

D-WASTE WHITE PAPER



Mobile Applications & Waste Management: Recycling, Personal Behavior, Logistics



D-Waste Team

This is a White Paper dedicated to start a global discussion regarding the use of mobile apps to improve waste management and recycling activities. Several already existing representative waste management apps are presented and different uses of mobile apps for waste management purposes are discussed. Special emphasis is given to the potential of improving the recycling performance on the individual level through the use of mobile apps.

WHITE PAPER

Mobile Applications & Waste Management: Recycling, Personal Behavior, Logistics

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Abbreviations

3G - 3rd Generation

4G - 4th Generation

BRICS - Brazil, the Russian Federation, India, China and South Africa

C-Governance - Conventional Governance

CEO - Chief Executive Officer

CIS - Common wealth of Independent States

E-Governance - Electronic Governance

EPA - United States Environmental Protection Agency

G2G - Government to Government

GPRS - General Packet Radio Service

GPS - Global Positioning System

ICT - Information and Communication Technology

IDC - International Data Corporation

ISWM - Integrated Sustainable Waste Management

IT - Information Technology

ITU - International Telecommunication Union

LDCs - Least Developed Countries

MBT - Mechanical Biological Treatment

M-Governance - Mobile Governance

NGOs - Non-Governmental Organization

PC - Personal Computer

PCs - Personal Computers

PDA - Personal Digital Assistant

SMS - Short Message Service

SWM - Solid Waste Management

T2T -Text2Teach

US - United States

WBIS - World Broadband Information Service

Executive Summary

Undoubtedly, “The future is mobile”. Nowadays, digital evolution and mobile developments are carving a new era that affects human behavior and global governance. Interconnectivity and information flow 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 applications (further apps) can become valuable tools for authorities, companies, civilians and other stakeholders, integrating these technologies in the battle for environmental protection, waste prevention, recycling, etc.

Aim of this paper is to examine the unexplored challenges of mobile apps to deliver sustainable waste management emphasizing on recycling and waste prevention performance, especially for emerging developing countries. Furthermore, it presents the opportunities that are involved in using mobile apps in order to improve both the systemic performance of a specific waste management system and the individual behavior of the users.

Towards this direction, the paper reviews the most important relevant literature of the recent international research concerning mobile apps and human behavior. In addition it presents authors’ main findings in five discrete chapters. It starts by outlining mobile and apps statistics that document the existence of the new mobile universe as a permanent layer of the human activities (Chapter 1). Then the importance of mobile governance is emphasized and few selected projects are presented in order to demonstrate the different aspects (Chapter 2). Following, Chapter 3 highlights the importance of mobile apps in the waste management sector and categorizes their potential uses according to two different dimensions, the “stakeholders’ view” and the “users’ view”. Examples of already existed waste management apps are provided at the end of this chapter. In Chapter 4 authors analyze the major challenge of behavioral change through mobile apps and their influence to waste prevention, circular economy and zero waste. Recycling activities in all their different forms can benefit a lot from the new mobile world. Finally Chapter 5 outlines the different ways that modern mobile technology could enhance recycling activities of different interested groups including citizens, local authorities, the informal sector, the private sector and scientists and researchers.

Last but not least, the paper’s conclusion draws readers’ attention for both the content and the format of the mobile apps required for recycling and waste prevention. According to the finding, there is a huge room for the adoption of recycling habits that are facilitated through mobile apps which different stakeholders can download easily to their smart phones. There is also a huge unexploited potential to improve the systemic behavior of waste management systems by using appropriate mobile apps. Moreover, according to the authors there is an urgent need to create a plethora of apps, globally useful and/or locally adapted, that will allow mobile phones to be enablers or gateways for high rates of recycling performance and sustainable waste management.

1. Mobiles & Apps

Historically, mobile technology really began to take off worldwide in the mid-1990s, when the ratio of mobile to fixed line phones went up from about 1:34 (1991), to about 1:8 (1995). 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. Thus, within the span of about 10 years mobile technology has moved from being the technology for a privileged few, to essentially a mainstream technology. The growth of mobile technology is conspicuous in developing countries where mobile phones serve as a substitute for fixed lines.¹

Nowadays, mobile communication technologies are diffusing around the planet faster than any other communication technology to date. According to the International Telecommunication Union (ITU) a dramatic increase in the use of mobile technology and a significant growth in mobile broadband subscriptions have been recorded around the globe in 2011. More specifically by the end of 2011²:

