

Urban Waste Management And The Mobile Challenge

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ABSTRACT

Digital evolution and mobile developments are carving a new era that affects human behaviour and global governance. Interconnectivity and flow of information through various types of modern means create new opportunities for cooperation and ways to work. Waste management could not stay unaffected by these changes. New potentials are arising for the sector, offering a novel field for innovation, changing the way waste practices are applied. In this framework, mobile products and apps can become valuable tools for authorities, companies, civilians and other stakeholders, integrating these technologies in the battle for environmental protection, recycling, etc.

This paper examines the unexplored challenges of mobile apps to deliver sustainable waste management with emphasis to recycling and waste prevention performance especially for emerging developing countries. It presents the opportunities that are involved in using mobile apps to improve both the systemic performance of a specific waste management system and the individual behaviour of the users.

Furthermore, the paper reviews the most important relevant literature and summarizes the key- findings of the recent research on mobile apps and human behaviour. Useful conclusions are drawn for both the content and the format of the mobile apps required for recycling and waste prevention. Finally, the paper presents the most characteristic mobile apps that are already in place in the waste management sector.

INTRODUCTION

Until recently, waste management was faced as a matter of appropriate storage, collection, transfer, treatment and disposal, and the main effort was to minimize environmental and health impacts. Thus, engineering and logistic tools were sufficient to plan and implement waste management systems. But today resource management and social behaviour are becoming an integral part of any waste management system. They are essential to address increasing recycling rates and better quality of recyclables, participation of industrial stakeholders, eco-design initiatives and closed loops of products and materials. Resource scarcity, the climate change challenge and the emerging recycling industry are the main global drivers that push to more and better organized recycling programs. Although during the recent financial meltdown recycling business faced major problems (Mavropoulos 2009), the long term perspectives of the industry have not changed and substantial growth is still expected. Especially in Europe, the recently adopted Waste Framework Directive (2008/98/EC) is expected to further stimulate the already expanded recycling activities because a. it clarifies the definition of recycling and reuse b. it commits Member States to higher recycling targets and c. it pushes to source separation of organic fraction of waste, as well.

Although recycling is already a main stream trend in EU and a wide-spread pro-recycling attitude has been repeatedly reported (Lyons et al., 2002), it has been proved (Woolam et al. 2003; Williams & Kelly 2003) that there is a gap between people's preference and public support for recycling activities and the actual participation of individuals during daily home routine. The relative inefficiency of recycling campaigns and their short - time dependent results is another indication for that gap.

Pervasive sensing and human behaviour understanding can help us in implementing or improving systems that can include behavioural change. In this sense a recycling system can provide more appropriate services to people only if it can address users' attitudes, daily habits, their routines and life-styles, etc. (Salah et al. 2011) At the same time, it is important to utilize persuasive technologies that would steer the

user's behaviour towards a desired recycling behaviour. In this sense the recent developments in mobile technology and the advent of the smartphones and mobile applications seem to be one of the most promising methods/tools for delivering behavioural change interventions among different socio-economic groups.

It is characteristic that within the span of about 10 years, mobile technology has moved from being the technology for a privileged few, to essentially a mainstream technology. This was actually the result of the spread of mobile internet and the rapidly declining prices of mobile devices and products that have becoming through the years an affordable tool to fill in the digital gap between developed and developing countries.

By 2000, there was one mobile phone to less than two mainlines, and by 2003 mobile phone subscriptions had overtaken mainline subscriptions for the first time (Castells et al. 2004). In 2011 there were 6 billion mobile subscriptions (86% global mobile penetration), whereas 4.5 billion subscriptions were recorded from developing countries (ITU 2012).

The latest achievement is the realization of the so called "smart phones" and of 3G and 4G networks with new built-in functions and a plethora of mobile applications.

