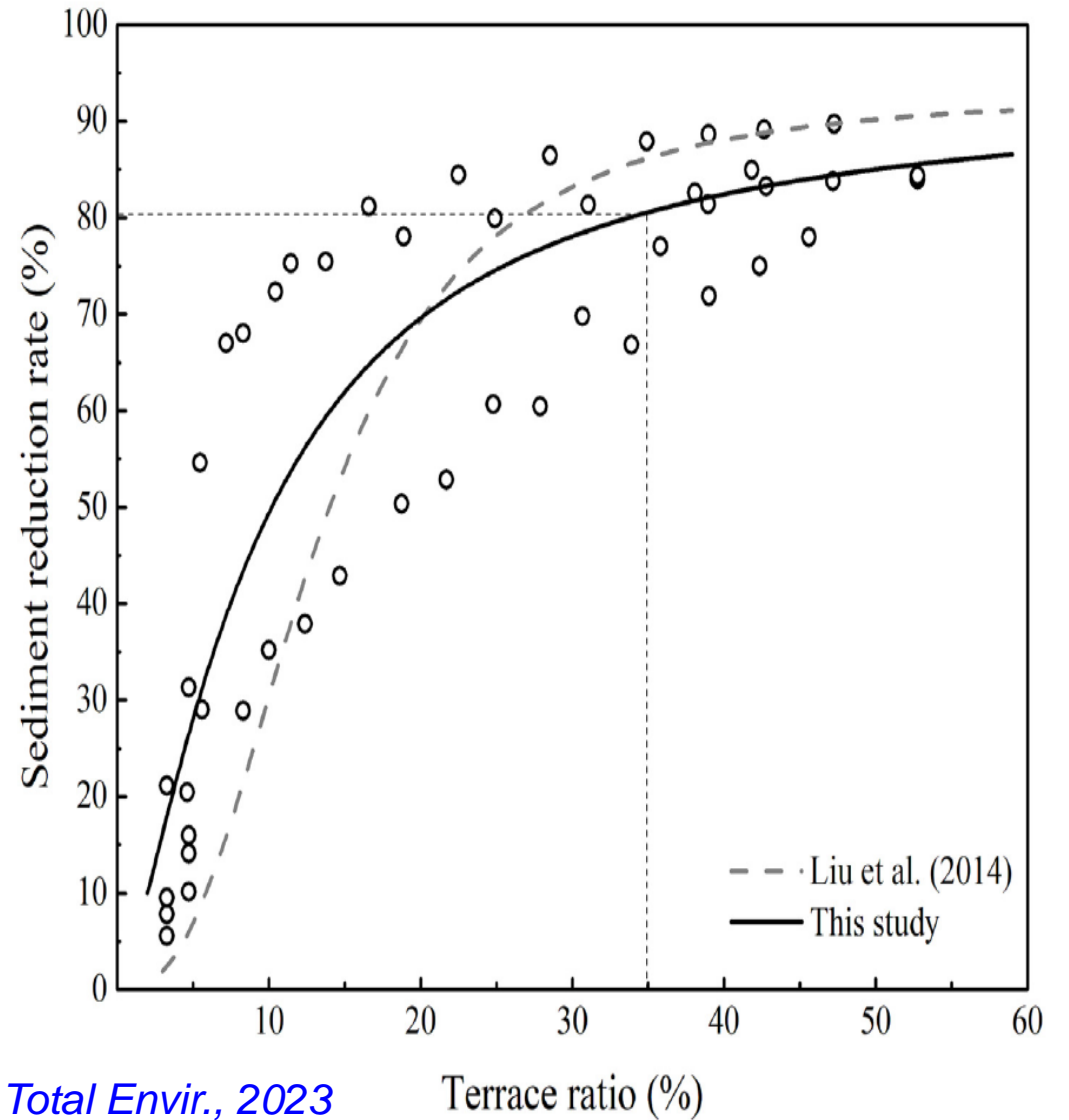


Terraced-cropland transformation for ecosystem restoration received a big success in the Loess Plateau!

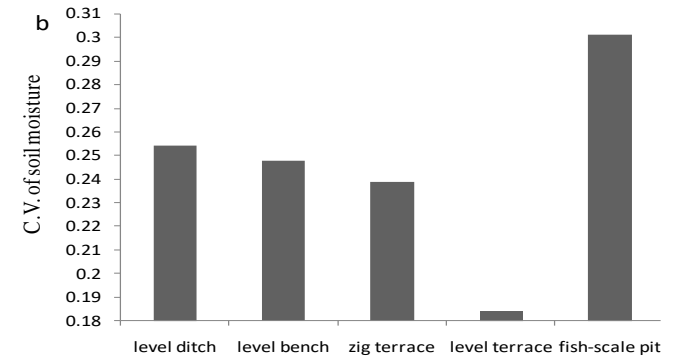
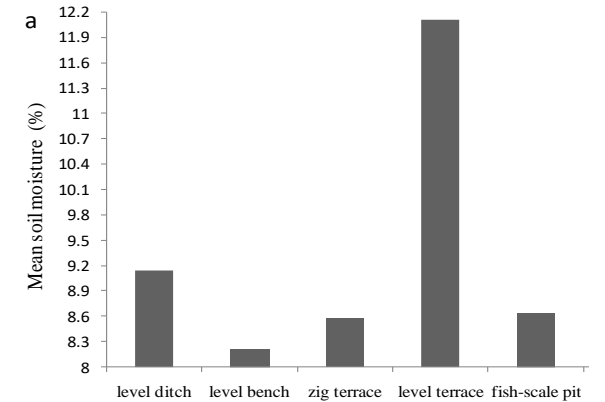
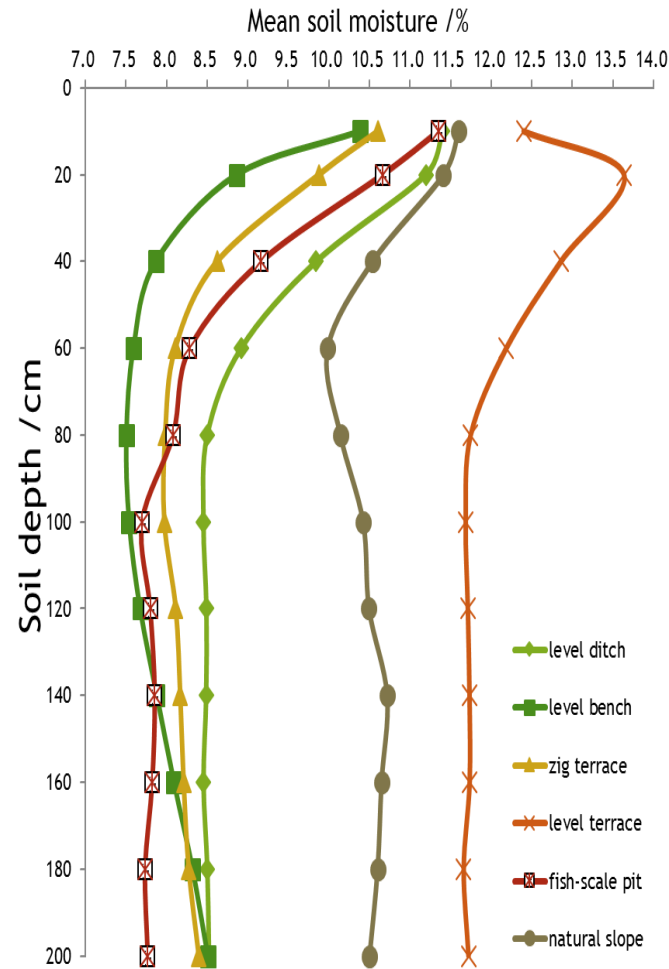
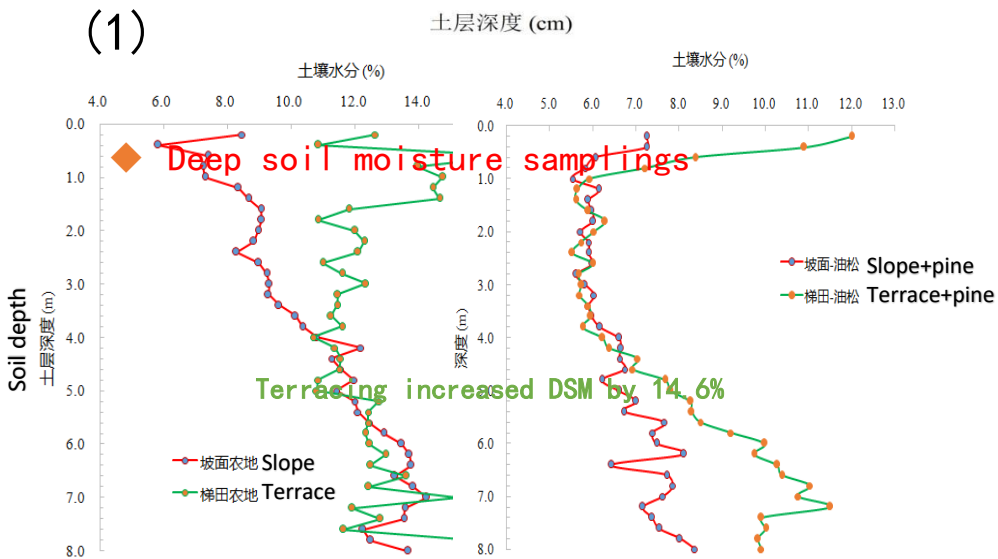
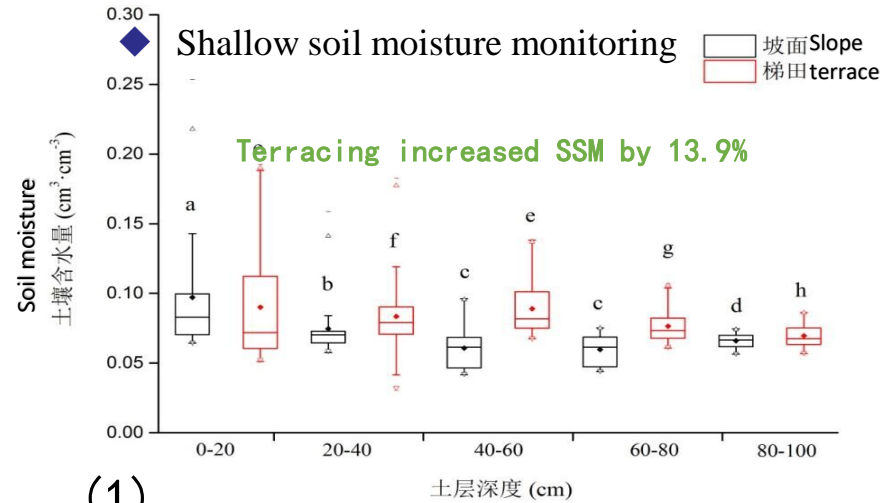