- there were 6 billion mobile subscriptions equal to 86% global mobile penetration;
- 4.5 billion subscriptions were recorded from developing countries with China and India to lead the way, each with around one billion mobile subscribers;
- worldwide mobile-broadband subscriptions were 1.1 billion while fixed (wired)-broadband subscriptions were 590 million;
- there were 105 countries around the world with more mobile-cellular subscriptions than inhabitants especially in many African countries;
- China was the top country on mobile web users around the globe. There were 431 million mobile web users in China at the end of 2011.
- Japan had 125 million mobile subscribers (95 percent of the population). Of these, 103 million (84 percent of mobile users) were mobile internet subscribers.

Latest achievement of mobile technology has been the realization of new generation mobile phones, or “smart phones”, and of 3G and 4G networks with new built-in functions and a plethora of mobile applications. 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.

Smartphones which nowadays enumerate 1.08 billion devices worldwide, will reach according to research 2 billion by 2015, clearly establishing them as the most pervasive computing and internet access device today and in the future. Tablets as well, have started gaining ground especially after the release in the market of the new lower-priced tablets in late 2011. According to IDC (March

¹Manuel Castells, Mireia Fernandez-Ardevol, Jack Linchuan Qiu & Araba Sey, 2004, “*The Mobile Communication Society: A cross-cultural analysis of available evidence on the social uses of wireless communication technology*”. Available at: <http://hack.tion.free.fr/textes/MobileCommunicationSociety.pdf>

²ITU, 2012, “*Measuring the Information Society: Executive Summary*”. Available at: http://www.itu.int/dms_pub/itu-d/opb/ind/D-IND-ICTOI-2012-SUM-PDF-E.pdf

2012) 68.7 million media tablets sold in 2011 and their number is predicted to rise to 106.1 million units by the end of 2012 and to 198.2 million units in 2016.³

Undoubtedly, this high growth recorded in the number of smart phones and tablets will have a major impact on the number of mobile-broadband subscriptions and Internet users and will reinforce the shift from mobile voice to mobile data traffic. As a result, significant upgrades of networks, higher speeds and more spectrum will be required.

In the above framework, development of mobile applications has brought unimaginable opportunities to mobile users, who have engaged apps in their daily activities. Most popular app categories are games, news, maps, social networking and music. 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 2012.⁴ Approximately 84 billion downloads of mobile apps were recorded in 2012 and their number is expected to reach nearly 182.7 billion in 2015 (IDC, 2012). In addition, an average number of 32 apps were installed on each smart phone device in 2011 and 41 in 2012. One thing is certain about the future of mobile apps: mobile apps business shows no sign of slowing down anytime soon.

³IDC, 2012, Press Release *"Media Tablet Shipments Outpace Fourth Quarter Targets; Strong Demand for New iPad and Other Forthcoming Products Leads to Increase in 2012 Forecast, According to IDC"*. Available at: <http://www.idc.com/getdoc.jsp?containerId=prUS23371312>

⁴Five Star Equities, 2012,, *"Number of Smartphones Around the World Top 1 Billion -- Projected to Double by 2015: Five Star Equities Provides Stock Research on Microsoft and Nokia"* press release. Available at: <http://finance.yahoo.com/news/number-smartphones-around-world-top-122000896.html>

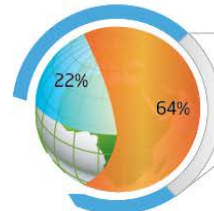
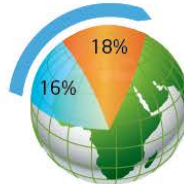
THE WORLD is becoming MOBILE



Within the span of 10 years mobile technology has moved from being the technology of privileged few to a mainstream technology

Global Mobile Penetration

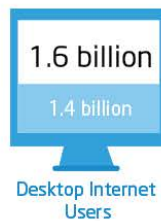
■ Developed World
■ Developing World



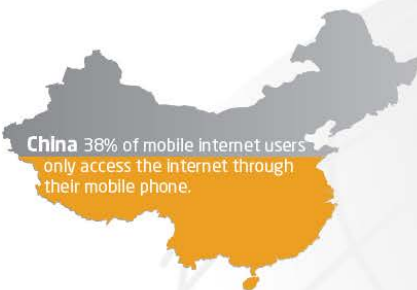
China and India
30%
of world subscriptions.

