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Perceived key elements of a successful residential food waste sorting program in urban apartments: stakeholder views

D.Y. Xu [a], Z.Y. Lin [a], M.P.R. Gordon [a, b], N.K.L. Robinson [a, b], M.K. Harder [a, b, *]

[a] Sustainable Behaviour Research Group, Department of Environmental Science and Engineering, Fudan University, Shanghai 200433, PR China
[b] Values and Sustainability Research Group, University of Brighton, Lewes Road, Brighton BN2 4GJ, UK

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ABSTRACT

A large, successful, residential food waste sorting (recycling) program in urban high-density housing was studied to elicit perceptions of the key elements of its success. An embedded mixed-methods approach was used with rigorous quantitative measures of weights and compositions of the waste to confirm the success of the program, combined with in-depth semi-structured interviews of stakeholders to reveal their opinions of the elements key for success. The program produced a 70% food waste capture rate slowly decreasing to 45% over 54 weeks, with <1% contamination. The key elements for success were found to relate to clarification of roles and responsibilities, and the usefulness of a 'broker' (here, an NGO (non-governmental organisation)) to co-develop new boundaries for stakeholder responsibilities. Residents first needed to be convinced of the serious intention of the local government to implement the policy, but then viewed waste sorting as a civic duty. This is different to the moderator of "authority' in earlier studies. The use of volunteers to demonstrate and interact on a personal level with residents was seen as a key element. The three month period of volunteer involvement was seen as key to good habit forming.

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1. Introduction

In order for mankind to learn to live more sustainably, it must change many of its behaviours. This is as true in aspects of transport and energy use as in waste generation and processing, and various foundations for those behaviour changes must be built up through new policies, legislation, and patterns of production and consumption. However, some are more prone to impacts of the behaviour of individual citizens, and one of these is source separation of residential waste in homes (Tai et al., 2011), in preparation for collection for recycling, composting or other uses. Recycling of 'dry recyclables' such as plastic bottles, cans and tins, paper and card has long been championed and developed by government authorities in developed countries around the world, and has been mainstream and reasonably successful in many for several years (Huang et al., 2014), albeit less so in high density housing in cities (Timlett and Williams, 2009). However, the successful segregation and collection of residential food waste faces many more challenges, and is still in its infancy (Boonrod et al., 2015). Unfortunately it is in the cities, and in particular in those of the less developed and quickly developing countries that the recycling of food waste is most urgent, as it comprises around 70% of residential waste (Liu and Wu, 2011). It is the category which most contributes to environmental degradation though methane production at landfill and the need for added fossil fuels in incineration (Cheng and Hu, 2010), yet which could potentially be a source of environmental benefit if converted to soil conditioners of good quality and/or biogas to substitute for fossil fuels (Levis et al., 2010).

In most cities policy makers make heavy use of information strategies to try to induce widespread recycling, but it is now recognised in a few countries that behaviour change is a complex phenomenon which has many other key determinants besides information (Eppel et al., 2013; Jackson, 2005). The metropolis of Shanghai introduced an information-based pilot program for food waste sorting in 2011, and a study of those across 5000 communities (5 million households) found no success (Dai et al., 2016). A parallel pilot program with a set of 42 communities using a 'more personal' approach produced outstanding results which were sustained even up to two years later (Dai et al.,2016). The community reported on in this paper is one of those.

* Corresponding author. Values and Sustainability Research Group, University of Brighton, Lewes Road, Brighton, BN2 4GJ, UK. Tel.: +44(0) 1273600900.
E-mail address: M.K.Harder@brighton.ac.uk (M.K. Harder).

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Although there are ongoing reports of failures of schemes for residential food waste separation (e.g. Seadi et al., 2013), and in some countries large-scale failures (e.g. Pariatamby and Tanaka, 2013), there are only a small number of reports of successes, and usually for very small numbers of households on pilots. Unambiguous data is difficult to find, and many reports claim success without any data or numbers at all (Seadi et al., 2013). In reviewing the generation and recovery of USA and Canadian municipal solid wastes (MSW) – which includes waste from restaurants and hotels as well as households – a capture rate of 2.6% was reported for food waste in the USA, based on 2007 EPA data (Levis et al., 2010). Across Taiwan, which has had intensive national food waste programs for a decade, a capture rate of 9.6% of food waste from MSW was reported for 2010 (Chang et al., 2013). In Thailand a trial scheme in four urban communities with a variety of housing types, using four different approaches consecutively over 20 weeks, produced a capture rate of 58%, but no longer-term results were reported (Boonrod et al., 2015). In Sweden, information and door-stepping campaigns reported food capture rates of 27% and 28% respectively after 18 months in 680 urban apartment households with 8.9% contamination levels (Bernstad et al., 2013) and another study reported 20–26% capture rates with 2–8% contamination levels. The most successful example published seems to be the town of Umea where 55,000 households in single and apartment dwellings have had high and stable capture rates, published as 27% in 2010 (www.umeva.se).