Smartphones which nowadays enumerate 1.08 billion devices worldwide (IDC 2012) allow for unobtrusive and cost-effective access to previously inaccessible sources of data related to daily social behaviour. Nowadays, these devices are able to sense different kind of behaviour related data such as i) location, ii) other devices in physical proximity, iii) communication data, iv) scheduled events v) the devices status (e.g. network coverage), vi) movement patterns, and vii) the user interaction with the mobile phone.

In the above framework, development of mobile applications has brought unimaginable opportunities to mobile users, who have engaged apps in their daily activities. Their number has grown significantly

during the last 3 years rising from around 300,000 in 2010 to 850,000 in 2011 and over 1,200,000 in 2012 (Five Star Equities 2012).

For the users of smart phones and tablets, green applications are already an important segment amongst the plethora of apps across all platforms. However, the waste management and recycling industry seems to have underestimated the mobile challenge and the overall number of waste management apps is extremely (D-Waste 2013).

MOBILES' SOCIAL FUNCTION

There are a number of social changes related to mobile revolution and the new mobile communication universe that have or might have substantial consequences for the sustainability perception and understanding.

It has been suggested (Manzini 2002) that there is a shift from a society that considers well-being in terms of accumulating products and the services they might provide towards a new social paradigm where well-being is increasingly perceived in terms of access to services, media and information available online. This shift results means that the quality of our life is increasingly conceived of in terms of "the quantity and quality of services and experiences which is possible to have access to", and this drives the emergence of the new idea of "freedom of access".

In that way, mobile phones are at the centre of any discussion regarding social and economic changes, something which is particularly true in developing countries. And this is due to mobile phones' social function which can be described as follows:

Projecting People's Life: Mobile phones are gradually becoming a mean of technological improvement that helps people to project their life in their surrounding environment. This kind of technology is supplementing, and even in some extreme cases "replacing" social lives of people. It mirrors activities, desires, anxieties, trends, habits, beliefs, moods, etc. Moreover it streams experiences outside each

person's small world, and projects them in the screen of a smart appliance, thus facilitating interventions in what is considered true, false and allowing the shaping of human desires and beliefs.

Enabling Devices: Mobile phones bring to people a sense of freedom and virtual mobility. They allow talking, seeing, sharing, searching, investigating, doing business, link to markets, no matter the distance, the place, or the time. Mobiles are following the owner like an extra "organ" of his body. As Manzini suggests, "smart phones (and e-tablets such as the iPad) need to be seen primarily as "enabling devices" (Manzini 2002) for accessing an increasing range of specific services.

B.J. Fogg has also stated (<http://www.youtube.com/watch?v=rW5kYiQ4m4I>) that a mobile device can influence our behaviour in the daily routines of our lives, differently than a computer or a keyboard. Mobile phones can be targeted to what we are doing at all time we are carrying them with us. When it comes to persuasion, timing matters a lot and mobile devices can do this in a much more efficient way than PCs, laptops or even tablets. A mobile phone, based on previous experiences of the user, or programmed functions, could tell us at the right time what to do, and be more successful in achieving behavioural change.

Providing Economic Solutions: In a world where economy plays an important role, where desire as well as demands for modern means of communication and services rise, mobile phones bring a fast, economic solution to people all over the world. The example of Africa and India, where mobile phones substitute the essential missing infrastructure of Internet and phone communication and, create new opportunities for many poor people to engage in small-scale mobile e-commerce and e-banking, (Dovi 2008, Ondiege 2010) is very representative of the potential involved in the new mobile universe.

Connecting People, Time and Space: Mobile phones have the unique characteristic of connecting spatial data with time, and information on thoughts, moods, activities, and status. This makes mobile phones get correlated with human behaviour, becoming a mirror of people's activities and attitude that can be studied and predicted in a large scale, providing data that can be grouped and used for planning reasons that suit

different human groups. These conclusions can be helpful for the waste industry as well, and especially for recycling, as it is mostly affected by human behaviour patterns.