Over **6 billion** global mobile-cellular subscriptions - **4.5 billion** mobile-cellular subscriptions in the **developing world**

The Web is becoming mobile



By 2014 mobile internet users is predicted to take over desktop internet users



A New Era: Smartphones, Tablets & Apps

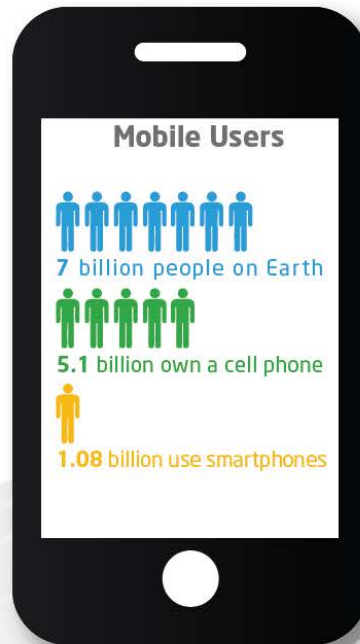
Media Tablets



sold in 2011



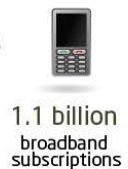
will be sold in 2016



Twice as many mobile than fixed-broadband subscriptions



VS



over 1.200.000 in 2012
850.000 in 2011
300.000 in 2010

APPS reached

By 2015
Smartphones
will reach 2billion

GROWING 7-9%

Across regions,
mobile browsing and application
usage is growing
at the rate of 7-9 % per year.

Smartphones are becoming the newest wave of mobile phones.

*This is the average number of mobile apps downloaded by smartphone users in US.

2. Mobile Phones for Good Governance

2.1 M-Governance Growth

Mobile governance (M-Governance) is an umbrella term that covers a number of initiatives involving the use of mobile technologies in the domains of citizens' participation, public awareness, management of emergencies and crisis, provision of public services, information, etc. It has been significantly developed in the recent years, mainly as a result of the expansion of mobile phones that have become the most ubiquitous communication devices worldwide, with higher penetration rates than the Internet.

In general mobile technologies such as mobile phones, laptops & PDAs (Personal Digital Assistants) with wireless connection have provided greater opportunities for the domain of governance than any other information and communication technology (ICT). They have brought citizens previously unimaginable opportunities to communicate conveniently with each other and to access both public and private information and services, by diminishing time and space boundaries and limits. In addition, cheap and ready-for-use mobile devices have removed existing barriers and have empowered citizens to connect to governments with the aim of accessing a wide range of information and services.⁵

The main reasons why mobile phones have become crucial for governance are:

Access. Penetration rate of mobile phones has increased in both the developed and developing world making m-governance applications and service available "anywhere and anytime".

Reach. Because mobile penetration exceeds internet penetration, public services that are offered via mobile phone are available to a greater number of people than those offered on the Internet. In addition mobile phones can reach areas where there is no other ICT infrastructure.

Adoption. As mobile phones are becoming more and more part of our daily life, m-governance will become the usual way of doing things. In addition, there is an increasing public demand for mobility and easy access to services.



Figure 1: Positive parameters that affect m-Governance

⁵ OECD/ International Telecommunication Union, 2011, "M-Government: Mobile Technologies for Responsive Governments and Connected Societies", OECD Publishing. Available at: <http://dx.doi.org/10.1787/9789264118706-en> & ITU Bookshop at www.itu.int/pub/D-STR/m-gov

Interaction. Mobile phones make it possible for real-time, two-way dialogue as opposed to radio, brochures, posters, public speech etc.

Cost. M-governance provides many cost saving opportunities for the government as well as for the citizens (data gathering; sending a stamped letter vs. the price of one SMS etc.).

The relative lower cost of mobile phone technology versus internet technology has lowered the entry barriers for poor people.

Efficiency. Due to high access, reach, adoption and real-time interaction, mobile phones offer efficient solutions to every government's communication challenges.

2.2 M-Governance in the Developing World

With mobile services becoming cheaper and more accessible in recent years, m-governance has gained ground in the developing world which has historically been limited by poor or non-existent communications infrastructure. Mobile and wireless communications records high rates of penetration in the developing world and outnumbers the total number of fixed telephone lines and computers. This actually includes 4 middle income and 36 low income countries. In many developing countries, where fixed telephone lines network takes years to develop and costs a lot, it is easier for citizens and more affordable to get a mobile phone connection. Moreover, it is easier to set up a new mobile phone network in countries where infrastructure is an issue.