There are many studies of different recycling schemes and tens of parameters which might provide the key to planning further successful schemes. The approaches vary depending on the discipline: in waste management the operations are the focus, with emphasis on factors such as facilities provided, frequency of collection (Williams and Cole, 2013), and extent of stakeholder involvement (Zhuang et al., 2008) and information provision (Read, 1999). In behaviour change literature with a psychology basis there is emphasis on psychological factors such as attitude (Refsgaard and Magnussen, 2009; Schultz and Oskamp, 1996) and beliefs, social norms (Abrahamse and Steg, 2013; Thomas and Sharp, 2013) and self-efficacy (Tang et al., 2010). In public policy there is consideration of legislation and enforcement (Chao, 2008; Huang et al., 2014), especially based on rational actor theory (Vatn, 2005). As repeated recently in integrative reviews of pro-environmental behaviour, new types of studies are needed which systematically evaluate the effects of interventions, preferably including monitoring of changes in behavioural determinants (Steg and Vlek, 2009). Many studies exist which show that a particular program *was* successful (Bernstad et al., 2013): very few provide evidence as to *why* it was successful (Abrahamse et al., 2005), although one recent study did that using a 'theoretical domains' framework approach (Dai et al., 2015). Outside of academia many planners and change agents are not making use of those approaches for planning purposes but following their own instincts, biases and pragmatics because the academics have not yet proven a reliable and operational approach to analysing and predicting success of such behaviour change programs.

Set against this background, the research reported here was designed to study, as observers, a successful food waste recycling programme in a contained residential community in Shanghai, designated Community #12, using a mixed-methods approach. Over 5000 communities in Shanghai have been involved in pilot food waste sorting programs implemented by the district governments which focussed on information delivery to residents as their main strategy, with negligible success (Dai et al., 2016). The delivery of this food waste sorting programme was led by a non-governmental organisation (NGO) which at that point had already shown its approach to be successful in two other communities, albeit self-identified as 'green'. The NGO did not use any particular framework of concepts or design approach other than to try to make the program implementation 'more personal' to residents (their own words). In the next tranche the NGO was allocated two communities to work with deemed 'ordinary' by the commissioning government body (their words: no demographic data are commonly available). Our research team was aware of the unhelpful diversity of academic concepts about such behaviour change, and thus set out to elicit perceptions from the main stakeholders in a grounded way, rather than work from more restrictive frames from academia which were not being used in practice. The main objective of our methodology: to explore local perceptions of *why* the program was successful – accepting that different points of view and approaches would see things differently and partially.

2. Background

Shanghai is a metropolis built of 24,500 communities composed of several walled and informally gated apartment buildings with communal gardens, parking areas and waste stations, and dedicated cleaners of communal areas. No formal classification system exists for Chinese urban communities, but apartment blocks range from six floors high and no elevators for those classified as 'older' ones by government officers, to those termed 'newer' with 30–50 floors and elevator provision. Community #12 is very typical of the 'older' type, with six-floor buildings without elevators, and 2 communal waste stations on campus. Residents typically placed household waste into small bags in their apartments and brought them down to the communal bins when en route elsewhere. Prior to the new program the residents brought down mixed waste in one bag. Valuable recyclables such as plastic bottles were typically not included as they were sold directly by residents to passing informal collectors who regularly visited.

The food waste sorting programme led by the NGO had one guiding principle: in their words, "to make 'more personal'" the policy implementation to residents. It involved pre-launch questionnaires delivered and picked up by block leaders which included questions asking residents if they would like to be visited to be given more information, if their household was willing to participate in food waste sorting, and for phone numbers of those interested in becoming volunteers for the program. The lowest branch of the government is the Community Committee, whose activities are based in such communities, and the NGO liaised with this and the higher tier government branch which commissioned the work (known as the Street/Ward Committee), as well as the Housing Association which was responsible for the management of the community estate and facilities, and hiring and supervision of the cleaners of the communal areas. Prior to the program launch the NGO held several meetings to facilitate these institutions to self-clarify their roles for the new activity of food waste separation into separate communal bins. They also held an 'Open Space' meeting for all stakeholder types including residents and volunteers to co-establish common visions and identify potential problems and solutions. A small number were taken to visit the local incinerator which has to add fossil fuels to the waste to burn it as it is so wet from the food waste. Volunteers were recruited, and trained over 3 sessions by the NGO, who also set up schedules for their shifts: to stand in pairs in the vicinity of the waste stations wearing bright tabards every morning 7–9 am and every evening 6–8 pm to encourage, demonstrate, and inform residents in a positive and friendly way about the waste separation. These shifts continued for three consecutive months – an innovation not previously seen by the researchers.