For the first time ever, people are constantly carrying with them a digital device that is able to send information about their location and activity, through talking, typing and sharing. Already there have been documented formal applications and case studies that portrait the mobility of people according to hour, time and place. Also, through social media it was possible to connect mood, age and activity to the above (Ondiege 2010). The digital traces that people leave behind - voluntarily or not - while using communication devices, such as mobile phones, or interacting with social media platforms reflect their behaviour in great detail.

MOBILE APPS AND WASTE MANAGEMENT

As it has stated above waste management was faced as a matter of appropriate storage, collection, transfer, treatment and disposal, and the main effort was to minimize environmental and health impacts. Thus, engineering and logistic tools were sufficient to plan and implement waste management systems. But today resource management and social behaviour are becoming an integral part of any waste management system, increasing this way the need to develop mobile apps for the sector.

Mobile applications in the waste management sector are at an early stage with a great potential for development to be offered in the next years. It would be useful to categorize potential uses of mobile apps in waste management according to two different dimensions, the "stakeholders' view" and the "users' view". Such a categorization outlines both the different uses available for waste management apps and the benefits that might be realized.

The Stakeholders View

From the stakeholders' perspective (the term stakeholder includes authorities, companies, NGOs etc.), there are actually four main areas where mobile apps can be applied. These are interactive communication; m-services; m-democracy and m-administration.

Interactive Communication: In the waste management sector mobile devices can provide an important access channel for waste management authorities to citizens and establish an interactive communication between these two entities. Without relevant information citizens are unable to form intelligent opinions and actions regarding issues such as active participation on recycling, clean up or collection activities. With the contribution of mobile technology municipalities and citizens will be able to explore together new opportunities for waste reduction and recycling through user driven innovation.

Furthermore citizens will be able to receive information regarding prevention or recycling programs that have been established at their area and relative guidelines on how to participate in these programs. Information such as market prices for recyclable materials is essential especially for the informal sector.

SMS is also a channel for citizens to communicate with waste authorities in order to ask for information or to comment and complain about waste management services. Illegal activities may be reported from citizens to relevant authorities through relevant mobile applications or simple mobile text messages.

m-Services: SMS and other mobile devices not only provide a channel of communication between citizens and government, but also they enable government-to-citizen transactions and payments. In this sense mobiles might be utilized in the waste management sector for applications such as on demand waste collection services and payment transactions between citizen, private companies and the municipalities regarding waste collection and waste processing activities.

m-Democracy: Sustainable waste handling requires active involvement of people outside the narrow circles of professional waste management. In other words citizens can be included in the decision making process for issues that are directly related to them. In addition in many cases waste authorities are choosing to involve their publics in waste management decision making because this lead to more technically competent and defensible decisions that reduce the risks for government.

Use of SMS and mobile devices for citizen input to political decision-making is an important m-government application with tremendous potential to enhance democratic participation. Voting via mobile

phones, can be one way to involve citizens in decision making for issues such as site allocation of waste treatment facilities.

m-Administration: Another potential for wireless technology is that it may provide a seamless environment for waste authorities' employees to stay connected from any device. Up-to-date waste authorities to employee information and services can be provided at any time, whether the data they need is on the internet, on their network, or on a portable device under their control. This way mobile applications can provide opportunities to waste management authorities to evaluate their performance and improve their internal operation. Furthermore, an essential number of geodatabases will be created.

The Users View

According to the users' view, someone can identify three types of apps, the informational - educational, the interactive - participatory and the functional ones.

Informational/Educational: These are applications that include technical details, guidelines, sample calculations or even calculation tools. Informational/Educational apps aim at making information available at an extended network of mobile internet users. Usually information is static and there is a little interaction between citizens and waste management authorities. These applications will transform information from static to dynamic and enable real-time communication between interested parties.