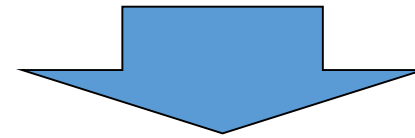
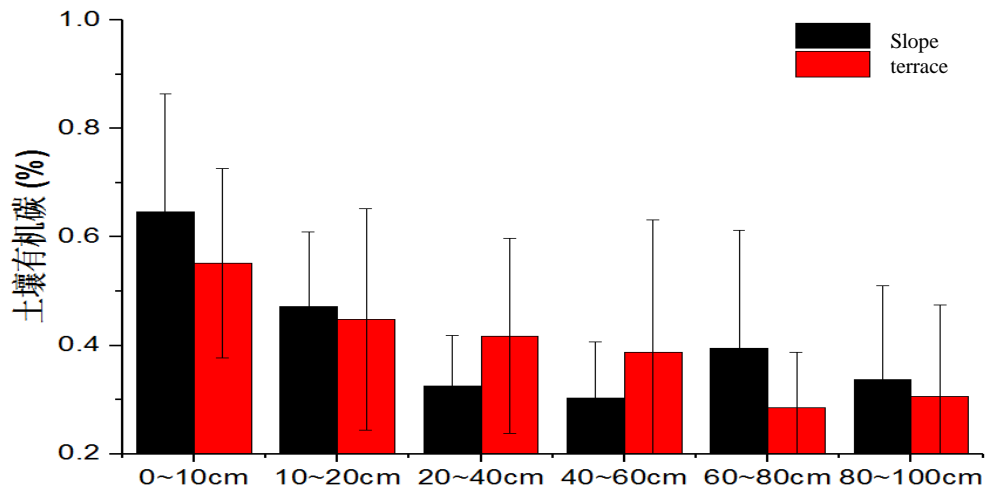
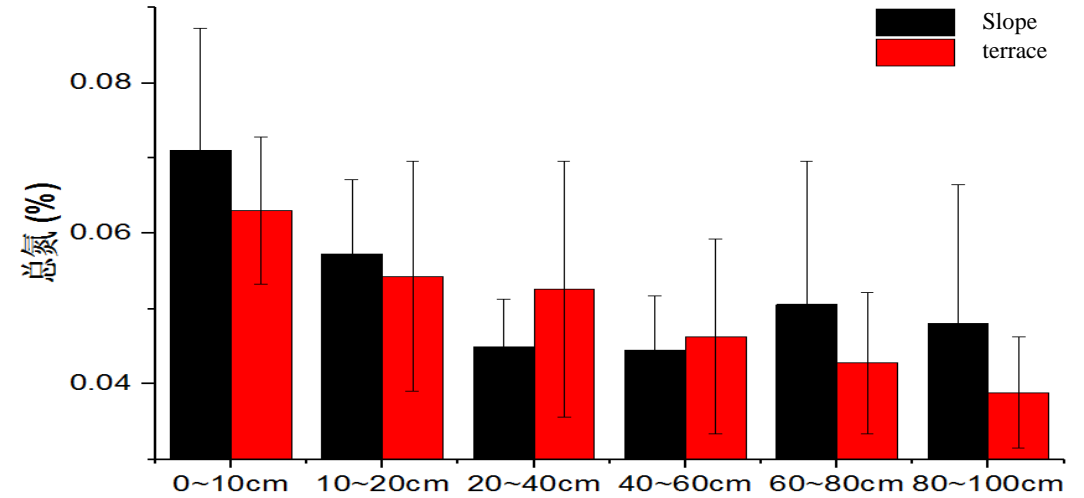
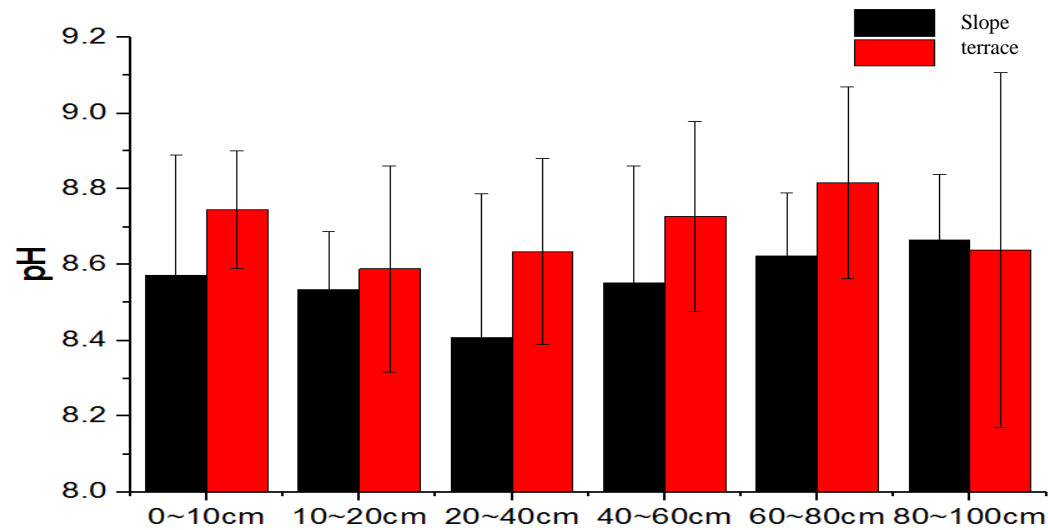
Guan et al., Science of the Total Envir., 2023



(2) Terracing: soil water retention

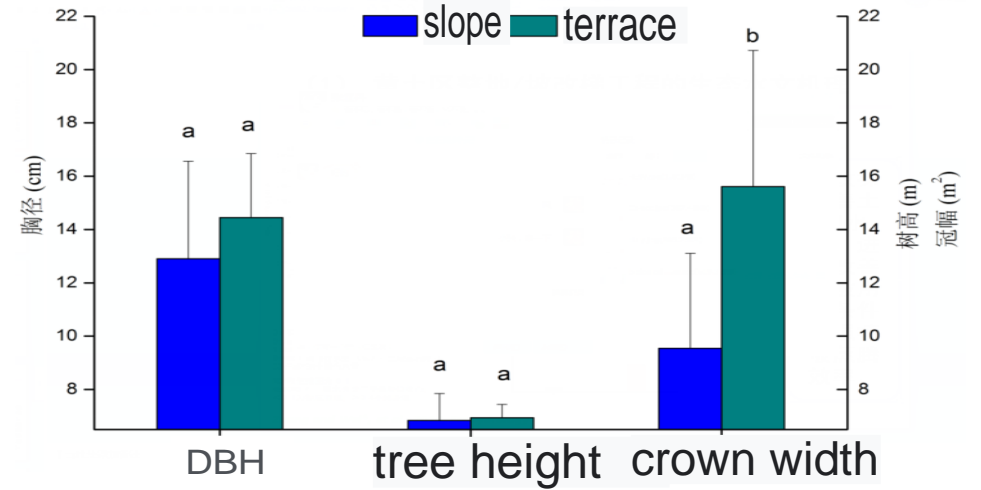
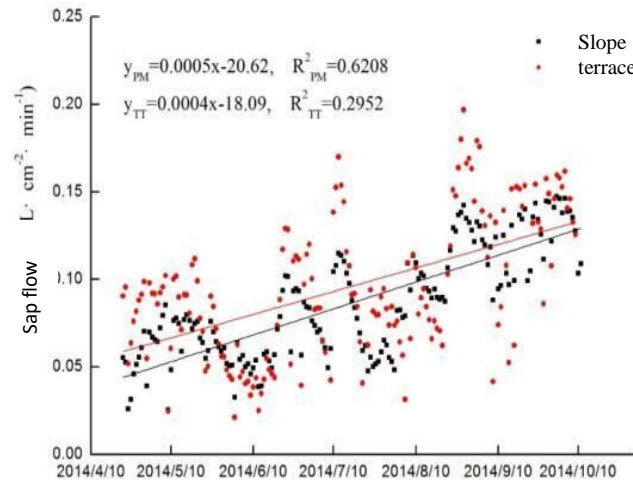
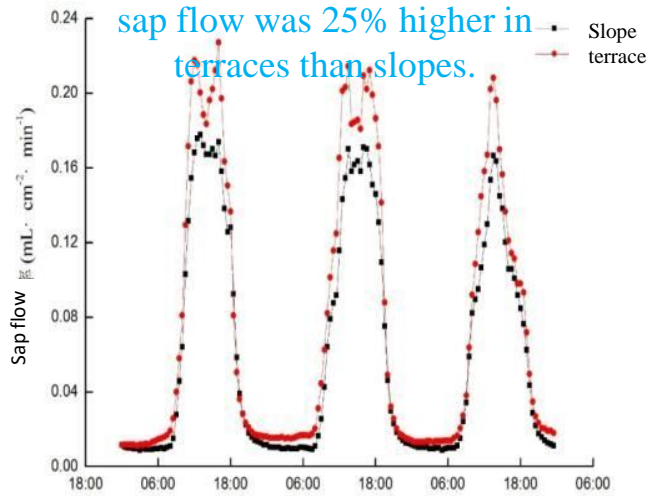


(3) Terracing: improving soil quality



Compared with steep slopes, terraced sites can reduce soil loss and increase soil particle accumulations, thus helps to improve soil quality and fight against land degradation.

(4) terracing : benefits carbon sequestration



Zhang and Wei* et al., *Ecohydrology* 2020



(5) biodiversity conservation and food security

Taking the Shexian drystone terraces as an example



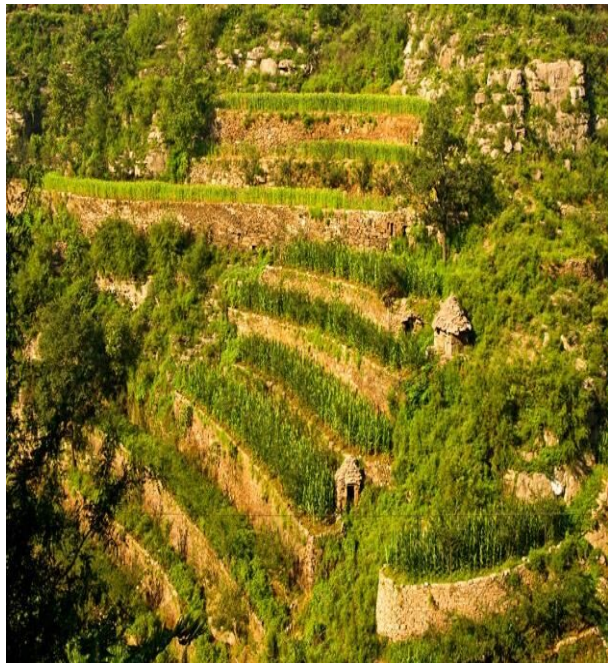
Terrace construction in Shexian of Hebei Province during ancient time

<http://travel.sina.com.cn/domestic/news/2017-06-15/detail-ifyhfnqa4206168.shtml>

(5) Terracing: biodiversity and food security

The system has rich diversity of agricultural species and crop varieties

The agricultural crop species which were still cultivated and managed in the system: 26 families, 57 genera, 77 species and 171 farm varieties.



(6) Terracing: historical and spiritual motivation

Zhuanglang terraces in Gansu Province



From 1964 to 1998, the Zhuanglang people worked for 34 yrs, spending 0.5 billion RMB, and removing 0.3 billion m³ soil in total.

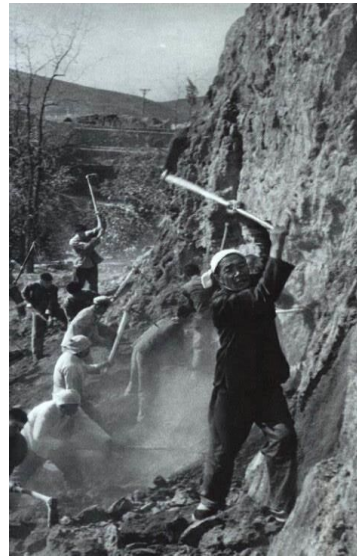


Zhuanglang terrace museum



(6) Terracing: historical and spiritual motivation

Former vice premier (during 1975 to 1980) of China :Chen Yonggui and DazhaiTERRACES



(7) Terracing: rural economy and development



The local government called on to construct 100 million MU terraces for accelerating the local rural economy.