The waste stations where communal bins were sited were refurbished to look "fresh" in the words of the NGO, which involved a deep clean, and new doors and signage. New bins of a new colour were provided for the food waste to be collected, and placed beside the existing bin for residential waste. Sinks were installed so that residents could wash their hands after dealing with the waste. At the launch event, tables were set out in the gardens to pass out kitchen caddies to the residents as they passed by, where they were also given information and mini-demonstrations of how to separate their waste in the kitchen.

3. Methods

In order to determine *if* the NGO's program had been successful, direct measurements were made of the weights and basic composition of the residual waste bins and the food waste bins. Standard quantitative waste management methods reported below involving weighing and inspection of the composition of the waste. This distinguishes the work from self-reported studies, whose relationship to actual behaviour change is not straightforward and seldom directly comparable (Williams and Kelly, 2003). As anticipated, the results from the NGO's program showed outstanding results at an internationally leading standard, justifying the next part of the study: *why* was the program successful? What factors were key to the results? We note that the focus in this work is at the interface between the residents, whose behaviour was targeted, and their immediate 'contextual environment' produced by the efforts of the various other agents. It does not focus on other interfaces such as between policy makers and executors, or between different levels of government.

Our methodology to allow us to explore *why* the program was successful was designed to take into account the points of view of the main stakeholders, who were expected to view it from different perspectives. In this case they comprised the local Community Committee, the NGO, and the residents themselves. We proceeded using the qualitative methods described in 3.2 below. A diary of all related events taking place in the community was also maintained to ensure that no confounding activities took place.

3.1. Quantitative measures of behaviour change: food waste capture rates

Direct measures were made of the weights of the household waste disposed of by all of the residents in the community (N = 432 households), i.e. for both the separated food waste destined for recovery processes, and the 'residual' waste in adjacent bins. These direct measurements were carried out 4, 10, 20 and 54 weeks after the launch of the recycling program, to determine the immediate effect, the effect after three months when reversion to past habits is expected, and then further measurements as resources allowed, which could document the long-term effect. In each case the measurements were carried out over three consecutive days, mid-week. This choice resulted from preliminary studies, where it was found that mid-week avoided potentially significant fluctuations due to weekend variations in behaviour, and three days was found to be sufficient to even out small fluctuations such as householders holding back their waste more than one day because of cold or rainy weather. Although these principles might suggest data collection over four days would be better, each measurement already required multiple researchers to man three waste stations for 16 h a day for three days in shifts, and resources for a fourth day were not available. Such continuous (but discreet) observation of the waste stations was necessary because the site 'cleaner' would circulate around the site to empty the bins into his tricycle carrier, and although he generally did this at set times it was decided that the integrity of the data needed to be protected in this way. Each and every bin from the three waste stations were thus weighed before the waste was removed from the site, for three days.

There are many different indicators of waste that can be measured and calculated in studies of recycling and source separation (Dahlen and Lagerkvist, 2008). In this study the only component, or category, of the waste of interest was household food waste: the extent to which it was sorted by residents out of the general residual waste, and into the special bin for food waste. A suitable indicator for this is the Capture Rate, FW_{CR}, defined as "the quantity of target material 'captured' divided by the total quantity of that type of material present" (WRAP, 2010). The same quantity is denoted 'Source Sorting Ratio', defined as "total collected source sorted materials/(total of collected sorted and unsorted waste materials) − % by weight" (Dahlen and Lagerkvist, 2008). This indicator requires that any contamination in the food waste bins be measured and properly accounted for, and that a composition analysis is made of the residual waste, to determine how much of it is non-diverted food waste. The 'Food Waste Capture Rate', FW_{CR}, can then be calculated:

$$\begin{aligned} FW_{CR} &= FW_{(\text{in recycling bins})} * 100\% \Big/ \text{total FW in all waste on site} \\ &= FW_{(\text{in recycling bins})} \Big/ \Big(FW_{(\text{in recycling bins})} + \%FW_{(\text{in RW sample})} \\ &\quad * (\text{Total RW}) \Big) \end{aligned}$$

where FW denotes food waste (with any contamination removed), and RW denotes residual waste.

The presence of contamination in the Food Waste can pose several problems for measures and reporting when it is significant. Not only would the weight of it need to be removed from the directly measured weight, but heavily contaminated food waste could be barred from processing upstream into recovered products such as biogas or compost, thus bringing into question the validity of considering it as sorted waste at all. However, in the preparatory pre-study for this work it was noted that contamination was very small indeed in programs run by the NGO: typically <1%. Thus, although measures of the contamination rates were planned as a regular part of the compositional analysis, it was not anticipated to be significant. Because of this, we also planned a spot check on a very large sample of food waste in order to collect enough contamination for a reasonable measure.

