





Ying Zheng, Larissa Naylor, Joe Oyesiku-Blakemore, Sarah Dennis, David Oliver, Shunhua Yang, David Edwards, Susan Waldron, and Paul Hallet Note: as some material is not yet published all rights are reserved.



Using Critical Zone Science to Understand Sustaining the Ecosystem Service of Soil & Water (CZO)

A joint programme between NERC-Newton (UK) and NSFC (China), provides unprecedented knowledge of how land works, from the top of vegetation, through soil, to the bedrock below.



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### Postdoctoral Scientists

## **Dr Ying Zheng**, University of Glasgow (2019-2020)

• Knowledge exchange and stakeholder engagement.

Dr Joe Oyesiku-Blakemore (2019)

• Adapting readily available DSTs with CZO data.





### **Project sites**





### Background: the UK – China Critical Zone Observatory (CZO)





#### Using Critical Zone Science to Understand Sustaining the Ecosystem Service of Soil & Water

Challenge	Loess	Karst	Peri-Urban	Red Soil
Fertiliser use & pollution	•••	•••	••	•••
Soil erosion	•••	•••	•	•••
Water abstraction	•••	•••	•••	•••
Contamination	•	•	•••	•
Waste re-use	•	•	•••	•
Farming practice & training	•	•••		•



### Why understand geoscience social science interactions?

A recent review of critical zone science suggests that "anthropogenic effects on critical zone processes have gone largely uninvestigated" (Minor et al., 2019, p. 5). Our work contributes to filling this gap.

The putatively global discipline of critical zone science has developed largely in the USA and Europe. In collaboration with our colleagues in China, our work seeks to apply CZO science principles in China to help address pressing social and environmental impacts of farming.





Environmental Science and Policy

Knowledge management across the environment-policy interface in China: What knowledge is exchanged, why, and how is this undertaken?

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### Science-policy interactions and farming practice & training

#### Science-policy practice:

- Very limited research in China exists on how environmental science is shared with practitioners
  - Two-way interactions between scientists and practitioners could be improved



#### **ICT-based or in-person interaction**

**Fig. 3** The major dynamic of KM for environmental management in China. Data is synthesised from the retained full-text articles (n = 13).

Zheng, Y et al. 2019. Knowledge management across the environment-policy interface in China: Environmental Science and Policy, 92, pp. 66-75. <u>https://doi.org/10.1016/j.envsci.2018.09.021</u>





## **Less KE Awareness of Chinese Scientists**

Significantly-less awareness and use of two-way KE methods by Chinese scientists, compared to the British groups.



How did you make these KM outputs

- With end users
- For end users
- Only produced scientific report/academic papers
- No experience

Types of KE processes used to deliver KM



No experience



### Science-policy interactions and farming practice & training



Agriculture, Ecosystems & Environment Volume 288, 1 February 2020, 106715

How does smallholder farming practice and environmental awareness vary across village communities in the karst terrain of southwest China?

David M Oliver ª 온 쩓, Ying Zheng <sup>b</sup>, Larissa A. Naylor <sup>b</sup>, Madeleine Murtagh <sup>a</sup>, Susan Waldron <sup>b</sup>, Tao Peng <sup>c</sup>

#### **Farmer practice and training<sup>2</sup>:**

- Labour & water source identified as being problems for farming viability.
- farmer environmental awareness key for improving land & water management.



Oliver, DM et al. 2020. How does smallholder farming practice and environmental awareness vary across village communities in the karst terrain of southwest China? *Agriculture, Ecosystems and Environment*, 288, 106715. https://doi.org/10.1016/j.agee.2019.106715



### Summary:

Key scientific advances in understanding functioning of critical zone processes have been made across China. These include:

- Excess nitrogen from fertilizer, manure and organic sources accumulates in soil. In Red Soil regions this is at 1-8 m soil depth, in Loess this is stored more deeply (30—50 m depth).
- Soil, water, fertiliser and contaminants move through Karst landscapes differently, requiring specialized agricultural management in these regions
- A clear need for greater two-way knowledge exchange between scientists and policymakers emerged, alongside key pressures affecting farm livelihoods



#### **Current Steps:**

- Research from these Phase 1 projects has been shared with Chinese policymakers via a series of reports, and soon a training webinar
- The data is being used to develop decision-support models that will create evidence-informed tools to improve agricultural productivity alongside environmental and social benefits.





#### **Systematic Review of available DST tools:**

- Analyse available decision support tools for type and input data requirements
- Select tools using a systematic review of available tools (filtering on subject, data requirements and ease of use).
- Guide review with feedback from stakeholders in form of seminars, questionnaires and interviews
- Present selected tools to stakeholders for feedback (example simulations on red soil field site data from S.E. China)



### **Available models**



More than 400 tools analysed.

Many were reported on but no longer available (>15%).

## DST tools – key findings to date





Large number of available models developed largely for global agriculture (few Chinese tools found). Many of these models (>30%) have been discontinued.



There is a lack of tools which deal with finance, agronomy and the environment. Environmental impacts is weakly covered by most existing tools



The inclusion of additional elements must be weighed up against increased data/computational requirements.



Feedback and development of tools is ongoing.



#### Some key references from Phase 1 of the project:

References

- 1. Jia X. et al. 2018. Mineral N stock and nitrate accumulation in the 50 to 200 m profile on the Loess Plateau. *Science of The Total Environment* (*STOTEN*), 633: 999-1006
- 2. Green S. et al. 2019. Soil functions and ecosystem services research in the Chinese karst Critical Zone. *Chemical Geology*, 527: 119107, https://doi.org/10.1016/j.chemgeo.2019.03.018
- 3. Xiang Q et al. 2018. Spatial and temporal distribution of antibiotic resistomes in a peri-urban area is associated significantly with anthropogenic activities *Environmental Pollution*, 235: 525-533
- 4. Yue FJ et al. 2019. Land use interacts with changes in catchment hydrology to generate chronic nitrate pollution in karst waters and strong seasonality in excess nitrate export. *STOTEN*, 696:134062, <u>https://doi.org/10.1016/j.scitotenv.2019.134062</u>
- 5. Wang ZJ et al. 2020. Rainfall driven nitrate transport in agricultural karst surface river system: Insight from high resolution hydrochemistry and nitrate isotopes. *Agriculture, Ecosystems & Environment*, 291: 106787
- 6. Buckerfield SJ et al. 2019a, How can we improve understanding of faecal indicator dynamics in karst systems under changing climatic, population, and land use stressors? Research opportunities in SW China. *STOTEN*, 646: 438-447, <u>https://doi.org/10.1016/j.scitotenv.2018.07.292</u>
- 7. Buckerfield SJ et al. 2019b. Rainfall-driven *E. coli* transfer to the stream-conduit network observed through increasing spatial scales in mixed land-use paddy farming karst terrain. Water Research X, 5: 100038, <u>https://doi.org/10.1016/j.wroa.2019.100038</u>
- 8. Zheng, Y et al. 2019. Knowledge management across the environment-policy interface in China: what knowledge is exchanged, why, and how is this undertaken? Environmental Science and Policy, 92, pp. 66-75. <u>https://doi.org/10.1016/j.envsci.2018.09.021</u>
- 9. Oliver, DM et al. 2020. How does smallholder farming practice and environmental awareness vary across village communities in the karst terrain of southwest China? *Agriculture, Ecosystems and Environment*, 288, 106715. <u>https://doi.org/10.1016/j.agee.2019.106715</u>





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