Institution: University of Brighton		
Unit of Assessment: C14 Geography and Environmental Studies		
Title of case study: Transforming recycling policy and food waste diversion in Shanghai, China		
Period when the underpinning research was undertaken: 2000 – 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:**
Marie Harder	Professor of Sustainable Waste Management (2008 – to date),	1989 – to date
Ryan Woodard	Research Fellow (2005 – 10), Senior Research Fellow (2010 – to date),	1999 – to date
Peter Tamas	Research Fellow	2016 – 2017
Period when the claimed impact occurred: 2014 **–** 2020		
Is this case study continued from a case study submitted in 2014? N		

1. Summary of the impact

University of Brighton (UoB) researchers have developed a general prescriptive theory that identifies the key determinants of residential recycling behaviour. Working with a Chinese environmental NGO and Chinese local government, this theory was used to develop policy recommendations that were incorporated into municipality-wide regulations on household waste in Shanghai (population 24,300,000). As a result, the total food waste recycled increased by 5,796 tonnes/day and was sustained 12 months later. This is equivalent to capturing 78% of domestic food waste in the metropolis, the highest urban rate globally. Food waste is now mostly diverted into biogas production instead of landfill, reducing emissions by 2.65mt CO_2-eq/year. Previously unacknowledged Chinese NGOs are now an accepted stakeholder and fully integrated into policy processes.

2. Underpinning research

Failure to enable residents to sort their waste for diversion into recycling, composting or reuse causes significant environmental challenges worldwide. These challenges are particularly pronounced for food waste, which makes up 30-40% of household waste in the Global North and 60-70% in China. Food waste is usually disposed of via landfill or incineration, leading to greenhouse gas emissions. City projects that divert significant food waste, for example for conversion to biogas or compost, are rare. A key policy challenge is identifying which of the many interrelated and context-specific determinants of recycling practice need to be targeted to encourage residents to sort waste sufficiently well for large-scale, sustained diversion pathways.

Professor Marie Harder and Dr Ryan Woodard have worked alongside UK local authorities since 1999, using a field-based approach to develop empirical evidence to underpin domestic recycling policy. Early research identified that factors such as the frequency of collection and number of waste types recycled are important, and that people-centred approaches, such as household and community level incentive schemes for recycling, can increase participation rates by 10-20% [reference 3.1].

In 2011, Harder began a collaboration with Fudan University (Shanghai), establishing a dual-institutional affiliation and partnerships with Chinese researchers. Shanghai Municipality has been at the forefront of China's household recycling initiatives since 2000, encouraging local pilots for food waste in 2011 and rehearsing scaling-up since 2014, but with minimal success. Capitalising on an opening provided by the municipality's 2012 Policy for Waste Sorting Pilots, Harder began to work with Ifine, a specialist Chinese NGO whose focus is on mobilising residents to recycle more effectively. A series of increasingly large and complex UoB-Fudan-Ifine projects were developed to identify which behavioural policy interventions could be targeted where, to maximise food waste recycling in the city. Ifine focussed on stakeholder relationships and interpersonal interventions, with UoB-Fudan researchers analysing field data. The research was aided by the 'village' structure of Shanghai (the largest city in China), which comprises ~25,000 residential compounds of 500-4,000 households – each with communal gardens,

cleaners, estates managers and waste bins – effectively providing 'living laboratories' for tests of interventions and triangulation of the determinants of recycling behaviour. Neither researchers nor NGOs are usually welcome in residential compounds, but by co-producing evidence with local stakeholders that improved recycling results, the university-NGO partnership gained the trust of governance committees at ward, district and finally municipality level.

The joint UoB-Fudan-Ifine research used a grounded empirical approach that identified which behavioural attributes were correlated to better recycling. As behavioural determinants became better-defined, causal links could be tested. Through separate published studies, work alongside Ifine established that: (i) providing *only* information about recycling programmes to residents failed to improve waste sorting, but interpersonal interactions with Ifine volunteers succeeded [3.2]; (ii) key volunteer actions included: modelling recycling behaviours, role clarification for residents, the provision of tailored knowledge, and eliciting emotions [3.3]; (iii) awareness of the environmental benefits of recycling was not necessarily a determinant of improved sorting [3.4]; (iv) incentives given to residents to recycle were less effective than social interactions with volunteers and staff [3.5]; and (v) interpersonal interactions with volunteers and staff had to be positive to be effective [3.6].