Realizing the benefits of mobile technologies, many countries are now implementing and developing solutions to better deliver government services to public.

With low internet access rates but rapidly growing mobile usage, in these countries, m-governance seems to be the best concept of governance in the developing world.

2.3 The Future of M-Governance

On the following years mobile devices are going to be equipped with additional features of larger computing power for the taking care of voice, text and multimedia content. This emergent behavior enabled by the convergence of personal communications and publishing technology with massive private and government data sources could empower individuals in their relations with governments. This provides a potential opportunity for government agencies to explore the ways to enhance the outreach of e-governance services with the use of mobile and wireless technologies.

2.4 Good Examples of M-Governance

Mobile governance efforts have made use of mobile's potential for wider citizen engagement and participation to strengthen accountability and transparency in public services and processes. These efforts are typically innovative, because they often change the delivery of management of conventional service or process. Mobile governance applications have been developed around the world in either developed or developing countries and greatly utilized by the private sector to deliver services such as banking, media, transportation, voting etc. Characteristic examples of initiatives in the Government sector are presented as follows.

Emergency Response - Haiti Earthquake

On January 12 2010, an earthquake of magnitude 7.0 devastated the small Caribbean country of Haiti, killing more than 222,000, injuring another 300,000 and displacing millions. Being one of the poorest countries in the world, Haiti was ill-equipped to handle the aftermath of the quake which affected 3 million people. The response to this emergency came through Facebook & Twitter. A digital campaign "The Day of Action" promoted on the above social media (see Figure 2), allowed people to text a number through their mobile device and to donate money to the Red Cross. This action raised donations to over 3 million US dollars in just 48 hours and to over 41 million US dollars until June 2010. (UNEP, 2010)

The Day of Action showed just how effective internet and mobiles can be in uniting otherwise unconnected people for a cause and respond immediately to emergency situations.



Figure 2: Bloggers day of action for Haiti

[Source: <http://itsohsogrand.blogspot.gr/2010/01/blogger-s-day-of-action-for-haiti.html>]

m-banking in Africa

In Africa, the majority of the population has no access to banking services, with only 20% of African families having bank accounts (Efam Dovi, 2008). Even Africans with bank accounts often face high charges for moving their cash around, due to high transactions costs (Peter Ondiege, 2010). Furthermore, only 4% of households in Africa have Internet access (Clinton, B., 2012). However, more than 50% have cell phones which have created a unique niche for mobile phone banking, enabling a growing number of people to access financial services. The evolution of m-banking in Africa came in 2007 with the establishment of the M-Pesa, an innovative and award-winning Kenya, money transfer system targeted at low-income people in rural areas who were not reached by major banks. According to Figure 3, subscribers of mobile banking in Africa have increased from 0.6 million in 2007 to 11.89 million in 2010.



Figure 3: Increasing trend of mobile banking in Africa

[Source: Peter Ondiege, 2010]

Text2Teach: Learning Using a Mobile in Philippines

The Ayala Foundation convened the Text2Teach (T2T) Alliance to roll out T2T in Philippines in 2003. T2T allows teachers to download short videos to a mobile device and screen their classroom. The project was originally satellite-enabled education equipment consisting of machine called Media Master, a television set, and a mobile phone. However, the T2T technology has since upgraded from this satellite-based delivery to a full cellular platform (OECD/ITU, 2011).

Law Enforcement in Turkey

Mobese (Mobil Elektronik Sistem Entegrasyon) or Mobile Electronic System Integration is one of the pioneer mobile government applications in Turkey. This application is a G2G (Government to Government) mobile government application for law enforcement agency. This project is mainly an infrastructure enabling law enforcement units to be more efficient and effective. It connects the law enforcement units to their respective police stations via a GPRS internet connection allowing mobile law enforcement units to query citizens regarding validation of their identity, checking their record history. This service allows the mobile law enforcement units to be more efficient in their job (A Farshid Ghyasi & Ibrahim Kushchu, 2004).

The Ushahidi Platform

Ushahidi, which means “testimony” in Swahili, is a platform that was created in the aftermath of Kenya’s disputed 2007 presidential election that collected eyewitness reports of violence sent in by email and text-message and place them on a Google Maps map (See Figure 4) (Stauffacher et al., 2012).