Such applications can be related to:

- General information for citizens (e.g. guidelines on home - composting, waste prevention practices, regulations, terminology, etc)
- Specific information (e.g. market prices of recyclables, news, waste services or fee changes, schedules and routes of waste collection activities, etc)
- Emergency alerts (case where citizens shall keep waste at their homes due to strikes of employees in the waste management sector, severe weather phenomena, etc)
- Health and safety education (health and safety practices for both the formal and the informal sector,

etc)

- Educational programs
- Notifications (social media posts etc)

Interactive - participatory: These applications are designed to use bottom-up approaches and citizens' participation. Through interactive applications citizens can in real time send queries, problems, comments or service requests to waste management authorities. In addition citizens can access forms, applications and databases. Such applications concern:

- Creating "maps" about waste collection, street cleaning and litter of the city, recycling programs etc.
- Citizens' claims and reporting problems (e.g. illegal dumping, inadequate waste collection/cleaning services etc)
- Services under request (e.g. schedule collection of bulk waste etc)
- Real time citizen feedback and information inquiry services (e.g. payment transactions between citizens and waste management authorities)

Functional: These applications refer to tools that are designed to resolve specific waste management problems; for hands-on immediate solutions or estimations and they are mainly dedicated to professionals and decision-makers. Such application could be related to:

- Mass balance models
- Cost benefit analysis
- Sizing of waste treatment facilities
- Designing waste recycling/prevention programs
- Defining collection routes

Mobile Apps & Recycling

Recycling is a characteristic platform upon which patterns of human behaviour can be projected. This is happening because, in comparison to other forms of waste management, recycling requires the most of

human intervention. Since waste is not simply discharged in a bag, or a bin, “recyclers” have to carry out a series of “unconscious” thoughts and actions in order to perform the act.

The same stands in regards to management. Recycling has a more complicated chain of handling than common residual waste, where the main target is their disposal. More specifically, recycling performance relies heavily on the actions and interactions of several stakeholders. Finally, recycling is a practice that requires and demands the actions of a broad audience, from citizens of all ages, to practitioners and scientists.

Due to the multidimensional aspects of recycling activities, the strong relation to behavioural human patterns, and the high demand for communication and interactions, mobile technologies can find significant application to this field.

The potential central role of mobile applications in a recycling system is better illustrated in Figure 1. Mobile applications are major elements of a recycling system since they can be utilized to deliver successful recycling campaigns, to improve the recycling services and infrastructure and to influence individual behaviour towards a recycling attitude. Even more they can be utilized to connect all the elements of a waste management and recycling system.

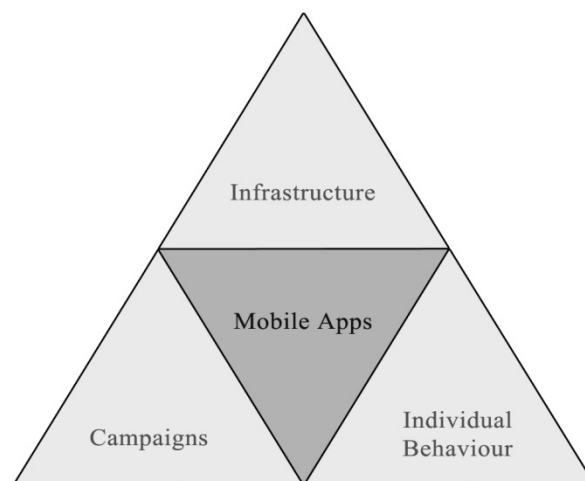


Figure 1. The role of mobile apps in a recycling system

Mobile phones can act as devices that connect different stakeholders. Through them, a municipal authority can spread information about its new campaign, introduce mobile applications that can help workers in the recycling sector acquire significant information and get organized. Residents from their side can find information on how to recycle different streams, organize their recycling efforts in cooperation with the municipality, send texts, pictures, comments, complaints, share special information with formal recycling schemes, as well as scientists, regarding their recycling handling, habits, quantities etc. In addition, people can get influenced and change their recycling habits. Information about recycling is one of the aspects that citizens can benefit from the use of smart phones and applications. In that way, there is a huge room for the adoption of recycling habits that are facilitated through mobile apps that citizens can download easily to their smart phones. But recycling does not involve only common citizens; it also involves private companies, formal recycling workers, local authorities, decision makers, waste pickers and informal sector, as well as scientists that study and try to improve the recycling norms.