To augment these findings and develop a generalisable prescriptive theory, an analysis of peer-reviewed studies of recycling worldwide (published 1990 – 2017) was undertaken. The aim was to synthesise all proposed determinants that influence recycling behaviour and use a line-of-argument meta-ethnographic approach to classify them into a typology. Where there were gaps in knowledge, bespoke field studies were designed, enabling patterns in the meta-ethnography to be drawn out. The result was a generalised typology of 16 determinant domains with causal links and mappings to field interventions that could be used to specify which interventions are best, under specified circumstances, to achieve effective recycling [3.4]. The typology includes determinant domains such as Knowledge (of a recycling programme), Social Norms (regarding recycling) and Action Planning (by residents or other stakeholders), providing a rigorous 'checklist tool' through which any community – not just in China – can be 'profiled' to identify the determinants for local prioritisation to maximise waste recycling.

The UoB-Fudan-Ifine team then worked with local authorities to profile tens of communities in two districts of Shanghai. The results revealed that Role Recognition and Interpersonal Interaction [3.2, 3.3] were the most critical local determinants to trigger successful recycling behaviour. Intervention-determinant mapping showed that the most effective way to do this was by: (i) using *interpersonal* delivery of programme information; (ii) distinguishing *different roles* (residents, cleaners) from the start; (iii) having *volunteers* attend communal recycling bins several hours a day, initially, to make clear to residents in a *positive, interactive* way that it was their role to sort waste; and (iv) training cleaners *not to assume the roles* of residents at any time. The existing government emphasis on incentivising residents to separate food waste was shown to be ineffective. A demonstration was carried out with 18 communities whereby staff were trained to apply these recommendations. Immediate increases in recycling performance were seen, correlated with the quality of implementations, which were written into a policy brief.

3. References to the research

[3.1] Harder, M. K., Woodard, R., (2007). Systematic studies of shop and leisure voucher incentives for household recycling. *Resources, Conservation and Recycling* 51(4), 732-753. https://doi.org/10.1016/j.resconrec.2006.12.001. [Quality validation: peer-reviewed publication in international waste management journal].

[3.2] Dai, Y. C., Lin, Z. Y., Li, C. J., Xu, D. Y., Huang, W. F., Harder, M. K., (2016). Information strategy failure: personal interaction success, in urban residential food waste segregation. *Journal of Cleaner Production* 134(A), 298-309. https://doi.org/10.1016/j.jclepro.2015.12.104. [Quality validation: peer-reviewed publication in international sustainability journal].

[3.3] Xu, D. Y., Lin, Z. Y., Gordon, M. P. R., Robinson, N. K. L., Harder, M. K., (2016). Perceived key elements of a successful residential food waste sorting program in urban apartments: stakeholder views. *Journal of Cleaner Production* 134(A), 362-370. https://doi.org/10.1016/j.jclepro.2015.12.107 [Quality validation: peer-reviewed publication in international sustainability journal].

[3.4] Dai, Y. C., Gordon, M. P. R., Ye, J. Y., Xu, D. Y., Lin, Z. Y., Robinson, N. K. L., Woodard, R., Harder, M. K., (2015). Why doorstepping can increase household waste recycling. *Resources, Conservation and Recycling* 102, 9-19. https://doi.org/10.1016/j.resconrec.2015.06.004. [Quality validation: peer-reviewed publication in international waste management journal].

[3.5] Li, C. J., Wang, Y., Li, Y., Huang, Y. Y., Harder, M. K., (2020). The incentives may not be the incentive: a field experiment in recycling of residential food waste. *Resources, Conservation and Recycling,* 105316 https://doi.org/10.1016/j.resconrec.2020.105316. [Quality validation: peer-reviewed publication in international waste management journal].

[3.6] Huang, Y. Y., Tamas, P. A., Harder, M. K., (2018). Information with a smile – Does it increase recycling? *Journal of Cleaner Production* 178, 947-953. https://doi.org/10.1016/j.jclepro.2018.01.006. [Quality validation: peer-reviewed publication in international sustainability journal].

4. Details of the impact

Despite huge investments in infrastructure, public information programmes and centrally co-ordinated and locally innovated pilots since 2011, the food waste stream from the 24,300,000 population of Shanghai Municipality yielded only 4,000 tonnes/day in December 2018. The majority of this was contaminated with other (non-food) waste and useless for composting without further hand sorting. Application of the generalised prescriptive theory of residential recycling behaviour developed by UoB researchers led to three impacts at metropolis level: (i) policy change, resulting in an increase in food waste recycling to 9,796 tonnes/day, sustained over the year following policy introduction; (ii) associated reductions in greenhouse gas emissions of at least 2,650,000 tonnes CO_2-equivalent per year; and (iii) improvements in the status of Ifine and other Chinese NGOs, which are now formally accepted as local authority partners and fully integrated into policy processes.