Suggested sample sizes for composition analyses vary in the literature, and there is no universal standard (Dahlen and Lagerkvist, 2008). To achieve a standard error of 2.5%, 5% of the population should be covered in the sample (Nordtest, 1995). Although (Maystre and Viret, 1995) recommended 300 kg as the minimum sample size based on their case studies in Switzerland using 47 categories, (Sfeir et al., 1999) discussed the problem of large numbers of categories commonly used in composition analyses, and indicated that the sampling size could contribute to bias if too many categories were used. While 200 kg was recommended as the minimum for commercial waste, 91 kg has been justified to be an appropriate sample size for measurement, if the number of categories is small ($n \leqq 10$) (Klee and Carruth, 1970; Sfeir et al., 1999; Sharma and McBean, 2007; G et al., 1993). In our case only two categories of waste − food waste and non-food waste − were investigated, so a sample size of 91 kg was deemed sufficient.

Furthermore, daily waste generation in Shanghai is approximately 0.8 kg/household based on our preliminary studies, so 91 kg would cover more than 26% of population in this community, which also meets the suggested threshold of 5% (Nordtest, 1995). Every day,

for three days, a sample of at least 91 kg was collected randomly from a different one of the three waste stations of our site.

No food waste was being sorted prior to this program. Permission was granted by the Community Committee for the data collection, but residents were not aware that weight and composition data were being taken. The on-site cleaners were fully informed and cooperative.

3.2. Qualitative data collection: perceptions of the source of success from stakeholders

Residents' interviews were conducted 22 weeks post-program, which is the point when it was established that the effect was more than short-lived. The NGO and CC key informant interviews took place 34 weeks and 36 weeks post-program respectively.

The NGO, as designers and leaders of the recycling program, might be expected to 'know best' which elements were most key. Certainly their general description of it being 'more personal' is what was reported back to policy makers who reviewed results from earlier pilots (Dai et al., 2016) Our approach does not, a priori, give precedence as to whose opinion should be the reference for the source of the success, so it was appropriate that opinions be collected from all of the main stakeholders. For this, the standard qualitative method of in-depth, open semi-structured interviewing (Babbie, 2010) was carried out of key informants, each lasting 2 h or more. Interviews were used rather than focus groups because the decisions and plans made were mostly led by only a few people, and eliciting information from a group might obscure the knowledge that was driving the activities. Surveys were not used for that reason also, and because they would not give the richness of detail needed. The key informant for the NGO was identified as the NGO officer responsible for the program in that community, who designed all the events and liaised with participants. The key informant for the Community Committee was identified as the relevant officer, who held the most power with respect to this project and had the authority to mobilize (or hinder) human resources within the community and informally approve events taking place in the community.

These interviews were carried out in quiet and private spaces to allow the respondents to feel uninhibited by others to give their responses, and informed consent was obtained. As direct questioning was not viewed by the researchers as typical nor appropriate in such circumstances in Shanghai communities at this time, warm up questions about the role of the different parties and how they worked together were first broached, followed by the main questions of, "Why do you think the program was successful?". The respondents were then encouraged to expand on their replies, but researchers were conscious not to draw them away from their own point of view or use of language. They were not, for example, asked to comment in terms of academic vocabulary such as social norms or demographics, but might themselves mention that "everyone eventually thought it was normal" or "the older people did better".

The interviews were recorded and transcribed, and then thematically open-coded following deep reading – all in the native Mandarin – and then analysed by bilingual native Chinese researchers.

Further data was collected from residents, who were also interviewed to explore their perceptions of the source of the success of the program. They were chosen randomly via random selection of apartment numbers, and a regular community block leader accompanied the researcher to that apartment to introduce them to the resident and ask for their cooperation. (It is standard practice in the communities for such introductions – residents will not normally talk to strangers – and the block leaders would move on to another task immediately afterwards, i.e. not remain in the area.) As the purpose of interviewing them was to obtain maximum variation of their perceptions about success, the number achieved in one session was deemed sufficient (expected to be n = 12–20 with the interviews expected to last 20–40 min each).

The following qualitative data sets were obtained:

- A transcript from a 2 h interview with a key informant of the community committee.
- A transcript from a 2 h interview with a key informant of the NGO.
- 18 transcripts of interviews with residents lasting 20–40 min each.

The full transcripts are attached in Appendix A.

4. Results and findings

4.1. Quantitative data: food waste capture rates

Of the food waste present in the community, 70% was found to have been correctly source segregated in the first measurement, taken 4 weeks after the launch (Fig. 1). This figure fell slowly to 63% and 59% in weeks 10 and 20, i.e. maintaining similar rates almost 6 months later. Over one year later, in week 54, the capture rate was still 45%. We do not know of any comparable results worldwide.

Contamination was rarely seen in the food waste: typically less than 0.1 kg in the daily samples checked of 50–60 kg. To get a more accurate figure we made a one-off spot check of the whole of one day's food waste and found the contamination to be 0.42 kg in 113.83 kg of food waste, i.e. 0.4% contamination. We thus report that contamination levels remained at <1% throughout, and for this reason the Food Waste weights were not adjusted for it.