There is an ancient Chinese fable called "The Foolish Old Man Who Removed the Mountains".



依赖梯田生存的人们，在脆弱的生态环境系统中通过生物多样性的保护和文化多样性的传承实现了农耕社会的可持续发展。

- Under the circumstances of fragile ecological environment system, through bio-diversity and cultural diversity, people who live on the terraced fields succeed in achieving sustainable development of agricultural society.



Terraces with traditional Chinese medicine plants increase economic value and enrich the local farmers.



黄芪

Astragalus membranaceus



黄芩

Scutellaria baicalensis



党参

Codonopsis pilosula



柴胡

radix bupleuri



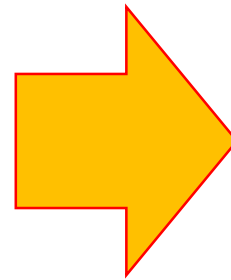
红芪

radix hedysari



冬花

Winter flower



(8) Terracing: Culture heritage and esthetic values



Drystone donkey terrace culture in Wangjinzhuang



Paddy terrace culture in southern China



(8) Terracing: Culture heritage and esthetic values

□ Diversified Agri-and local traditional cultures

Festivals and customs of local nationalities



Cultural Landscape of Honghe Hani Rice Terraces



Bali's UNESCO World Heritage Site



Jatiluwi Rice Terrace makes is part of a Bali's UNESCO World Heritage Site known as the Cultural Landscape of Bali Province: The Subak System as a Manifestation of the Tri Hita Karana Philosophy.



Hakka terraces, Chongyi, Jiangxi





TERRACED LANDSCAPES IN SLOVENIA



esthetic values and fantastic landscapes

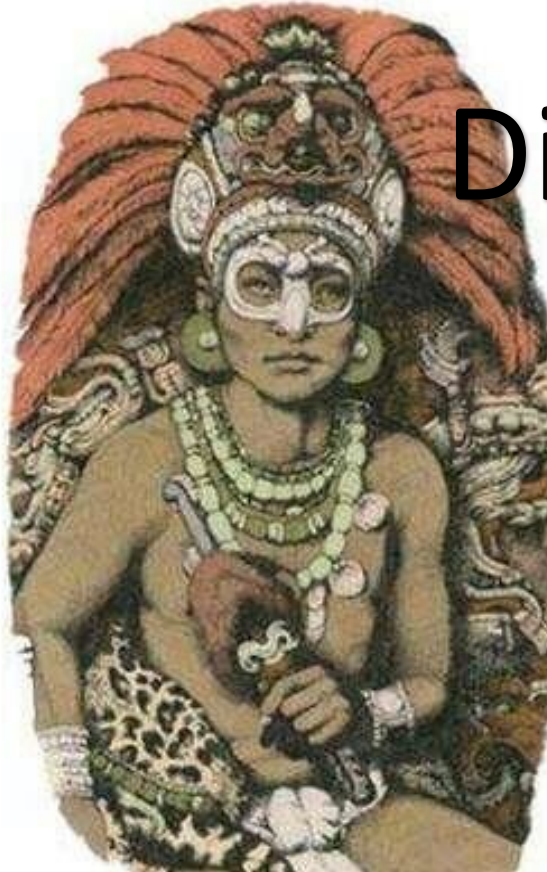


esthetic values and fantastic landscapes





Ancient Maya civilization



Diverse cultures



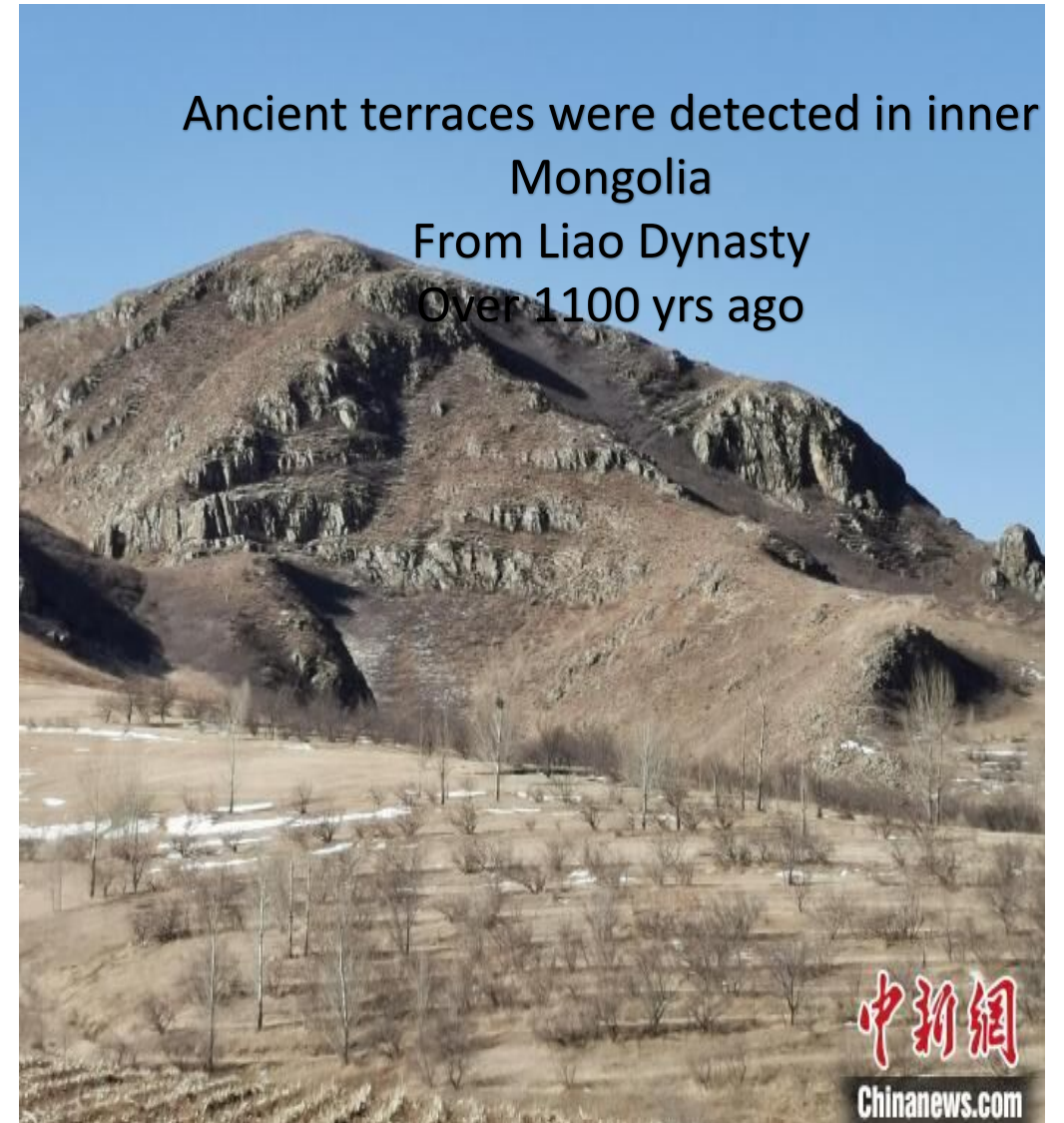
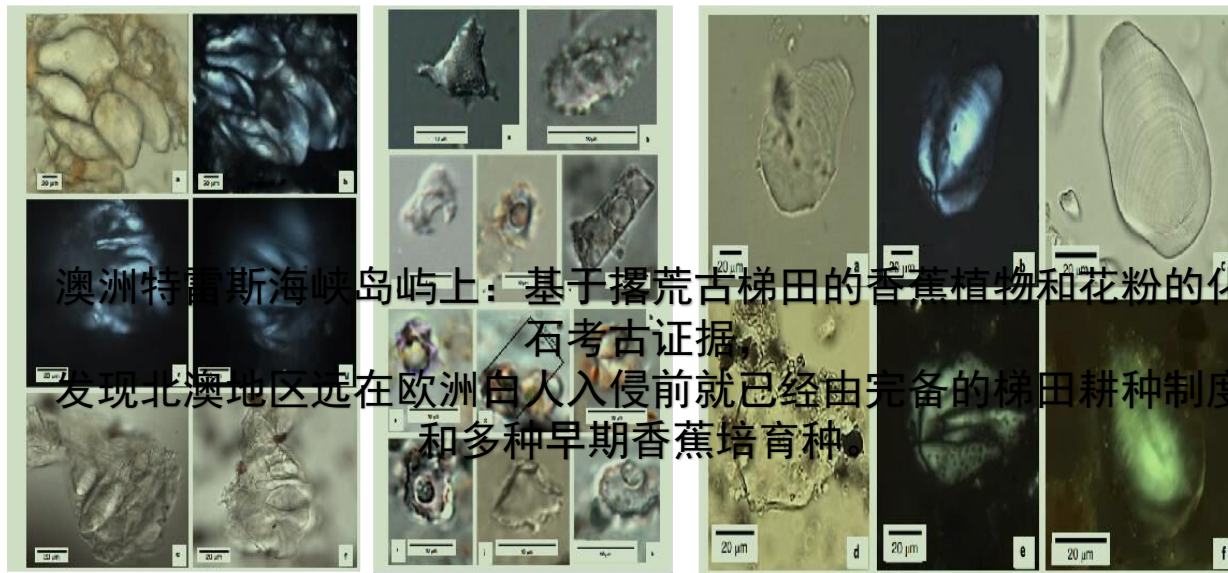
(9) TERRACING: archaeology value

nature ecology & evolution ARTICLES
<https://doi.org/10.1038/s41559-020-1278-3>
Check for updates

Multidisciplinary evidence for early banana (*Musa cvs.*) cultivation on Mabuyag Island, Torres Strait

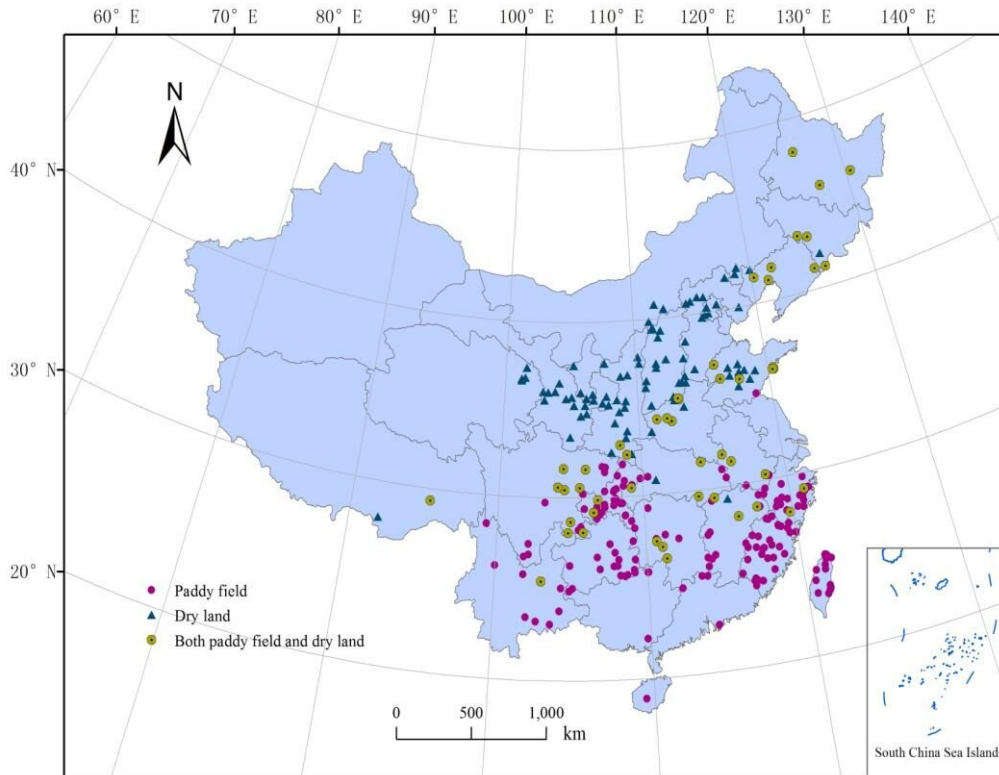
Robert N. Williams¹, Duncan Wright², Alison Crowther^{3,4} and Tim Denham²