4.1 Policy and practice changes

To maximise the benefits of the research into policy, UoB-Fudan researchers cultivated communication routes at community, ward, district and Municipal levels in Shanghai. In the two-year period 2017 – 2018, the team was invited to present informally and then formally to highest-level Municipality officers. Initial recommendations to improve domestic food waste recycling performance were submitted to the Municipality in December 2017; these were derived from the application of the UoB-Fudan general prescriptive theory and intervention-determinant mapping described in section 2. The recommendations stated that Municipal recycling strategy should focus on providing role clarification for residents through positive interpersonal interactions (especially using volunteers) and not rely on the provision of incentives to residents or cleaners. The recommendations were accepted for implementation and testing at scale and were included in draft city-wide Regulations on the Administration of Municipal Household Waste (2018).

To confirm that the recommendations of the UoB-Fudan team were practical and scalable, training materials were produced for stakeholders and trialled in different wards, under Municipality scrutiny. Then, a new set of 15 communities were trained and evaluated 4-6 weeks later on the effectiveness of their own localised food waste recycling programmes and implementations: there was a direct correlation of improved recycling performance with adherence to the recommendations. A final policy brief was submitted to Shanghai Municipality in November 2018 [source 5.1]. On 31 January 2019, the Municipality issued its new compulsory household waste regulations, fundamentally incorporating the concepts of the UoB-Fudan team, with Municipality-wide implementation made mandatory for all residents from 1 July 2019. The role of every stakeholder is set out in the regulations, including an emphasis on where interpersonal interaction with residents is needed. The use of incentives is de-emphasised. As is common in China, a formal letter/certificate was issued acknowledging the level of incorporation of the research-led recommendations into policy and, in this case, including a comment on their usefulness [5.2]. The letter/certificate concludes: "*In summary, the research results of your unit* […] *have produced a wide-ranging social value*."

4.2 Environmental impact reductions

The city-wide change in residential food waste recycling policy in Shanghai produced a sharp and sustained effect on the environment. Figure 1 shows published waste collection data from Shanghai Municipality for 2018 – 2020. Food waste collections existed (in large pilots) before July 2019 but had such high levels of contamination (typically >30%) that most of the 4,000 tonnes/day collected prior to the policy change were mixed back in with other waste for incineration, and many composting facilities were closed. The July 2019 policy-driven shift in recycling behaviour resulted in the sustained diversion of ~9,500 tonnes/day (peaking at 9,796 tonnes/day) of residential food waste of such low contamination (<5%) that it is now used routinely for biogas production. This equates to 2,120,000 tonnes/year additional food waste recycled, which is more than the entire UK 10-year target for food waste reduction in the Courtauld Commitment 2025 [5.3]; some 78% of all domestic food waste in Shanghai Municipality is now captured and diverted [5.3], the highest urban rate for food waste globally.

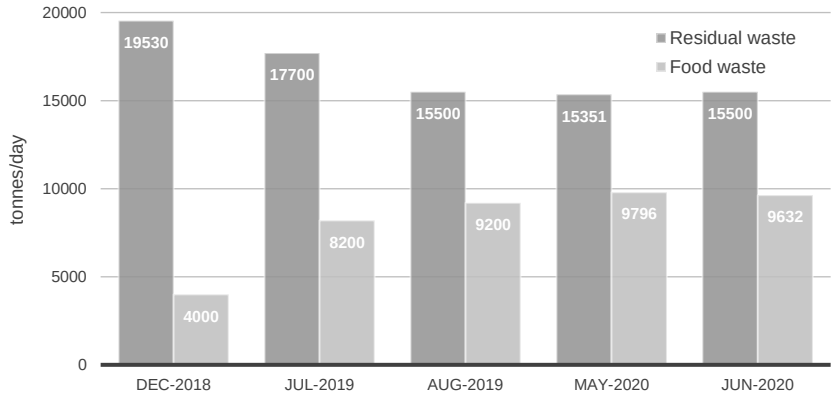

Figure 1: Changes in residential food waste and residual waste recycling in Shanghai Municipality (Dec 2018 to Jun 2020) [full data in source 5.3]. Regulatory changes incorporating UoB recommendations became mandatory on 1 July 2019.

Residual residential waste has also fallen to ~15,500 tonnes/day (Figure 1), reducing incineration and landfill due to shifts to anaerobic digestion for biogas. Using very conservative calculations, from the baseline scenario of December 2018, CO_2-equivalent emissions in Shanghai have been reduced by 2,650,000 tonnes/year as a result of the new policy implementation [calculations are provided in 5.3, using a breakdown of the final treatment facilities in use in Shanghai in May 2019 and May 2020, and the European Environment Agency recommended figure of 1.2 tonnes CO_2 per tonne of food waste when diverted from landfill]. This is equivalent to 22% of the UK Carbon Target for one year (from the Climate Change Act 2008) or taking 1,084,589 cars off the road per year [using DEFRA figures for CO_2 emissions per car; see 5.3], all from research-driven regulatory interventions in a single Chinese city.