4.2. Findings from community committee

The following three themes concerning the reasons for the success of the food waste source separation program were obtained from the analysis of the interview information provided by the key informant of the Community Committee:

4.2.1. Overcoming difficulties due to complex stakeholders' relationships

There are several different stakeholders involved, which work together but in different ways and involving different sub-group combinations. The relationships and task overlaps between these stakeholders are not clearly defined even in normal circumstances, and this situation became accentuated when the new requirement to initiate a food waste sorting practice was brought in by the Street

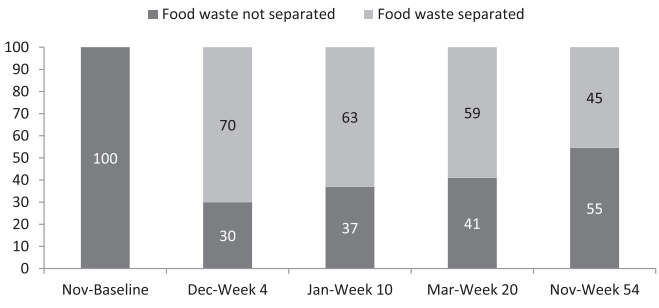

Fig. 1. Food waste capture rates from Community #12 over 54 weeks (%).

Government. None of the tasks required to achieve it were already within any stakeholder's current remit, and in fact there was no specific indication as to which set of tasks should or could be used. In short, none of the stakeholders were clear what the roles and tasks of each were or could be. Because of this, several problems arose which were of unexpected nature, and there were no natural fora in which they could be resolved. For example, the site cleaner was hired and managed by the housing association (HA), which was not itself based on site: the cleaner interacted much more with Community Committee members and residents but they had no authority to direct him. The CC believed that their role was limited to the usual publicity and direct communication with their residents, as per any other public policy: they expected 'other' stakeholders, for example the NGO, to execute the implementation of this new, unestablished program, and for the residents to fully and immediately take on board their responsibilities to sort and then de-bag food waste into the communal bins.

The CC felt that all activities which helped sort out these complications were very important to the success of the program.

4.2.2. The NGO brought in new ideas to promote the recycling project

The CC implied that previous recycling programs didn't work due to 'insufficient publicity', but that the NGO brought new approaches which were more similar to 'education' of residents. Residents were informed *why* source separation was needed, and that "unsorted waste required more energy than if it were composted"(sic). They took (a small number) of residents to visit the incinerator, and had small one-off activities like children's 'recycling games'.

The NGO had an approach to recruit new volunteers to the usual community cadre: at the end of a questionnaire survey to each household, residents were asked if they were willing to be contacted about becoming a volunteer. Only a few came forward, but the idea was new and it brought in some fresh members. To involve volunteers from both inside the community and outside it (from the NGO and local colleges) was also a new idea from NGO.

4.2.3. Importance of volunteers standing at bins – respect/acknowledgement

The CC said that having volunteer shifts of standing by the bins for two hours, morning and evening, every day for two months was a very important intervention element and also a strong motivation for other residents to recycle, because residents were greatly moved on seeing these volunteers, for example standing in the cold outside in the early morning and late evening.

4.2.4. Relationships in the community

The CC mentioned that older residents performed better at the waste sorting. They thought that this was because they spend more time inside the community, and since the CC's duties are centred on helping residents with living affairs, so they tend to be in direct and frequent contact with the older people and have a good relationship with them. Elders believe the CC will do the "good things" or "right things" for the community; that they trust them and rely on the CC a lot. The elders are seen to be often the first to cooperate with the CC when requested.

The recycling program created more opportunities for residents to communicate with each other. For example, the block leaders knocked on doors initially, to inform residents about the new project and to persuade residents to join the volunteer group. Volunteers gathered together to be trained, and stood by bins to assist or educate residents. But when asked, the CC stated that there was no obvious change in the sense of community, nor in the relationships between the CC, housing association and residents.

In summary, the data shows four main points of view of the CC were:

- Overlaps of responsibilities, and relationships, between stakeholders are complex, which causes many difficulties, and meetings to sort these out were important.
- The NGO brought in several new ideas and approaches, e.g. educational publicity.
- The volunteers were an important part of the intervention due to a kind of respect for their efforts from the residents.
- The older residents performed better than others, perceived to be due to a stronger relationship with the CC.