Multiproxy archaeobotanical analyses (starch granule, phytolith and microcharcoal) of an abandoned agricultural terrace at Wagadagam on Mabuyag Island, Torres Strait, Australia, document extensive, low-intensity forms of plant management from at least 2,145–1,930 cal yr BP and intensive forms of cultivation at 1,376–1,293 cal yr BP. The agricultural activities at 1,376–1,293 cal yr BP are evidenced from terrace construction, banana (*Musa* cultivars) cultivation and dramatic transformations to the local palaeoenvironment. The robust evidence for the antiquity of horticulture in western Torres Strait provides an historical basis for understanding the diffusion of cultivation practices and cultivars, most likely from New Guinea. This study also provides a methodological template for the investigation of plant management, potentially including forms of cultivation that were practiced in northern Australia before European colonization.



However, we do not know how terraces distribute at different spatial scales, which is

We used meta-analysis and data-mining methods to check how many formal publications and local un-published materials related with terracing, and thus can better capture the recorded terraced sited in China and the whole world.



Chen and Wei et al.,2017, Earth-Science Reviews*

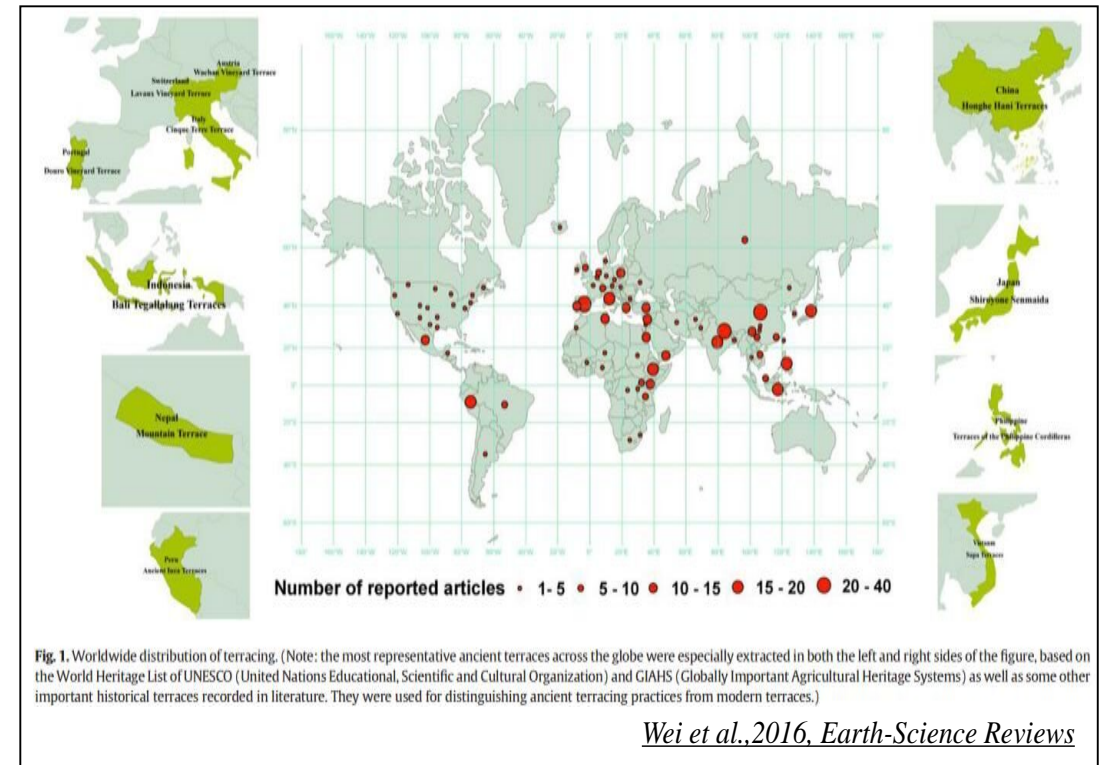
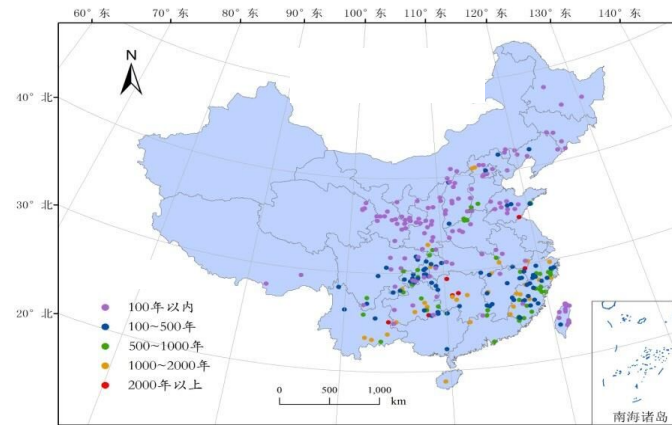
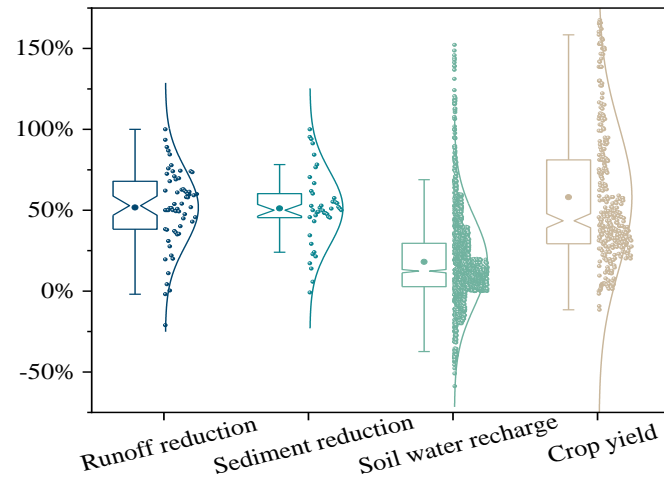


Fig. 1. Worldwide distribution of terracing. (Note: the most representative ancient terraces across the globe were especially extracted in both the left and right sides of the figure, based on the World Heritage List of UNESCO (United Nations Educational, Scientific and Cultural Organization) and GIAHS (Globally Important Agricultural Heritage Systems) as well as some other important historical terraces recorded in literature. They were used for distinguishing ancient terracing practices from modern terraces.)

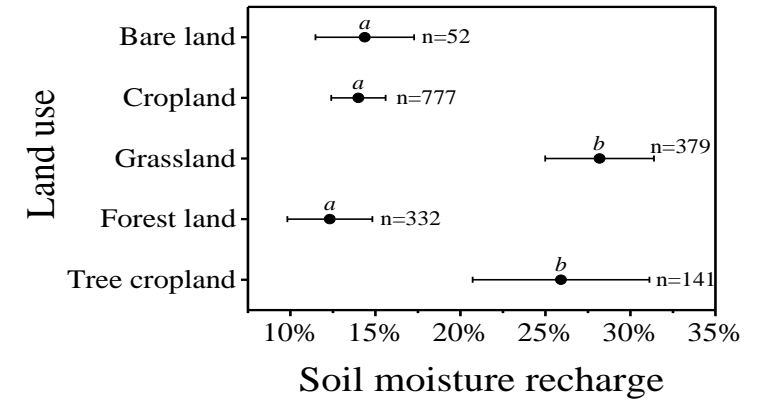
Wei et al.,2016, Earth-Science Reviews

Wei et al.,2016, Earth-Science Reviews

The meta-analysis approaches were used to detect national terrace distribution and their roles in erosion control, soil water recharge and carbon sequestration in China

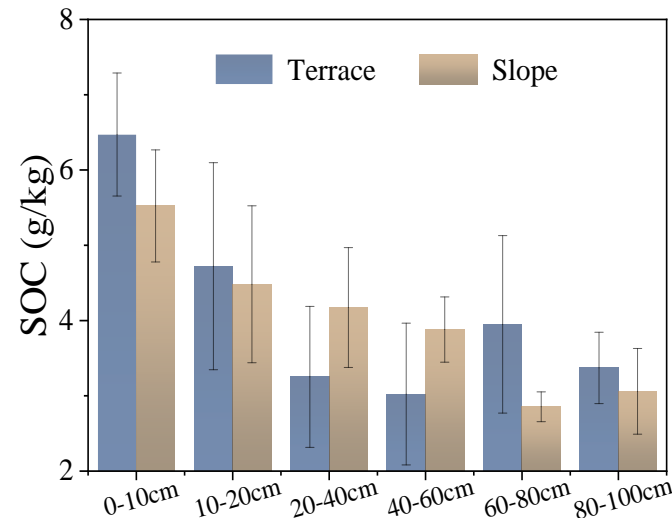


Chen and Wei et al., 2017 Earth-Science Reviews*



For China's terraced landscapes, terracing generally improved the soil moisture by 12.9%