4.3 Improved status of Chinese specialist environmental NGOs

Harder began the collaboration with Ifine in 2012, at a time when environmental NGOs were not formally acknowledged by Chinese governments and foreign NGOs were being closed. Official registration was difficult. Early interventions by Ifine that improved food waste recycling had been viewed with scepticism that they could not be reproduced more widely. However, the NGO obtained funding for a pilot to develop ideas in two large communities and opened their field data and community access to the UoB-Fudan team in exchange for formal performance evaluations. The verification of Ifine's work by the UoB-Fudan team resulted in government offices treating the NGO as more serious and 'safe' and generated funded opportunities for further pilot projects in the metropolis [5.4, 5.5].

The UoB-Fudan team co-designed twelve studies with Ifine. These provided increasingly high-quality inputs into the prescriptive theory-building, but also highlighted the need for local, specialised knowledge and public engagement to complement traditional government implementation and maximise recycling rates. Such scientific evidence, including primary data, was uncommon in China, and it led first to endorsement and then a change in the status for Ifine-type environmental groups. In 2014, a Shanghai Municipality Guidance Note included, in Article 25, that lower government bodies "*can support social organisations to participate in the activities of reducing the amount of household waste by purchasing services*" [5.4]. This enabled

local governments to commission NGOs without political risk. Ifine expanded, offering advice to other groups in Shanghai, and developed formal models of their community-based approach for training, dissemination, and presentation to government offices.

In May 2019, another Guidance Note was published, dedicated to this single issue, entitled *The Use of the City's Community-level Governance and Social Organisations to Promote the Sorting of Household Waste*. This formalised the status of environmental NGOs, especially for public engagement with community-level governance committees. Ifine and other local environmental NGOs won many more contracts, sharing their approaches through annual conferences, demonstration projects and training, and established links with national and international NGOs including Zero Waste Alliance and GAIA, and San Francisco city officers [5.4, 5.5]. The UoB-Fudan team regularly assisted with design, workshops, and presentations at those events.

4.4 Roll-out of the general prescriptive theory to other cities in China

Targeted partnerships have spread the influence of the UoB-Fudan-Ifine research to other cities in China. In 2019, the UoB-Fudan team were commissioned to develop policy recommendations on waste management and community involvement for Hangzhou City (population 10,000,000) via the Society of Entrepreneurs and Ecology (SEE) Foundation [5.6]. In Nanjing City (population 8,000,000), the main public-private-partnership recycling service, ZhiDa, collaborated in large-scale research experiments to optimise their services, and arranged formal meetings with government officers at Nanjing City and then Jiangsu Province levels [5.7]. Harder made further policy recommendations at the China National government level [5.8]. The general prescriptive theory was a major presentation in an online conference with 10,000 participants (2020) considering ways forward for Beijing's waste sorting programme [5.5]. Harder was presented with the Magnolia Silver Award by Shanghai in 2016, one of only 50 awarded each year to non-Chinese nationals who make significant contributions to the municipality.

5. Sources to corroborate the impact

[5.1] A copy and translation of the policy brief to Shanghai Municipality.

[5.2] An official and authorised Letter/Certificate from the government office responsible for recycling policy development (Shanghai Municipality Greening and Municipal Management Bureau), identifying the specific contributions from the extended research towards the Regulations on the Administration of Municipal Household Waste (July 2019) and the impacts and causal links perceived by them.

[5.3] Detailed calculations for determining the equivalences of food waste diversion in Shanghai Municipality and associated reductions in CO_2 emissions, including references and links to full Shanghai data sources.

[5.4] Letter from the Shanghai NGO, Ifine, detailing the impacts of our relationship and collaboration over several years (2012 – present) on their status and work. Includes mention of the relevant, specific, formal Guidance Notes by Shanghai Municipality.

[5.5] Letter from a China-wide umbrella waste NGO, Zero Waste Alliance, detailing their perspective on how our work has influenced NGOs through them and their events.

[5.6] Letter from the SEE Foundation stating they have acted as a channel to take our work to Hangzhou city officers for policy consideration.

[5.7] Letter from the main government-Public-Private-Partnership recycling company in Nanjing City, ZhiDa, testifying to their partnership with UoB researchers and their coordination of formal meetings between the research team and relevant city officers in waste management to input to policy (2014 – 2019).

[5.8] Statement from the Dean of the Department of Environmental Science and Engineering (Fudan University) that confirms (i) Harder was hosted there as a China National Thousand Talents Professor; (ii) an active UoB-Fudan formal collaboration with staff and student exchanges occurred 2011-present; (iii) contracts for work with city governments/agencies of Shanghai, Nanjing and Hangzhou were received by Harder; (iv) policy recommendations were made by Harder to Shanghai municipal government and China national government.