**Institution:** SOAS University of London

**Unit of Assessment:** 17 – Business and Management Studies

**Title of case study:** Improving climate-change risk management in Shanghai and Hangzhou

**Period when the underpinning research was undertaken:** 2014–2020

**Details of staff conducting the underpinning research from the submitting unit:**

| Name(s): | Role(s) (e.g. job title): | Period(s) employed by submitting HEI: |
|---|---|---|
| Laixiang Sun | Professor of Chinese Business and Management | 2001–present |
| Huan Zou | Senior Lecturer in International Management | 2010–present |

**Period when the claimed impact occurred**: 2015– 31 July 2020

**Is this case study continued from a case study submitted in 2014?** N

**1. Summary of the impact** (indicative maximum 100 words)

SOAS researchers examined risks of extreme events under future climate change conditions in Shanghai and Hangzhou, two most important cities in the Yangtze River Delta. The research contributed to (1) the design and formation of the 'Implementation Blueprints of Shanghai's 13th Five-Year Plan on Adaptation to Climate Change', in particular the adoption of climate-change increments on the existing standards for urban drainage system design and building design in Shanghai and Hangzhou; (2) long-term engagement and capacity building on climate change risk monitoring and management in these two cities; and 3) generating political will for further climate-change related collaboration between the UK and China.

**2. Underpinning research** (indicative maximum 500 words)

Floods caused by torrential rainstorms, tropical cyclones and storm surges have been the most expensive and devastating natural hazards in the Yangtze River Delta (YRD) metropolitan region, centred at Shanghai. Major flood events occurred in YRD in 1931, 1954, 1998, 2010 and 2020, displacing millions of people, causing large-scale infrastructure damage and economic losses. Climate change is expected to cause future significant increases in their frequency and intensity, and as cyclones, rainstorms, high tides, etc often occur jointly, city authorities have to manage and analyse complex data from multiple sources – including meteorological – when making decisions about their planning and mitigation strategies.

To contribute to the mitigation and adaptation efforts in Shanghai and Hangzhou, SOAS researchers Laixiang Sun – Professor in the School of Finance and Management (SFM) at SOAS since 2001 – and Huan Zou Sun – Senior Lecturer in SFM at SOAS since 2010 – worked on two consecutive Foreign & Commonwealth Office (FCO) China Prosperity Fund projects (2015–2017, GBP194,520 in total), and two further projects funded by the UK Met Office (2017-2019, GBP168,000) and by the Engineering and Physical Sciences Research Council (2017-2021, GBP324,064). The researchers conducted a knowledge co-creation process using modelling and scenario planning together with the departmental authorities of the two municipal governments, including the Development and Reform Commission (DRC), Water Bureau, Department of Housing & Urban-Rural Development (DoHURD), Department of Environment & Ecology, Meteorological Bureau, and infrastructure experts in both power supply and transportation. They developed an integrated framework for flexible testing of multiple mitigation strategies under the condition of deep uncertainties. This tool assisted flooding control and heatwave defence decision-making in the two cities (see section 4).

This knowledge co-creation research approach has been employed in subsequent projects. The two FCO projects (2015–2017) examined the challenges Shanghai, Hangzhou and YRD face under the increasing climate risks and uncertainties. Sun and Zou, in collaboration with researchers from the Shanghai Climate Change Research Centre (Landong Sun, Zhan Tian and others), Shanghai Meteorological Bureau) (Guangtao Dong, Baode Chen), Shanghai Institute of Technology (Dongli Fan, Xinxing Huang), Hangzhou Climate Centre (Zhuoran Liang) and ARUP (Lanzhu Shao, Laura Frost, Lewis Fox-James) undertook a series of modelling experiments to simulate climate change. They developed an assessment tool to compare the vulnerability and exposure of city infrastructures towards climate change risks in the YRD Region **[3.1]**. A scoping study (also FCO-funded) on flooding control in London enabled the transfer of London's experience and knowledge to Shanghai, facilitating a comprehensive understanding of how to mitigate the flooding risk there and in similar cities.