Mobile Apps & Urban Complexity

Finally, mobile devices and applications are the appropriate tools to deal with the urban complexity. Recycling, waste prevention and reuse programs are of high importance for the emerging metropolises since they improve self-reliance and relief waste management systems. However, those programs are directly linked with social behaviour and the emerging systemic performance is a result of thousands or millions daily interactions. Since mobile applications are major behaviour influence they can deal successfully with such complex systems.

Available Waste Management Applications

Some characteristic waste management apps are presented in Table 1. It is mentioned that this list is indicative and it has been created in order to outline the different potential uses of mobile apps for improving waste management. However, as it has been already mentioned, the overall number of waste management apps is extremely low and their use has just started.

Table 1. Examples of characteristic waste management and recycling applications

Application	Type	Description
Waste Atlas	<i>Informational/ Educational</i>	Waste Atlas is a crowdsourcing open source map that visualizes municipal solid waste management data across the world for comparison and benchmarking purposes. D-Waste Atlas is made with the contribution of scientists from different countries and the utilization of published data.
EPA iWARM	<i>Functional</i>	The app has been created by USA EPA and it helps the user to calculate the energy benefits from the recycling of different products. The user selects the type of recyclable materials (cans, bottles, magazines etc.) and the number of items recycled. Then the app returns the user the energy saved in kWh and in minutes or hours of operation of specific home appliances.
European Waste Catalogue	<i>Informational/ Educational</i>	European Waste Catalogue enables users in the European Union to categorize the waste types. This allows also the member states to report their waste statistics. The application's database based on the European Waste Catalogue which established by European Commission Decision 2000/532/EC and its amendments.
Hazardous Waste Chemical Compatibility	<i>Functional</i>	Hazardous Waste Chemical Compatibility is an application that enables users to determine in a simple and comprehensive way the possible hazards that can be expected on hazardous waste storage, based on the chemicals contained in these wastes. This application

		<p>plays a key role in assessing potential chemical reactions, foreseeing adverse reactions and then enabling handling procedures of hazardous waste to be carried out without risk of unexpected chemical reaction. The application is based on EPA's Chemical Compatibility Chart (EPA-600/2-80-076 April 1980).</p>
iAverda	<i>Interactive - participatory:</i>	<p>iAverda is an iPad and iPhone application that allows Abu Dhabi communities to take action in the cleaning of their environment. The application is provided by Averda, one of the environmental solutions providers in the region.</p> <p>iAverda allow communities to quickly address any waste issue in their area, by reporting the incident directly to Averda. It allows the submission of queries, feedback and requests for services and information.</p> <p>All residents need to do is to send either an image or text message through the application, and Averda will deal with the report, providing status updates and completion notifications.</p>
iScrap App	<i>Informational/ Educational</i>	<p>iScrap App is an online tool created for scrap metal recyclers. iScrap App offers scrap metal recyclers a director of scrap yards that can be accessed, anytime, anywhere, through any internet connected device. The app automatically locate scrap yards within 100 miles or search anywhere in the US and Canada. Customers can simply push the locator icon to find all of the recyclers and scrap metal companies within 100 mile radius of their current</p>

		<p>location. They can also view all recyclers or scrap metal companies nationwide inside the app. From there the user can begin to interact with them directly. The app also saves the most recent recyclers they visited for quick reference every time they use the app.</p> <p>Once the user has selected a yard he/she can easily upload a picture of a material he/she wish to know more information about and send it directly to the yard of his/her choice.</p>
LandVol	<i>Functional</i>	<p>LandVol (Landfill Volume & Area) calculator is a tool developed by D-Waste, to support waste managers to roughly estimate the Landfill Volume and the required Active Landfill Area for the final disposal of Municipal Solid Waste. This application takes into consideration all the necessary data that affect the Landfill Volume and Area. It also makes an assessment of the expected waste body settlements and demonstrates the impacts of the various operational features in the calculated parameters.</p>
My Waste	<i>Informational/ Educational</i>	<p>This is an application on managing household waste in communities. The app provide residents with collection schedules tailored to each household and allows them to create custom reminders for regular, holiday and special collections. Furthermore, it provides information on proper recycling/disposal procedures for most materials and the location and hours of operation for local drop off facilities. A recent update of the app has added a new feature allowing residents to “Report a Problem”. More specific the</p>