Ushahidi is an open source platform that anyone may use to create an incident reporting system by crowd sourcing information using multiple channels such as SMS, email, Twitter, and the web. The information is used to create a map of events to give users a visual image of event hotspots. It has been applied in circumstances as diverse as election monitoring, disaster recovery, and crime reporting. It offers products that enable local observers to submit reports using their mobile phones or the internet, while simultaneously creating a temporal and geospatial archive of events.

Ushahidi now serves as a prototype and a lesson for what can be done by combining crisis information from citizen generated reports, media and NGOs and mashing that data up with geographical mapping tools (<http://www.ushahidi.com>).

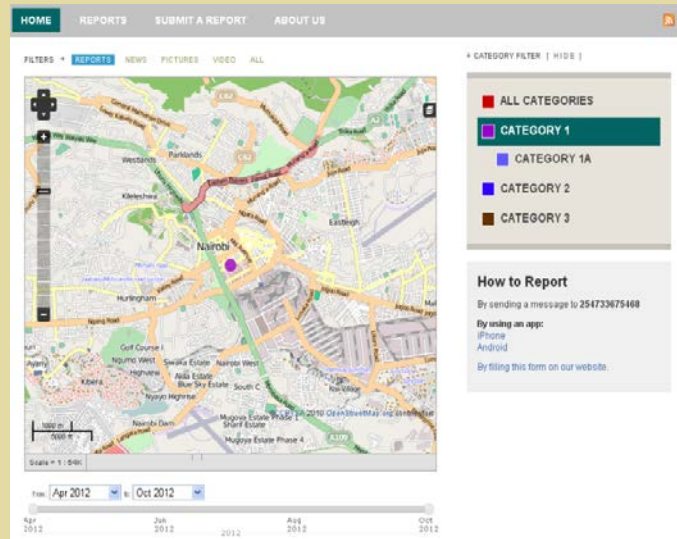


Figure 4: Screenshot of the original Ushahidi demo platform
[Source: <http://demo.ushahidi.com/>]

Text Messaging Critical News in the Aftermath of a Disaster

More than 5,000 people died and 1.6 million were displaced as a result of the May 2006 earthquake in Yogyakarta and Central Java in Indonesia. During the days and weeks following the disaster, ordinary citizens received valuable news via text message. The text messaging service was put in place by Internews, a U.S.-based NGO that works to improve people’s access to information around the world.

The service was run through an emergency AM radio station, Radio Punokawan, established by the Indonesian Press and Broadcast Society, with support from Internews.

In addition to radio broadcasts, important information was sent and received from the newsroom via text messaging. Outgoing messages warned of aftershocks and identified communities that had not yet received government assistance. More than 180 Indonesian journalists distributed and received information through the service (Sheila Kinkade & Katrin Verclas., 2008).

Municipal Transport Company of the Cities of Madrid, Zaragoza and Malaga, Spain

The Municipal Transport Company of the City of Madrid offers real-time information on its bus network. Sending an SMS stating the code of the stop and the bus line number, is answered with approximate waiting time until the arrival of the next bus. A similar service has been deployed by the Municipal Transport Company of the City of Malaga.

The City of Zaragoza has deployed a similar service for municipal bus network described in cases of Madrid and Malaga. Additionally, to improve mobility in private transport, it has developed an appealing application for Apple and Android devices to visualize traffic conditions in the locality, which allows drivers to choose the best route to travel between two points in the locality. The Network of Public Airports (AENA) enables real time information on takeoffs and landings at airports in Spain to mobile devices of any kind. This information is accessible on Wap technology (Peter Ondiege, 2010).

3. Mobile Apps & Waste Management

Before going in further details, it is essential to highlight the importance of Integrated Solid Waste Management (ISWM), according to the UN-Habitat approach. In a simplified way the concept can be represented by the two triangles (Hardware and Software) of Figure 5⁶.