With UK Met Office funding (2017–19), Sun and Zou established large-scale indicators related to climate impacts in multiple urban sectors/systems in Shanghai, Hangzhou and four other cities in the YRD. They evaluated the indicators in a systems-analysis manner using City Resilience Simulator (CRS) with the support of system dynamic modelling techniques. The project thereby provided a policy supporting tool for identifying vulnerabilities and adaptation approaches to cope with risks posed by future climate change. Climate-change increments over the existing standards for heatwave defence design in Shanghai and Hangzhou were evaluated, and robust standards were recommended to the authorities in reports co-authored with Shanghai and Hangzhou meteorologists (Guangtao Dong, Zhan Tian, Xiaochen Liu, Wei Wu and Tingting Gu in Shanghai, Zhuoran Liang in Hangzhou), Shanghai Center of Disease Prevention and Control staff (Chunfang Wang), and researchers at various universities in China and the US (Hengzhi Hu, Jiahong Wen, Zhan Tian, Junguo Liu, Dandan Zhao, Hanqing Xu, Klaus Huback, Kuishuang Feng, Honglin Zhong) **[3.1, 3.2, 3.4, 3.5]**.

With EPSRC funding (2017–2020), the researchers built on the above three projects, focusing on the flexible testing of multiple flood-risk mitigation strategies under the condition of deep uncertainties. The research quantified the flooding risks posed by co-occurrence of multiple extreme events in the future based on the latest developments in climate and hydrodynamic modelling, and assessed both direct losses (physical damage of buildings, assets and infrastructures, etc.) and indirect ones (economic losses along the input–output chain of the economy) caused by such compound events. The plausible mitigation and adaptation alternatives with a focus on Shanghai over the period of 2017–2050 were evaluated based on the enhanced Robust Decision Making (RDM) method. Alternative parameters of climate-change increment standards for urban drainage system design in Shanghai were evaluated, and robust standards recommended to the authorities **[3.2 and 3.3]**.

**3. References to the research** (indicative maximum of six references)

3.1. Sun, L., Tian, Z., Zou, H., Shao, L., Sun, L., Fan, D., Huang, X., Frost, L. and Fox-James, L. (2019). 'An Index-Based Assessment of Perceived Climate Risk and Vulnerability for the Urban Cluster in the Yangtze River Delta Region of China'. *Sustainability,* 11(7), article no. 2099, pp. 1–15. https://doi.org/10.3390/su11072099 **Peer-reviewed** (Impact Factor: 2.592; 5-yr IF: 2.801)

3.2. Hu, H., Tian, Z., Sun, L., Wen, J., Liang, Z., Dong, G., Liu, J. (2019). 'Synthesized trade-off analysis of flood control solutions under future deep uncertainty: An application to the central business district of Shanghai'. *Water Research,* 166, article no. 115067. https://doi.org/10.1016/j.watres.2019.115067 **Peer-reviewed** (IF: 7.913; 5-yr IF: 8.424; CiteScore: 14.5)

3.3. Zhao, D., Hubacek, K., Feng, K., Sun, L., Liu, J. (2019). 'Explaining the virtual water trade: A spatial-temporal analysis of the comparative advantage of land, labor and water in China'. *Water Research* 153, pp. 304–314. https://doi.org/10.1016/j.watres.2019.01.025 **Peer-reviewed**. (IF: 7.913; 5-yr IF: 8.424; CiteScore: 14.5)

3.4. Liu, X., Tian, Z., Sun, L., Liu, J., Wu, W., Xu, H., Sun, L., Wang, C. (2020). 'Mitigating Heat-Related Mortality Risk in Shanghai, China: System Dynamics Modeling Simulations'.

*Environmental Geochemistry and Health* 42(3), pp. 3171–3184 https://doi.org/10.1007/s10653-020-00556-9 **Peer-reviewed** (IF: 3.252)

3.5. Liang, Z., Tian, Z., Sun, L., Feng, K., Zhong, H., Gu, T., Liu, X. (2016). 'Heat wave, electricity rationing, and trade-offs between environmental gains and economic losses: The example of Shanghai'. *Applied Energy* 184, pp. 951–959. http://dx.doi.org/10.1016/j.apenergy.2016.06.045 Peer reviewed (IF: 8.426; 5-yr IF: 8.558),

3.6. Feng, K., Hubacek, K., Pfister, S., Yu, Y., Sun, L. (2014). 'Virtual Scarce Water in China'. *Environmental Science and Technology* 48(14), pp. 7704–7713. http://dx.doi.org/10.1021/es500502q **Peer-reviewed** (IF: 7.194).