4.3. Findings from NGO interviews

Consistent with the other stakeholder interviews, the NGO was asked to discuss why they thought this program had been successful – sidestepping their general pre-conception that making it 'more personal' was key. Based on our analysis of the transcripts of the interviews three main themes were found:

4.3.1. The NGO is "the glue that binds the project together" – stakeholder facilitation

The way that the NGO was able to slowly bring key stakeholders together and forge good working partnerships was very important, as this was not likely to have happened under normal circumstances because of lack of clarity about roles, and lack of precedent for recycling:

> "*The government doesn't express a very strong will to do recycling, and does not put strong pressure on subordinate units. If the government were to set up a systematic and political mechanism for a recycling program, such as mutual monitoring system, it will be more useful and helpful.*"

This was identified as the greatest overall difficulty. The NGO set up an 'Open Space' meeting for all stakeholders to generally develop their shared awareness of what was needed in order for the program to work. However, from the start the relative roles of the NGO with the Community Committee and the District Committee were not well defined, or indeed able to be well defined, as it was not clear what the relative formal responsibilities were for different partners. In this particular community, the CC was deemed passive, not particularly cooperative, and the cause of delays. The NGO felt they ended up doing much of the leg work behind the tasks that nominally were 'owned' by the Community Committee:

> "*CC doesn't really want to engage with NGO and the waste sorting program. So NGO did lots of work instead of the CC, such as designing the information for blackboard and posters.*"

The NGO had to find a variety of ways to assist the program within and around the pieces of activities that were developed by other stakeholders: to support other contributions. They were very conscious of the need to troubleshoot early on, and then on a regular basis:

> "*We visited once every week before the launch, and made 3–4 visits every week after the launch.*"

4.3.2. Importance of the volunteers

Of all the activities planned in the community which directly impacted on the residents, the NGO stated that the most important was the volunteer duty of standing at the bins each day:

"*Some residents are touched by the old volunteers standing by the bins, regardless of bad weather, hardness and dirtiness. So they become motivated to join in the program. There are still some residents who are very headstrong and ignore the hard work of volunteers: the volunteers have less impact on those residents*."

Because of the major impact of the volunteers, their training and scheduling was deemed very important by the NGO, not only in knowledge of the details of the program itself but in how to be positive, and to nurture understanding that it is a long term transition:

"*Teach them what volunteering is and the volunteer spirit … communicate with them, get feedback from them, and answer their questions. They accept the idea of recycling, and also believe that it will not be easy; maybe it will take 2–3 years for the residents to form the habit of recycling*."

4.3.3. Relationships with the community committee

The NGO commented that they saw two kinds of residents:

"*… one can be touched and change behaviour. But the others are really headstrong and feel no shame (embarrassment) when they do not (publicly) sort*."

The younger residents were also thought not to recycle as much because they are less aware about the need for it. However, some of them had some overseas experience and did a good job.

The NGO noticed that residents' participation also seemed to depend on the relationship with the Community Committee and sense of community:

"*… the young people are busy with work and have less need of and connection with the CC, so they don't pay much attention to the community affairs …*"

Furthermore, the publicity and awareness-raising events often occurred when the young people were at work, so the NGO felt that in future there was a need to design some targeted events for them.

In summary, the interview data shows three headline points of view of the NGO:

- The NGO played an important role of being "the glue that binds the project together", rather than by doing huge amounts of the work themselves.
- Committed volunteers with good volunteering spirit were crucial to the project's success
- Relationships between the residents and the CC or the NGO were important to success but for groups like younger people new types of relationship building was needed.

4.4. Findings from residents' interviews

The residents' interview questions were covered within a larger interview schedule designed for several research questions. The relevant two questions were: Q1: Why do you do waste sorting? And, Q2: What do you think is necessary to be for a community to be successful in recycling?

A total of 18 residents were interviewed, of which 15 answered one or both of these questions. They are discussed in more detail below, and the full transcripts are given in Appendix A.

Seven of the respondents commented that *"we residents were required to do sorting, (implying … therefore we do it)"*. The Community Committee is the branch of governmental organization inside the community, which is responsible for many administrative jobs at this most local level. The implication from the wording used is that those residents believe that the government knows how to take good care of those things and it follows that residents have a natural duty to comply. In fact most of those interviewed expressed the view that waste sorting would not occur without the appropriate actions of the residents: seven said that it was therefore their responsibility to cooperate properly with all the other stakeholders that were trying to educate, guide and assist them. The expressions *"self-reliance"* and *"integrity"* were used, implying that residents should be self-motivating and not need external pressure to act.

Ten residents mentioned publicity as an important factor. The words used implied not only knowledge about the program but a clear embedded message that the leadership of the CC had a strong intention to deliver this particular program, and to take it very seriously. A contextual point to note is that policies are sometimes introduced which are not taken seriously, and then allowed to 'die off'. Thus, this indication of 'seriousness' is what some residents said spurred them to make an effort. Four respondents provided publicity slogans as reasons that they thought the program was important: *"good for the environment"* and *"good for ourselves"* (e.g. health), but when asked for more details they were unable to give any. Thus, publicity rather than an understanding of the environmental consequences was seen to be the key element there.