		<p>user can report any problem by taking a photo, register the exact GPS location and email the report directly to the department that can respond.</p>
<p>Recycle for Greater Manchester</p>	<p><i>Informational/Educational</i></p>	<p>The App has been created for the citizens of Greater Manchester offering a snapshot of the 3Rs - Reduce, Re-use and Recycle in their area. The App mainly offers:</p> <ul style="list-style-type: none"> • Maps and routes to local Recycling Centres using Google maps, current position and GPS. • Info on what citizens can put in their recycling bins • Handy Hints and Tips • A-Z of what it can be recycled
<p>Urban Spectra</p>	<p><i>Interactive-participatory</i></p>	<p>With the contribution of citizens and the cooperation of local authorities, the Urban Spectra application enables direct recording of the daily problems facing municipalities, and informs service departments in real time. This allows for a better management of problems from the relevant authorities.</p> <p>The user can report any problem relating to municipal responsibility and inadequate waste management, by activating the application, taking a photograph and sending it to the relative authority.</p>
<p>MBT MassBal</p>	<p><i>Functional</i></p>	<p>This is a tool that gives the opportunity to the users to have the mass balances and process of the main types of MBT facilities in</p>

		their hands. It also provides rough estimations of treatment products according to the quantity and composition of input, that the user enters.
Waste2EnMas	<i>Functional</i>	Waste2EnMas is a tool developed to assist solid waste managers to have a rough estimation of the Mass & Energy Balances of WTE (Mass Burn Facilities). Waste2EnMas is taking into consideration all the necessary data that affect a Modern WTE Mass Burn Facility and calculates the transferred Heating Value of a given amount of MSW to recovered amounts of Energy (Heat or/and Electricity) & produced byproducts

THE NEED FOR A FRAMEWORK

Mobile waste management and recycling applications are efficient and functional only if they are well designed (user fit) and utilize the adequate behavioural persuasion pattern that will make the users achieve tangible improvements. However, both those characteristics are determined by a suitable accompanying framework. A proper “ecosystem” is essential in order to develop and flourish a sustainable mobile recycling application that will realize environmental and social benefits.

Several obstacles do exist that should be taken into consideration and be surpassed. First of all there is a lack of understanding of the mobile apps potential benefits. This drives to difficulties in acquiring financial resources for research and innovation, necessary to drive developments in producing waste management applications that bring real results in improving the waste management sector.

There are also certain difficulties of implementing relevant projects in cases smart phones are not used by a substantial amount of the population or in cases (like in rural, or distant and underdeveloped places)

where both citizens and professionals many times lack the means, knowledge and other capacities to utilize, and develop such technologies.

As the experiences from the health sector app development (m-health) demonstrate (Qiang et al. 2011) strategic interventions and financing is necessary in order to expand in large scale and bring tangible results. There is a need that funders, governments, multinationals and financial institutions should set the ground for collaboration in order to explore needs-based interventions that can support the scale and sustainability of successful recycling models, helping them tap into public environmental budgets (Qiang et al. 2011).

Another important factor for the continuity and the large scale implementation of mobile recycling applications is the standardization of the relevant mobile systems. This will allow different platforms to cooperate, exchange information, and be developed further in a smart way. With that approach, international coordination (necessary for recycling efforts, due to their globalized and interconnected character) will gradually emerge and strengthen.

Last but not least, it is important to consider the importance of literacy of citizens as well as workers in the waste management sector, who can use, implement and spread the use of such technologies. Information and education should be focused both to the new mobile technologies and use, in combination to making well known the importance of sustainable waste management and the protection of the environment.