**4. Details of the impact** (indicative maximum 750 words)

The research projects discussed above have been ground-breaking in that they have trialled a knowledge co-creation process, which emphasizes the generation of usable science for decision-making through sustained and meaningful dialogue with scientists and their institutions, policy makers, and other stakeholders in the Yangtze River Delta, the economic engine and population centre of China. This process improved the way the 5-year plans address climate change adaptation and risk management, enabled sustained engagement as plans become implemented, and created a space for more UK-China collaboration on climate change. The significance of this impact lies in the fact that China's policy-making processes differ from those of the UK. The role of outside expertise is never openly acknowledged in central planning, and planning documents have no 'author'. Institutions involved in policy making often keep reports submitted to central and/or local planning committees confidential, providing instead cover letters acknowledging inputs and thanking the planning committees for accepting their reports – which are public.

*Improvements to planned climate change adaptation in Shanghai's five-year plans*
Five-year planning and long-term master planning have played arguably the most important role in the Chinese policy arena. The research provided very timely assistance to the Shanghai Meteorological Bureau, a part of Shanghai municipal government, in drafting 'Shanghai's 13th Five-Year Plan on Adaptation to Climate Change'. The plan now includes 1) new standards on urban drainage and buildings, which will protect Shanghai's buildings and roads from flood damage and make the city more resilient to heatwaves, and 2) schedules of improvements to the city's early warning and risk management systems **[5.6a]**.

The Science and Technology Development Office of the Shanghai Meteorological Bureau acknowledged that **[5.1]**.

> ''Since 2015, Professor SUN Laixiang and Senior Lecturer ZOU Huan . . . have been in collaboration with relevant researchers of the Bureau on two research projects . . . namely "A Study of Flood Control Strategies from London Experience for Shanghai to Respond to Climate Change" and "Climate Risk Assessment for the City Cluster in the Yangtze River Delta Region". Based on the two research projects, the policy brief "Report and Recommendations on Pro-active Adaptation to Rising Flood Risks under Climate Change in Shanghai" **[see 5.2**] was completed and received comments and written instructions by the then Deputy Mayor of Shanghai, SHI Guanghui. The research output contributed to the composition of "Shanghai's 13th Five-Year Plan on Adaptation to Climate Change", providing technical support for the formulation of the blueprints for Shanghai's adaptation to climate change.'

In the 'Shanghai Meteorological Bureau Work Report' submitted to the Mayor of Shanghai in November 2017 by the Director General of the Shanghai Meteorological Bureau **[5.3]** and in the Official Certificate for the submission of the policy brief entitled 'Progresses Made by the Collaborative Researches on Climate Change Risk Management with British Research Institutions and Policy Suggestions' to the Major of Shanghai' **[5.4]**, the above two FCO-funded projects were acknowledged again. He placed an emphasis on the contributions of the two projects to the adoption of climate-change increments on the existing standards for urban

infrastructure design and construction in Shanghai with the city benefiting from the fact that the UK was 'one of the earliest countries' to recognise climate change as an environmental and political challenge, 'and among the first to take action' **[5.3]**. Based as they were on 'London's experiences', the Director General acknowledged the urgency of the researchers' assessment of 'the risks of flooding control and urban infrastructure in Shanghai' **[5.3]**. A Hangzhou policy brief provided analogous evidence in Hangzhou **[5.10]**.

The relative ease of implementation of Shanghai's 13th Five Year Plan on Adaptation to Climate Change and relevant elements of its Master Plan **[5.6a and b]** was acknowledged in state media. A blueprint for implementing the plan, developed under the leadership of the Shanghai Meteorological Bureau was found to be 'clearly defined and implementation measures reasonably crafted' and 'provided important guidance on enhancing adaptation to climate change and ensuring the safe and secure functioning of the city.' **[5.5]**.