Two respondents mentioned that those who do not sort would feel peer pressure because there are volunteers and CC members standing by the bins to *"watch residents"* – a weak but slightly negative emotion which was implied to cause motivation. In fact, the volunteers were standing there to play a role of communicator to express knowledge about sorting, and as an assistant to help them with skills of separating out the waste. Three other respondents mentioned that they were touched by the long-term efforts of the volunteers and thus motivated to participate and to continue over time – strong and slightly positive emotion. One respondent indicated that the leaders of CC should participate actively and set up a good example to the whole community, which would have more influence than other residents, and help to build a community norm. This sense of action leadership emanating from the CC as a whole or from its individual members was a nuance attached to several statements. A different but similarly impactful nuance was affiliated with comments about the volunteers: "the interactions with the volunteers"; "communications with the volunteers" which spoke to the personal interactions they provided.

In summary, the data shows three headline points of view of the residents:

- The residents tend to comply with the CC.
- If the CC is seen to be 'serious', with a firm message, residents will be clear that their own role in the recycling project is to definitely implement separation of waste.
- Volunteers can improve recycling results because of personal interactions over time.

4.5. Findings across the three points of views

Looking across all of the data, we get the three sets of views from the above interview data, as summarised in Table 1 below:

Table 1
Elements of the waste sorting program which were considered key, by different stakeholders.

Stake- holder	Elements key to success of the waste sorting program
Community committee	1 Overlaps of responsibilities, and relationships, between stakeholders are complex, which causes many difficulties, and meetings to sort these out were important.
	2 The NGO brought in several new ideas and approaches, e.g. educational publicity.
	3 The volunteers were an important part of the intervention due to a kind of respect for their efforts from the residents.
	4 The older residents performed better than others, perceived to be due to a stronger relationship with the CC.
NGO	5 The NGO played an important role of being "the glue that binds the project together", rather than by doing huge amounts of the work themselves.
	6 Committed volunteers with good volunteering spirit were crucial to the project's success.
	7 Relationships between the residents and the CC or the NGO were important to success but for groups like younger people new types of relationship building was needed.
Residents	8 The residents tend to comply with the CC.
	9 If the CC is seen to be 'serious', with a firm message, residents will be clear that their own role in the recycling project is to definitely implement separation of waste.
	10 Volunteers can improve recycling results because of personal interactions over time.

5. Discussion

The NGO and local government did not have specific pre-definitions of success, but when pressed by the researchers indicated that capture rates of over 10% with less than 30% contamination would be considered 'successful', and capture rates over 20% and with contamination levels of less than 10% 'very successful'. The data on the tonnages of waste and composition, leading to capture rate calculations, indicate that the program was successful in its mission to divert significant amounts of food waste from the residual waste stream. There is no set definition of a 'successful' food waste sorting program (Dahlen, 2005), but from the literature cited in the introduction, it seems that capture rates above 10% for MSW figures across regions or nations, and capture rates above 20% for communities around a year later from launch are presented as successful, and rates of 30% or more as very successful – with the caveat that the contamination levels must be low enough for the upstream processing to remain effective. Where reported in the examples above, it was below 10%. Against this benchmark, and against the expectations of the stakeholders involved, the program studied in this report can be said to be very successful, with capture rates at 70%, 63%, 59% and 45% in weeks 4, 10, 20 and 54 respectively, and contamination levels of <1%. The low contamination level is consistent in those reported in a 'snapshot' study across n = 32 communities which used similar approaches led by the NGO, which typically had <1% levels and averaged at <5% across all 32 – most of which had more than one year elapse since the intervention (Dai et al., 2016).

The interview data in this study provide some new insights on possible key elements for a successful food waste sorting program, as well as touching on some others already known in the literature. Importantly, the data relates elements to each other against an interconnected background of tensions between roles, responsibilities, voluntary duty and relationships.

The sorting of residential food waste is often a new task in communities like this one, i.e. not already established or specified as a responsibility in contracts or job descriptions of any of the stakeholders. This situation tends to be repeated in communities around the world, including for sorting of 'dry recyclables' like plastics and cans. To achieve success, many actors must be involved, yet none has complete authority over the others: a new ecology of relationships needs to be developed. When a new recycling or waste sorting policy arrives, it is generally unclear what the boundaries are to the responsibilities of each stakeholder, especially since so many factors can vary before equilibrium is reached. For example, if insufficient tonnages are diverted, then collection may not be viable: if contamination is too high then health issues or production problems downstream may force the materials to be diverted elsewhere – at one stroke potentially causing large scale changes in plans.