In the recycling sector, mobile systems (applications), dedicated to encourage recycling behaviour change, shall be well designed with careful consideration given to how they will fit into everyday life. Based on a study of Klasnja and Consolvo (2009), the following aspects shall be taken into account when designing mobile application for recycling behaviour change:

Support recycling goals: The literature (Fitzsimons and Bargh, 2004) suggests that goals can be activated through environmental cues and that such “primed” goals can effectively guide goal-directed behavior.

By supporting persistent activation of recycling goals can be a powerful means of fostering recycling behavior change. Unfortunately the already available mobile applications such as the ones that track individuals 'green footprint do not provide the persistent visual reminder about user's commitment to recycling activities.

Encourage an extensive range of recycling behavior: Mobile applications can substantially influence how the individual engages in recycling behavior change. Specifically the activities that the application supports or encourages can become the focus of the user's efforts, potential to the exclusion of other relevant activities. For example in many cases the users abstain from applications because the latest do not provide proper credit. Therefore, it is important that the system not only will help individuals to track and modify their behavior, but also to provide them the appropriate credits to invest in using the system. Providing customization that allows the user to select the aspects of the system that are appropriate for the user's current needs and adjust the system as his/her needs change, may improve the effectiveness of the system over time.

Focus on long-term patterns of activity: Behavioral economics claim that individual actions can change when their effects are understood and explained as results of certain social patterns or when they are directly linked with benefits or damages (Rachlin, 2000). When for instance an individual is deciding between throwing organic waste in a common bin (no effort) or separate the organic waste to home compost (effort and time), it seems easier for him/her not to recycle. However if recycling is linked with economic benefits as in the case of Pay as You Throw systems or when recycling appears to be the social norm he/she might find home composting an appealing activity.

Facilitate but not depend on social support: While social support might be a powerful strategy for encouraging behavior change, it can also hamper motivation and even introduce social friction (if, for example, someone initially shared his/her data, then later decides to stop). Although, recycling behaviour change applications could benefit from facilitating social support, they should not depend on it. Future

work should explore how to incorporate social support. For example while the system should allow users to determine what to share with whom, an open design challenge is how to allow the users to adjust these settings easily as circumstances change (Klasnja & Consolvo 2009).

CONCLUSIONS

There is a real challenge out there, waiting to be realized. And this is to make mobile phones enablers for a more sustainable way of living and more particularly for a better waste and resource management.

It is time to create a plethora of apps, globally useful or locally adapted, that will allow mobile phones to be enablers or gateways for a more sustainable waste management. In this way, the mobile phone's content can substantially contribute to better and more responsible consumer behaviour, to a better selection of products that are environmentally friendlier, to an online interaction between people that try to recycle more etc.

More specifically, mobile apps can be very useful in identifying, registering and addressing recycling problems in urban and rural areas, either in terms of problems in quality and quantity or in terms of recycling attitudes in every neighbourhood.

They can also be very useful to stimulate or track personal behaviour and recycling performance, calculate the benefits involved and create a better atmosphere that will support behavioural change.

Mobile apps can be used to create recycling networks and local context competitions in each and every neighbourhood, promote waste exchange initiatives and involve citizens in decision - making regarding major waste management and recycling issues. This will also result in behavioural change since it will allow a more participatory approach to take place.

A mobile app for recycling will be successful only if it fits a more general waste and recycling policy and plan that will incorporate all the integrated sustainable waste management features (social, technical, environmental, economic). In other words mobile apps can substantially improve both the individuals'

behaviour and the systemic performance of a waste management system but the system must be in place in order to utilize the apps.

Finally, a successful mobile recycling application that delivered results in a certain community, it can't be replicated in another "audience" without considering the cultural, social and historical evolution of the new audience. As it is widely recognized and understood, in the waste management community the only successful way is to combine global principles and lessons learnt with local conditions and expertise. The same is true for mobile applications dedicated to recycling and waste management.

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