*Sustained engagement, building capacity and monitoring with Shanghai policy makers*
The process promoted sustained and meaningful dialogues with policy makers from the Development and Reform Commission (DRC), Water Bureau, and the Shanghai and Hangzhou municipal governments' departments of Housing and Urban-Rural Development (DoHURD). Since 2012, Sun has been the Executive Chairman of the Academic Committee, Shanghai Climate Change Research Centre (SCCRC), within Shanghai Municipal Government. This strategic advisory role has greatly facilitated the policy impact of these projects. For example, Sun co-organized a High-level Symposium at the Chinese Academy of Engineering on the 'Impact of Climate Change on Urban Rainstorms/Compound Disasters and Adaptation Strategy', which was hosted by SCCRC in September 2016 **[5.7]**. Attendees included prominent policy influencers: Mr Yanhua LIU, Counsellor of the State Council; Prof. Xiangwan DU, Chairman of China Climate Change Expert Committee; Mr. Qiang ZHOU, Secretary General of Shanghai DRC; and other policy makers at both the national and municipal levels. Sun was frequently invited to make presentations and provide advice in a number of important policy forums organized by Chinese Academy of Engineering, Chinese Meteorological Administration, and Shanghai DRC.

*Greater potential for UK-China collaboration on climate change*
The success of these projects in delivering policy impacts also attracted recognition and appreciation from high-level British officials When the British Ambassador, Dame Barbara Woodward DCMG OBE, wrote to the Mayor of Shanghai in 2017 **[5.8]**, she focused closely on the Met Office and EPSRC projects led by Sun, highlighting the benefits to Shanghai of the UK-China collaboration stating: 'I believe that these projects will support Shanghai to maintain its leadership position in responding to climate change.' **[5.8]**

In planning the visit of Prime Minister Theresa May in China in January-February 2018, the British Embassy in Beijing recommended that 'senior government officials, meteorological representatives from both countries and **the scientists of the China-UK Climate Science for Service Partnership (CSSP) projects** meet at Shanghai Meteorological Bureau to review and report to [the] PM the output of UK-China collaboration on climate change and look into the future' **[5.9**, emphasis added**]**. As a result of these discussions, and in recognition of the importance of the previous collaborations to the UK's policy-making initiatives, the SOAS team, with Imperial College London and ARUP, won 2 new CSSP projects (2019–2021) on 'Providing predictions of typhoon season characteristics for shipping in the Pearl River Delta' and 'Climate Risk Assessment Tool for Chinese Cities'.

**5. Sources to corroborate the impact** (indicative maximum of 10 references)

5.1. Shanghai Meteorological Bureau, official certificate of policy impact, 14 January 2020

5.2. First page of Policy Brief (2015), 'Report and Recommendations on Active Adaptation to Rising Flood Risks under Climate Change in Shanghai', submitted to Shanghai Municipal Government, June 2015, by Shanghai Meteorological Bureau.

5.3. 'Shanghai Meteorological Bureau Work Report'. Cover page submitted to the Mayor of Shanghai, November 2017, by the Director General of Shanghai Meteorological Bureau.

5.4. Official certificate for the submission of the policy brief entitled 'Progresses Made by the Collaborative Researches on Climate Change Risk Management with British Research Institutions and Policy Suggestions', submitted to Shanghai Municipal Government in November 2017 by Shanghai Meteorological Bureau.

5.5. Media report on the evaluation and approval of the 'Implementation Blueprints of Shanghai's 13th Five-Year Plan on Adaptation to Climate Change'

5.6. Impact on Shanghai municipal planning: **a**) 'Shanghai's 13th Five-Year Plan on Adaptation to Climate Change', 1 March 2017, Chapter 6: <http://www.cnki.com.cn/Article/CJFDTotal-SREZ201707001.htm> (Chinese, with English translation); **b**) 'Shanghai Master Plan 2017–2035 (public version)' of Shanghai Municipal Government, 1 August 2018, Part III, Chapter 3: <http://www.shanghai.gov.cn/newshanghai/xxgkfj/2035004.pdf> (in English and Chinese).

5.7. Impact on Climate Change on Urban Rainstorms compound disasters and adaptation strategy, agenda, 23 Sep 2016

5.8. Letter from Dame Barbara Woodward to the Mayor of Shanghai.

5.9. Fax letter from Mr Neal Carlin, First Secretary on Climate Change at British Embassy in Beijing, to China Metrological Administration (CMA) – Chinese with English translation

5.10. Cover page of policy brief: 'Policy Suggestions on Combating Climate Change in Hangzhou', submitted to Hangzhou Municipal Government in January 2019 by Hangzhou Meteorological Bureau – Chinese with English translation