Our findings show that clarifying roles and responsibilities was key at several levels. Table 1 shows both the NGO and the CC referred to the difficulties of the existing stakeholders to negotiate where elements of the policy implementation would fit within and between their existing boundaries: it was very helpful to have an eternal party like the NGO to anticipate these difficulties and to arrange appropriate workshops or meetings to provide 'space' for the exploration of complimentary accommodations. Involvement of NGOs or CBOs (community-based organisations) has been correlated with better performance (Suttibak and Nitivattananon, 2008) but the reasons have not been identified but rather postulated as being due to having better networks of local leaders, or experience with strategic decision making (Folz and Hazlett, 1991). Our data suggests that the ability of the NGO to broker new relationships was key, even though they did not have prior contact with the community. Studies have repeatedly confirmed the early findings of (Noehammer and Byer, 1997) that "there is no single ideal residential curbside recycling programme design", and who maintained that the variety of combinations of options will need to be tailored to the preferences and context of local communities. It seems that in this case the NGO was able to achieve this contextualisation not by being indigenous itself but by being experienced in facilitating local stakeholders to negotiate together.

Furthermore, the specialist knowledge of the NGO in knowing effective ways to engage with residents on issues of waste sorting, and to make effective use of volunteers and appropriate publicity, was seen to be useful in our study. Such qualities have been noted as "of premier importance" in other work (Folz and Hazlett, 1991). The impressive results of the NGO-led program both in the short-term with initial capture rates of 70%, and in the longer-term with capture rates of 45% over one year later, support such studies which suggest NGOs can be effective, and appear to contradict the findings presented by others that such groups are probably only effective, and slightly, in longer term, "slow-burn" projects (Lyndhurst, 2007).

Where roles were clearly defined, the residents showed that they were content to fall in with the requests of the CC, which represented the local government body to them, to sort their waste. However, point 9 in Table 1 indicates that an important moderator was the 'seriousness' of the message: the CC had to pass on government messages sometimes that even it did not take seriously. Residents seemed to only act once they had indications of clear intention, in which case they reverted to a simple sense of civic duty. This is an interesting complimentary finding to previous research on the moderating influence of the 'messenger' which suggest the authority of the messenger is key (Dolan et al., 2010).

Where more formal roles and affiliated responsibilities were not clear it seemed that relationships were key to engagement. Points 4 and 7 in Table 1 indicate how the relationships of different community members appeared to influence their involvements: those with a stronger relationship to their CC were perceived to perform better. This aspect does not seem to be mentioned much in research on recycling, except with respect to civic duty, as above. A possibly related concept is sense of community, which has been mooted in the literature (e.g. Chatterton, 2011), but not specifically studied or linked to success of recycling or waste programs.

The factor that was mentioned the most across all the stakeholders was the influence of the volunteers. Volunteers and local action via CBOs have been mentioned previously (e.g. Folz and Hazlett, 1991; Suttibak and Nitivattananon, 2008) with postulates that their social networks might underlie the positive effect they have. However, in the recently reported successful Thailand pilots, the three elements of program establishment, education and encouragement were considered vital for success (Boonrod et al., 2015), and all of those were conveyed through the volunteers in our study. Interestingly, the NGO articulated their intention as to nurture "volunteer spirit", which the residents commented on as a "motivating effect". The personal interactions of the volunteers standing at the bins were mentioned rather than information transmission, enforcement or shaming. In particular, the volunteers were perceived by some to be encouraging, at a personal level, and the characteristic of "personal encouragement" has previously been reported as increasing recycling behaviour (Spaccarelli et al., 1989). This finding is interesting in light of a meta-analysis study (Abrahamse and Steg, 2013) which analysed results from a large range of pro-environmental behaviour change studies and concluded that those with social interactions performed better. It would be interesting if similar studies could be undertaken to consider personal interactions as a subset. For pragmatic purposes of replacing volunteers with alternative intervention elements which are less expensive and reliant on specialist training, studies could be conducted similar to that of Lin et al. (unpublished) who found that using brightly coloured covers with sunflowers on the recycling bins could produce equivalent food waste capture rates, at least in the short term. Studies which can implicate causal determinants would help bridge the theory and practice.

It is interesting that an innovation of the NGO's program studied here was that the volunteers carried out their shifts each day for an extended period: three months. Several comments in the data referred to the time needed for establishing such a new habit, and the effectiveness of the volunteers in that habit formation. This aspect deserves further study.

6. Conclusion

Large scale, successful residential food waste sorting programs are rare, and long-lived ones even more so. The program in this study was deemed as successful: it delivered food waste capture rates of 70% at the start, falling slowly to 45% one year late, for a community of 432 households. In this exploratory study the key stakeholders in a successful waste sorting program were interviewed for their perceptions of the key elements for success, and they were found to focus around clarification of roles and responsibilities, and the usefulness of a 'broker' (in this case an NGO) to co-develop new boundaries for stakeholder responsibilities. Residents who acknowledged their responsibility to sort their waste viewed it as civic duty, but first needed to be convinced of the serious intention of the local government to implement the policy. Residents with good relationships with the local government – e.g. due to greater ongoing interactions – were perceived to perform better. The use of volunteers to demonstrate and interact on a personal level with residents was seen as a key element. The three month period of volunteer involvement was seen as key to good habit forming.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.jclepro.2015.12.107.

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