Chen and Wei, et al., 2020, Agricultural Water Management*

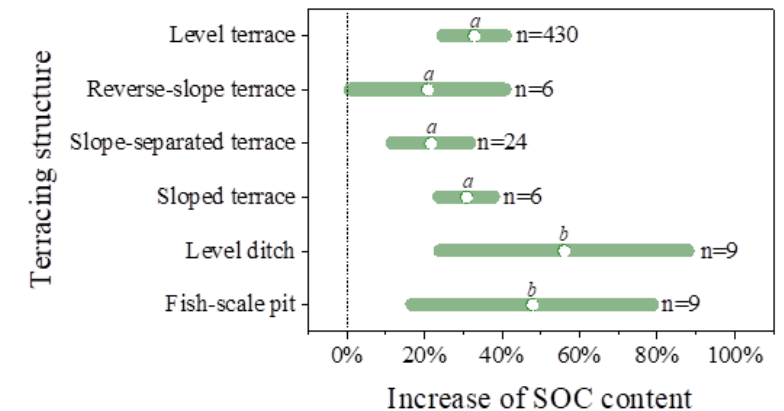


Chen and Wei et al., 2022 Geography and Sustainability*



Zhang and Wei et al., 2017 Ecohydrology*

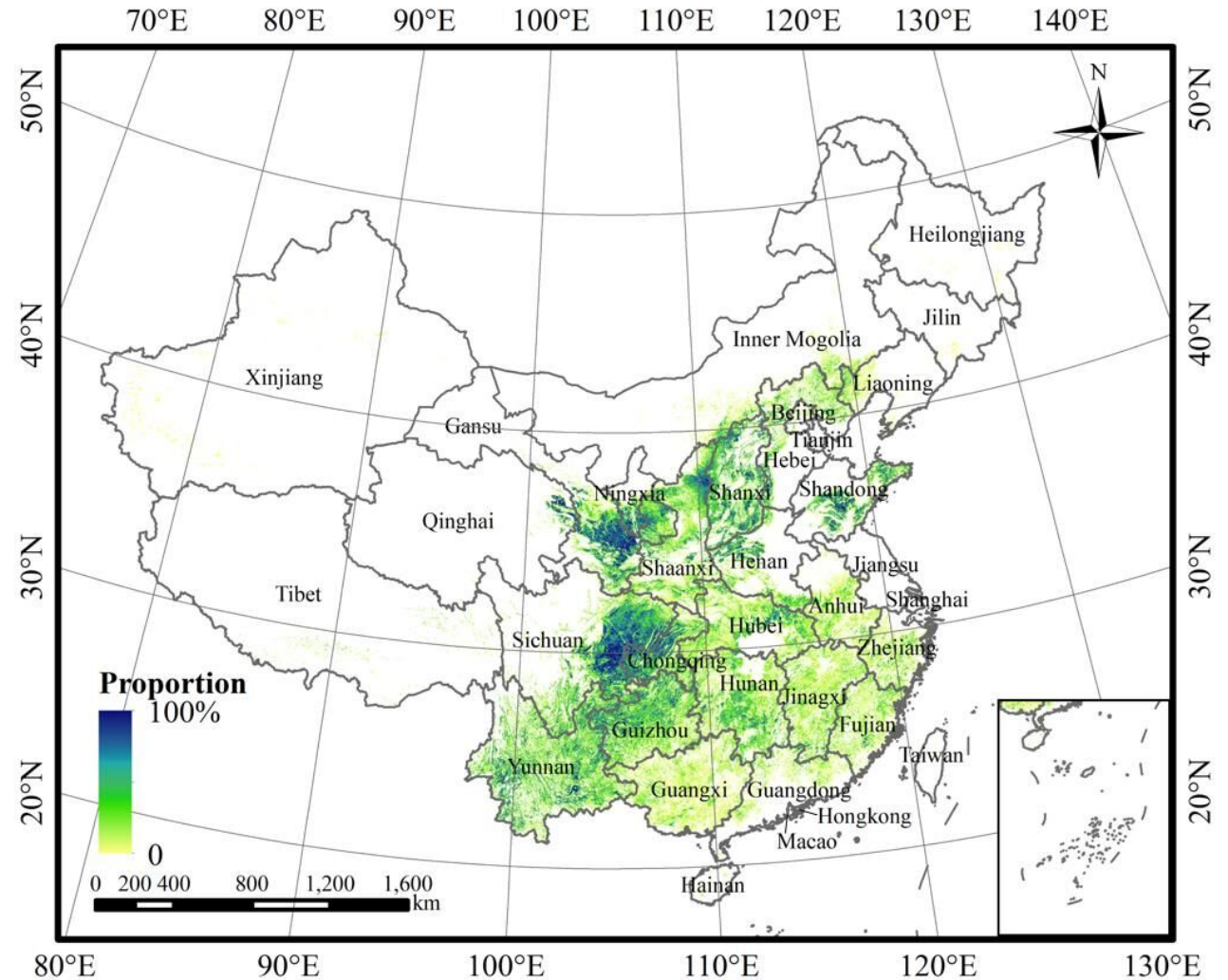
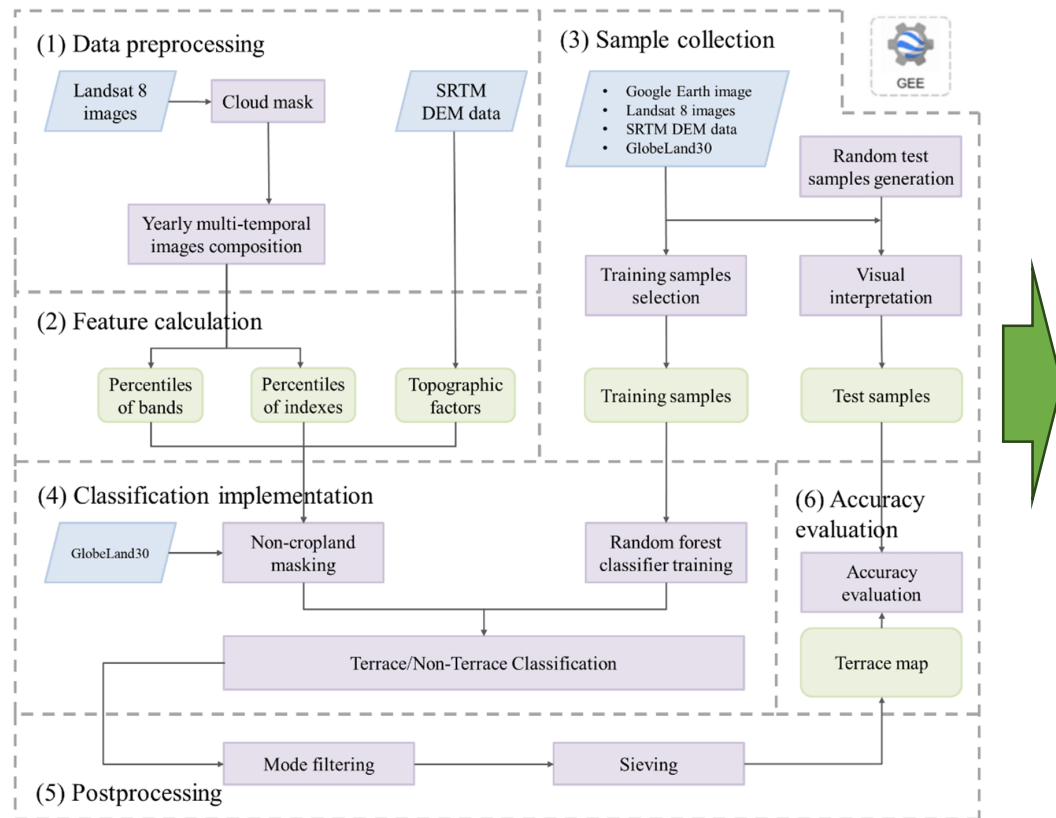
- The average runoff and sediment reduction were 51.7% and 51.1%,
- water conservation benefit is 18.1%, and crop yield increase 57.0%



Terracing increased SOC sequestration by 32.4% on average in China

Chen and Wei, et al., 2020, Science of the Total Environment*

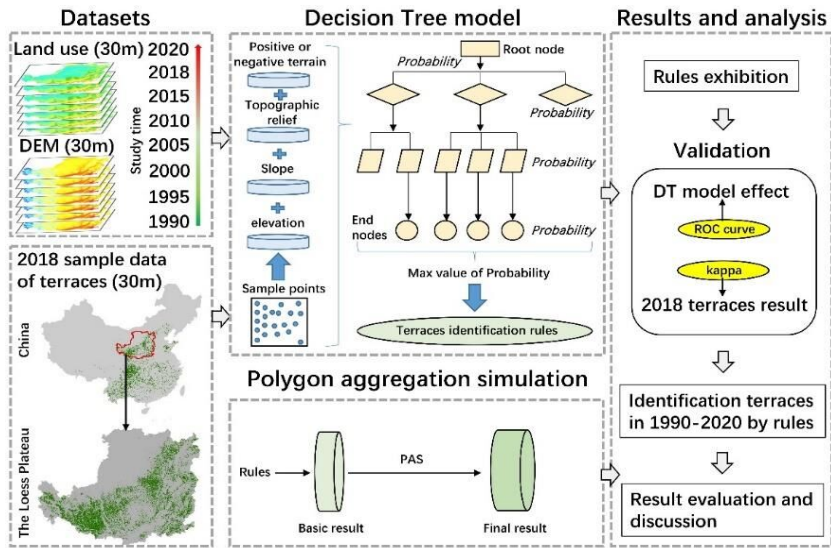
A 30 m terrace mapping in China using Landsat 8 imagery and digital elevation model based on the Google Earth Engine



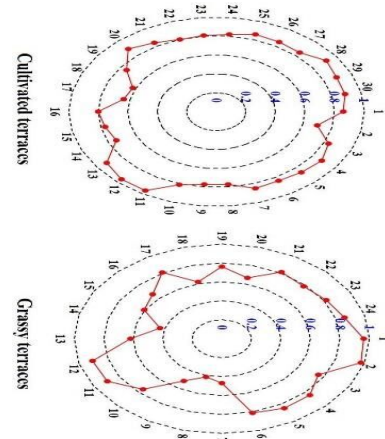
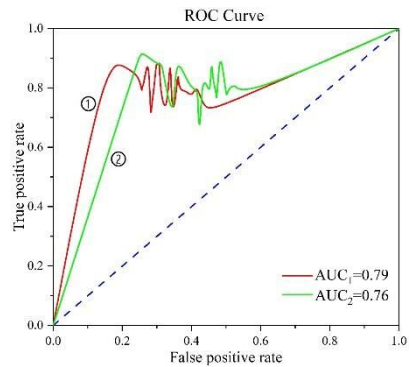
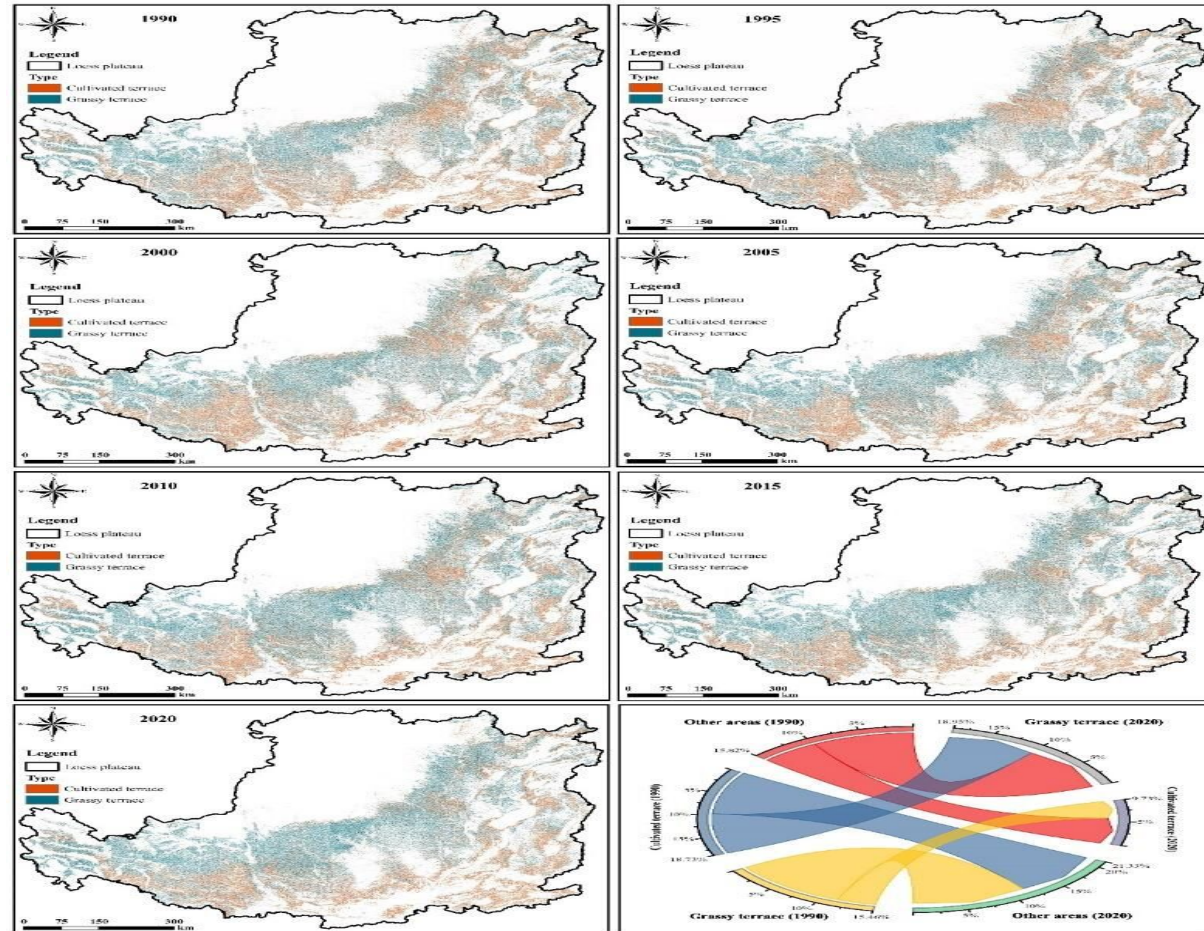
Cao... and Wei, et al., 2021 ESSD

Mapping terraces in the Loess Plateau based on DEM and land use data

Extraction model and validation

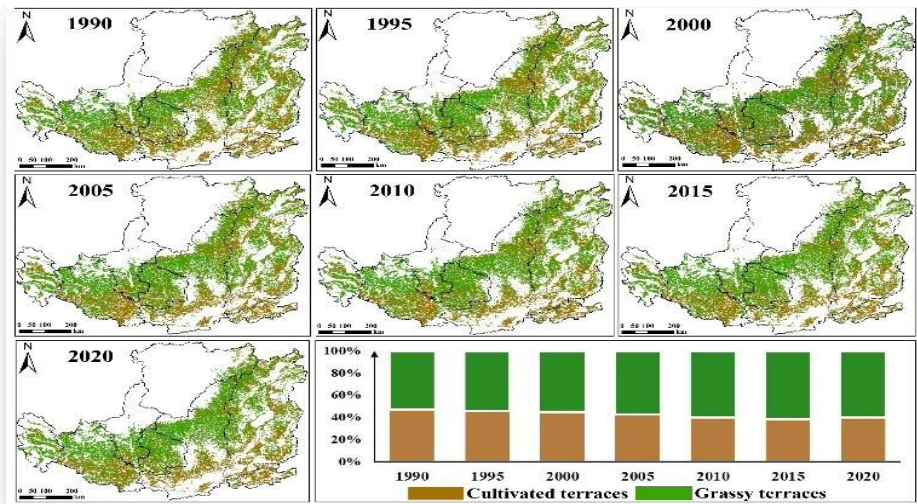


Visualization of spatial terrace pattern in 1990-2020

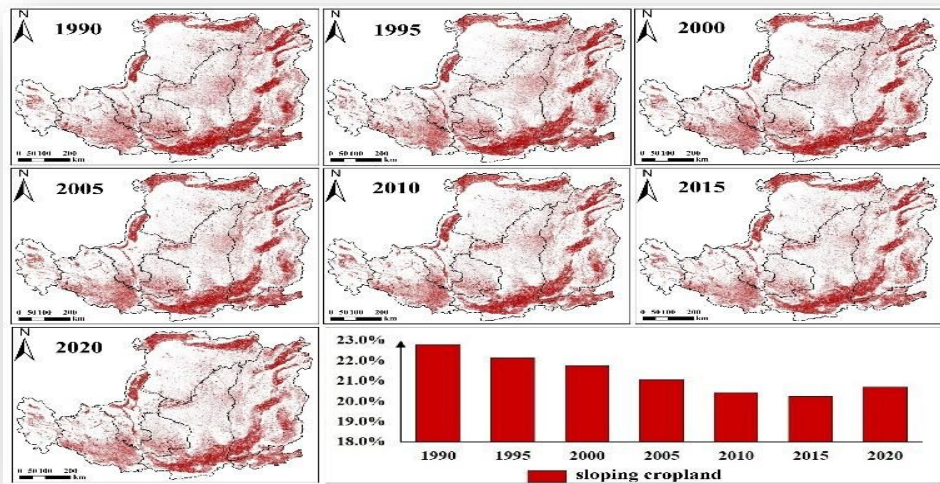


Exploring the effects of terracing on grain production on the Loess Plateau

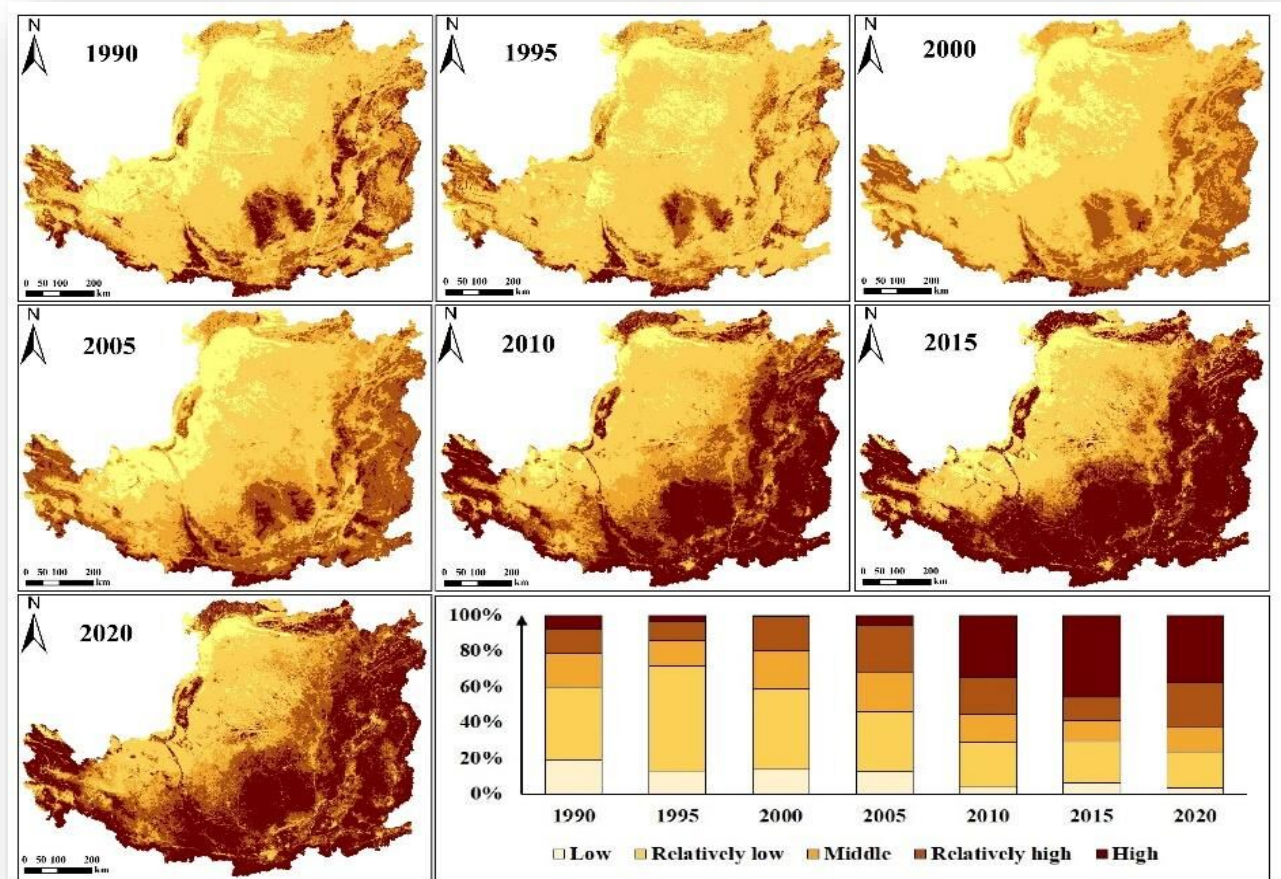
Terrace pattern in 1990-2020



Slope cropland pattern in 1990-2020

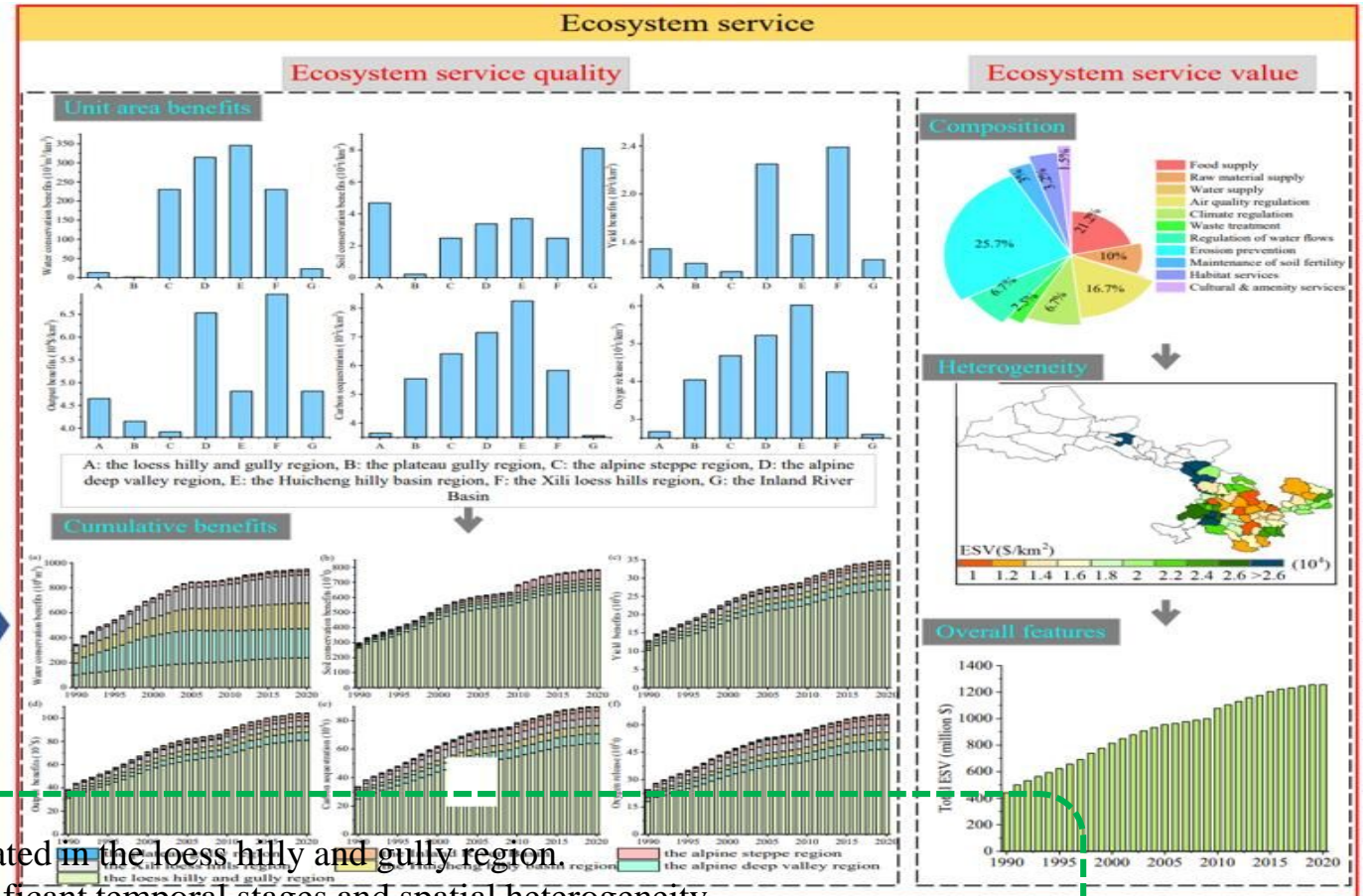
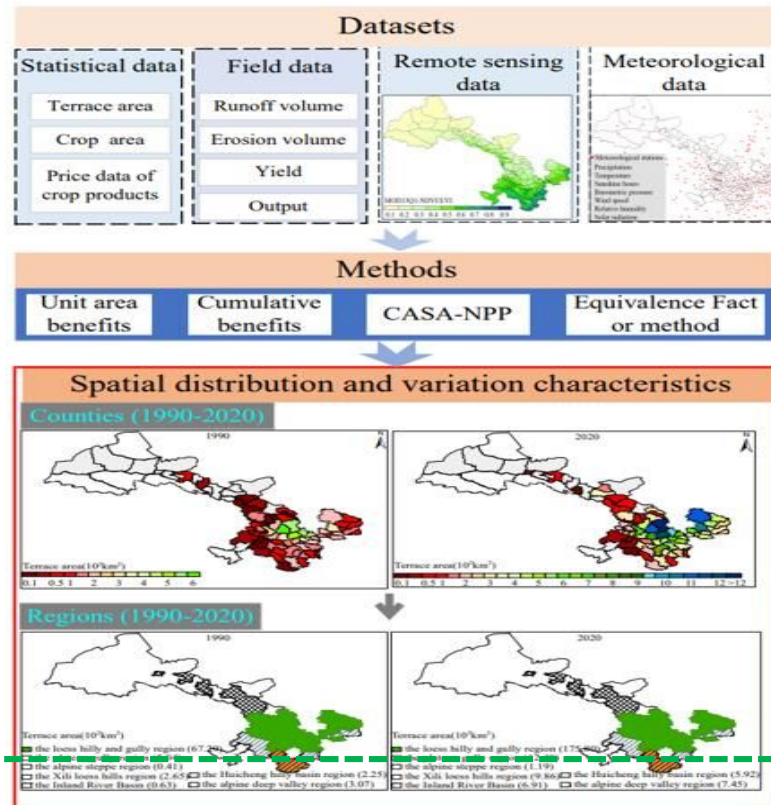


Grain production pattern in 1990-2020



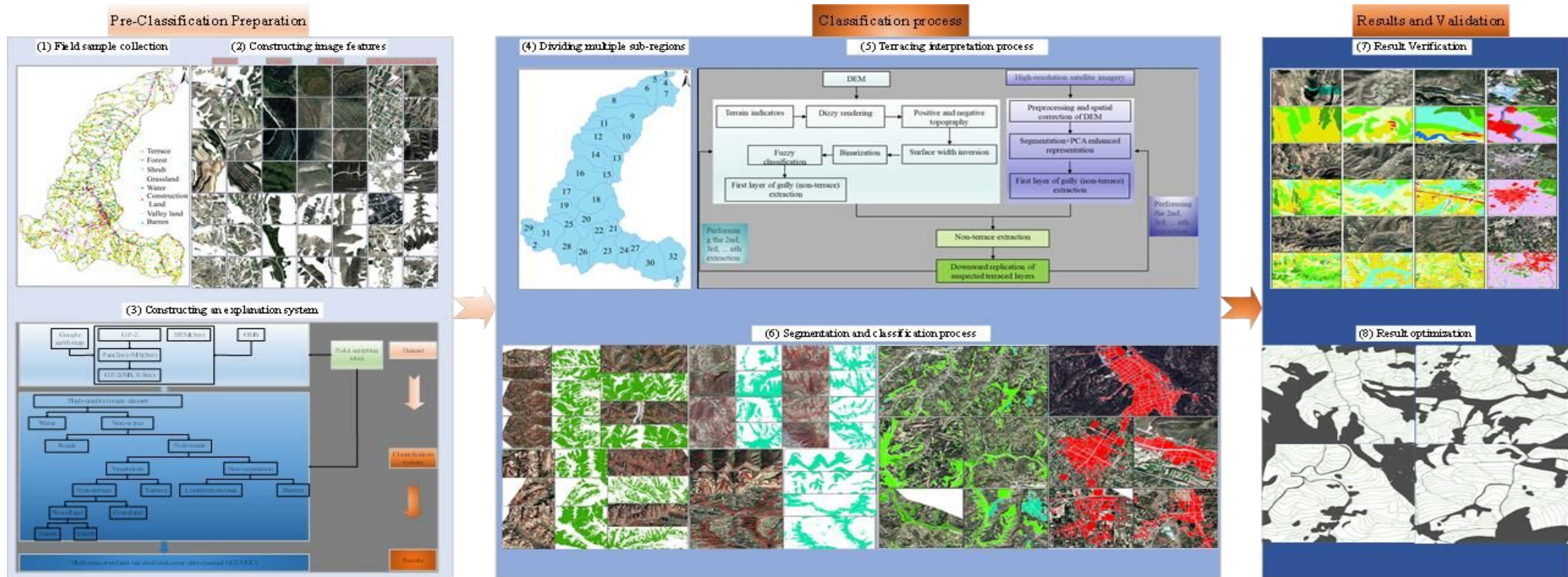
From 1990 to 2020, terraced areas had higher grain production and a higher growth rate in average grain production compared to slope cropland. *Shi and Wei*, 2023 Under review*

Long-term terrace pattern change and ecosystem service response at provincial scale



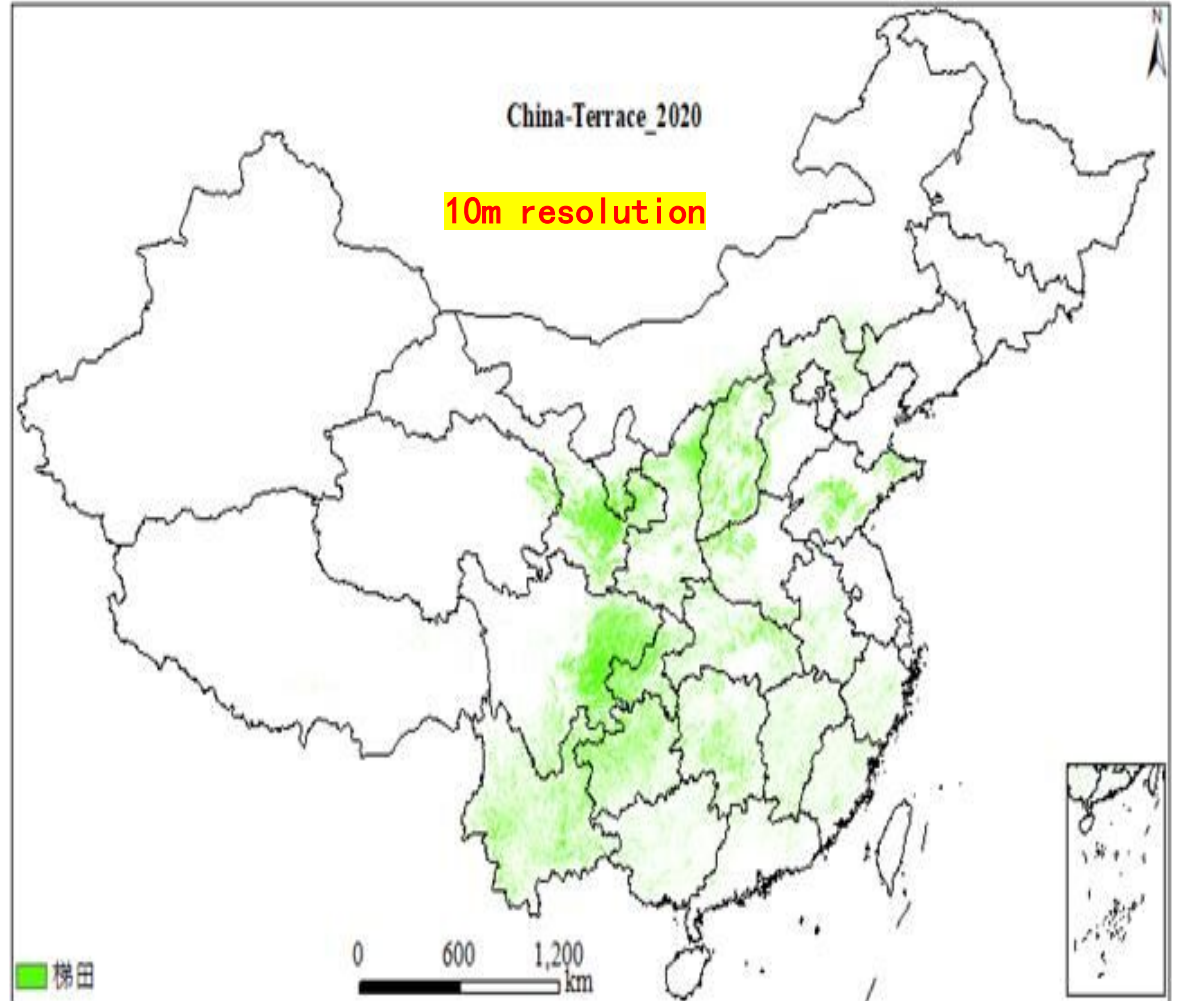
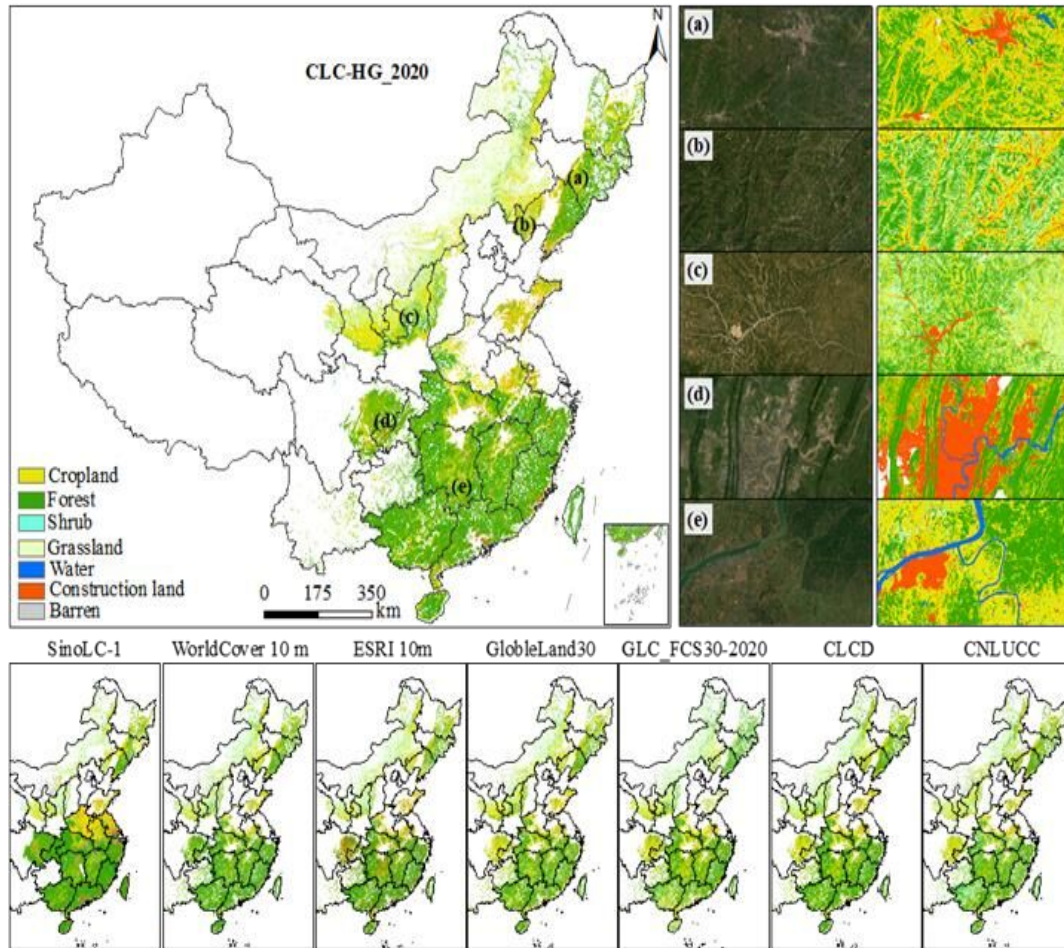
- Terraces account for 83% counties in Gansu, mainly located in the loess hilly and gully region.
- The changes in terraces have been characterized by significant temporal stages and spatial heterogeneity.
- Terraces have substantial benefits in soil and water conservation, yield and output, carbon sequestration, and oxygen release.
- The expansion of terraces increased ecosystem service value by \$820 million, with regulating services and habitat services accounting for 35% and 32%, respectively.

1-m High-Resolution terracing mapping using Object-Based Image Analysis



- (i) **Data collection:** field samples, satellite imagery, and DEM were collected during the preparation stage in summer 2020, including 6400 samples.
- (ii) **Terrace extraction:** a specialized method was used to extract non-terrace information, minimizing confusion between terraces, grassland, and forests through segmentation, stratification, and extraction.
- (iii) **Result validation:** Google Maps, statistical data, and field samples were used for validation
- (iv) **Result:** The product had a 1-meter spatial resolution and achieved over 95% accuracy in both sub-regional and overall classifications.

10-m resolution land use and terrace mapping of hilly and gully regions in China



1 NO POVERTY


2 ZERO HUNGER


3 GOOD HEALTH AND WELL-BEING


6 CLEAN WATER AND SANITATION




7 AFFORDABLE AND CLEAN ENERGY


12 RESPONSIBLE CONSUMPTION AND PRODUCTION


13 CLIMATE ACTION


15 LIFE ON LAND


Linking terraces with SDGs

Challenges: terrace abandonment and collapse

The security and sustainability of terracing

--many processes, services and eco-hydrological effects remain unclear



Bare bench terrace

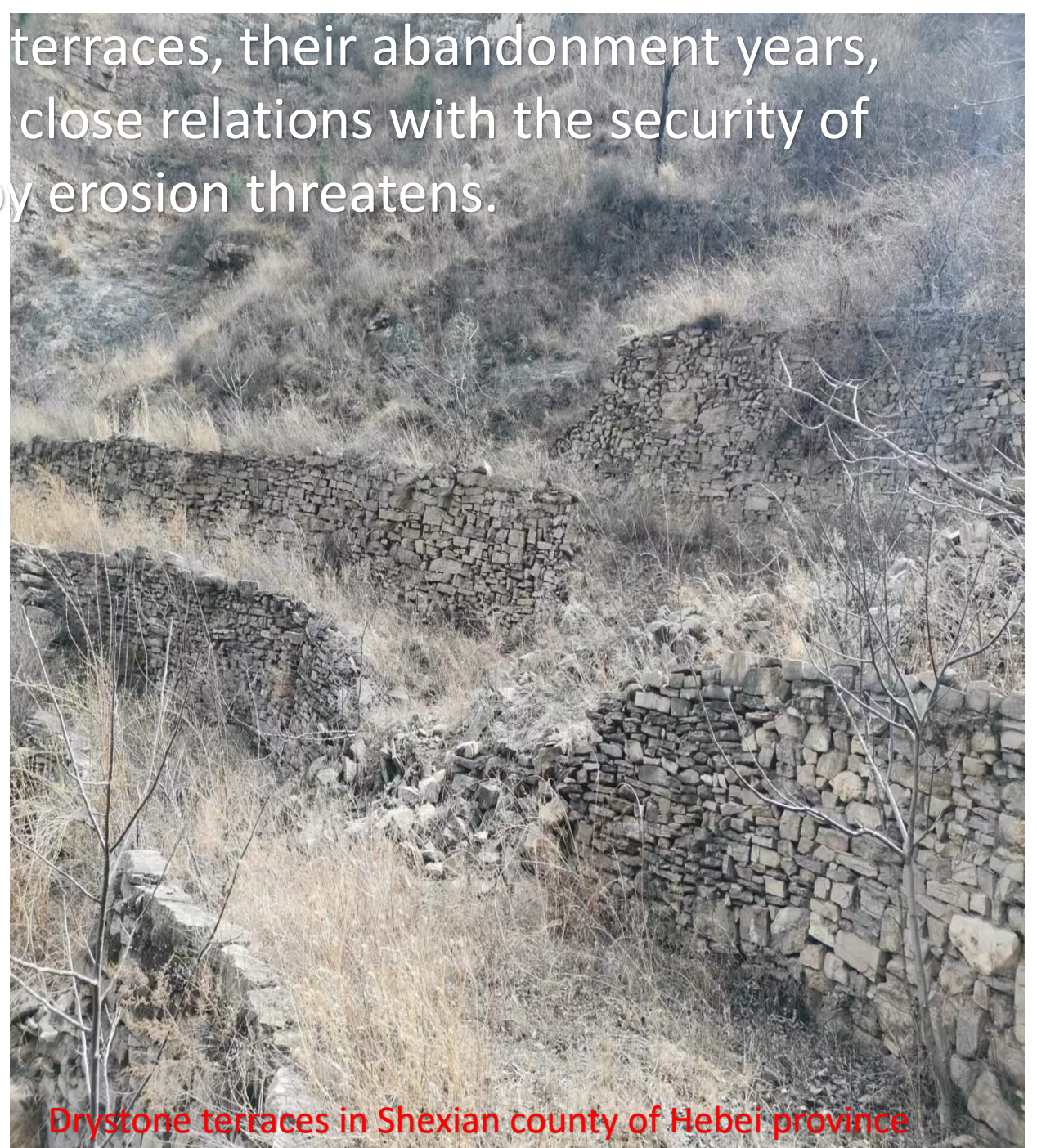


Weed covered bench terrace

Terrace failures remain a big challenge

How the performance of terracing with or without diverse vegetation coverage on ecosystem and its functions?

The specific physical structure of terraces, their abandonment years, abandonment locations all have close relations with the security of terraces caused by erosion threatens.



Dry stone terraces in Shexian county of Hebei province

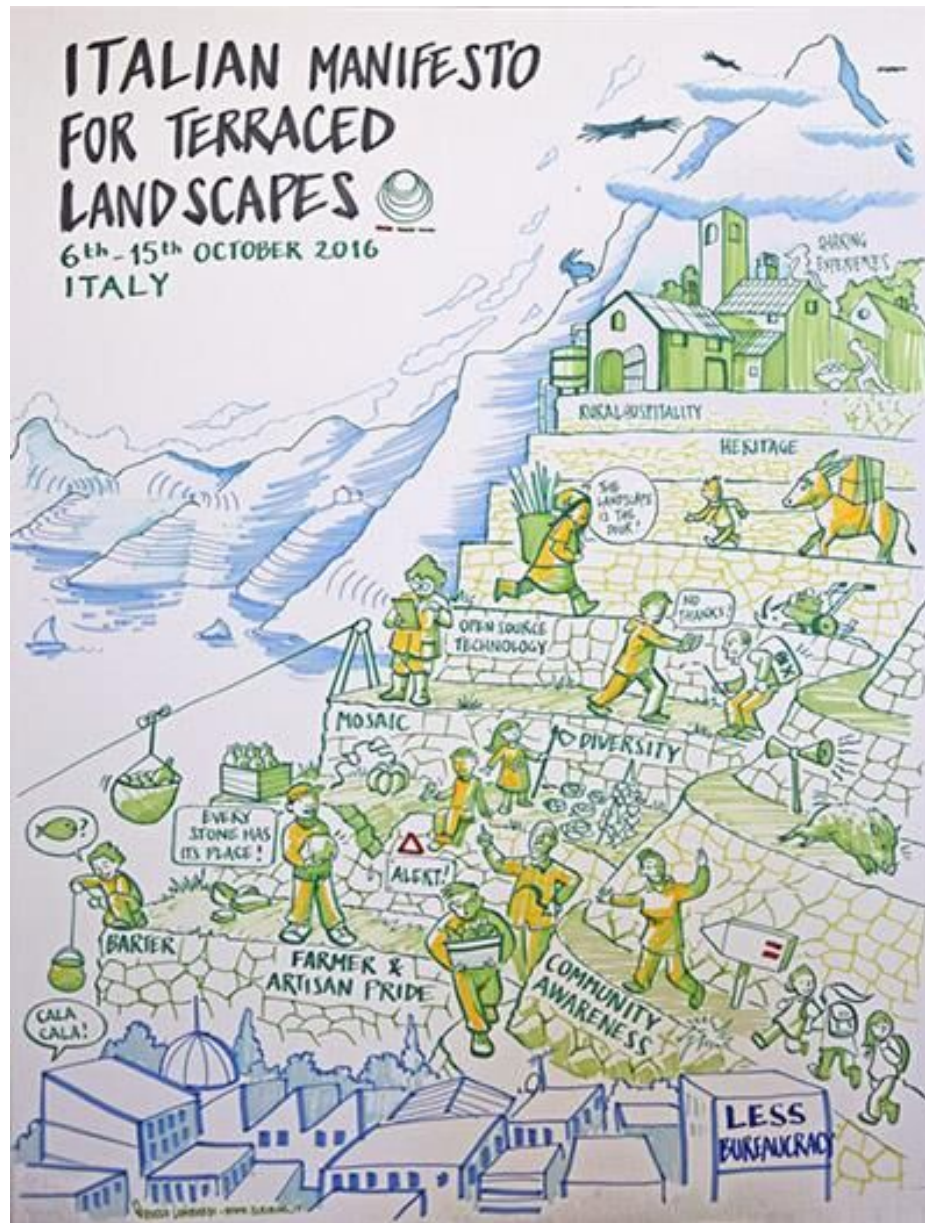
History of the World Congress on Terraced Landscapes

	Theme of the congress	when	where
First	Inheriting and Developing	2010. 11	Honghe county, Yunnan, China
Second	--	2014. 05	Cusco, Peru
Third	Choosing the Future	2016. 10	Italy
Fouth	Rechanting terraces	2019. 03	Spain
Fifth		2024	Bhutan

The International Terraced Landscapes Alliance (ITLA) was established in Yunnan of China in 2010.



ITLA logo



THE 3RD WORLD CONGRESS ON TERRACED LANDSCAPES IN ITALY, 2016



Thanks for your listening!