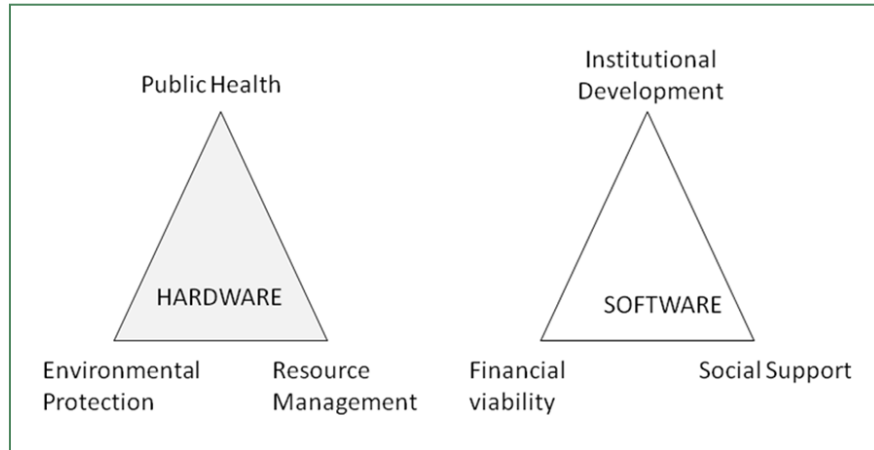


Figure 5: The triangles of Integrated Sustainable Waste Management simplified concept.

[Source: A. Mavropoulos, 2011]

The first triangle comprises the three key physical elements that must be addressed for any waste management system that has to work in a sustainable way over the long term⁷:

1. *Public health: maintaining healthy conditions in cities, particularly through a good waste collection service;*
2. *Environmental protection: throughout the waste chain, especially during treatment and disposal; and*
3. *Resource management: “closing the loop” by returning both materials and nutrients to beneficial use, through preventing waste and striving for high rates of organics, recovery, reuse and recycling.*

Therefore the 1st triangle is characterized as the “Hardware” of an ISWM system.

The second triangle focuses on ISWM’s “Software”: the good waste governance (strategies, policies and regulations) to deliver a well functioning system. This means that there is a need for the system to:

4. *Be inclusive, providing transparent spaces for stakeholders to contribute as users, providers and enablers (Social Support);*
5. *Be financially sustainable, which means to be cost-effective and affordable (Financial Viability); and*
6. *Rest on a base of sound institutions and pro-active policies (Institutional Development).*

When planning a Solid Waste Management (SWM) system, it is of great importance to achieve a sustainable and harmonious cooperation between Hardware and Software. It is exactly like in any PC. Unless the hardware is appropriate for the software used (and vice-versa) the PC will never work efficiently.

⁶ Antonis Mavropoulos, 2011, “Globalization ,Megacities and Waste Management” ISWA conference, Daegu.

⁷ D-Waste, 2012, “The Planning Challenge: A Road Map for Waste Management Planners”. Available at: <http://www.d-waste.com/reports.html>

Moreover, not all software is suitable for all hardware and not all hardware is capable to perform with certain software.

Perhaps the most important characteristic of the ISWM concept is that it demonstrates that the performance of a SWM system results from the holistic emerging behavior of the Hardware combined with the right Software.

Under this framework it is significant to stress that a) Mobile applications can improve the city's waste Software, through several smart tools for the city administration and local community, but it can also b) contribute to city's waste Hardware infrastructures and organization.

M-Governance and the use of apps 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.

3.1 The Stakeholders' View

From the stakeholders' perspective (the term stakeholder includes authorities, companies, NGOs etc.), there are actually four main areas where mobile apps and m-Governance 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.

User involvement as well as participation in decision making in today's welfare society are key issues in creating a sustainable waste system based on dialogue and local participation.

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 m-Governance provides opportunities to waste management authorities to evaluate their performance and improve their internal operation. Furthermore, an essential number of geodatabases will be created.

3.2 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

3.3 Available Waste Management Applications

For the users of smart phones and tablets, green applications are already an important segment amongst the plethora of apps across all platforms.

Some characteristic waste management apps are presented below. 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.

D-Waste Atlas



D-Waste Atlas is a crowd sourcing 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.

European Waste Catalogue



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



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 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).

iScrap App



iScrap App is an online tool created for scrap metal recyclers. iScrap App offers scrap metal recyclers a directory 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. They can also view all recyclers or scrap metal companies nationwide inside the app. In addition, the app saves the most recent recyclers the user has visited, for quick reference every time he uses the app.

Once the user has selected a yard he/she can easily upload a picture of a material he/she wishes to know more information about and send it directly to the yard of his/her choice.

EPA iWARM



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.

iAverda

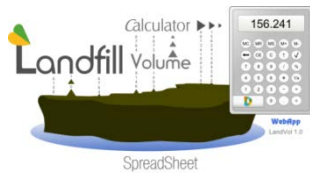


iAverda is an iPad and iPhone application that allows Abu Dhabi communities to take action in the cleaning of their environment.

iAverda allows 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.

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.

LandVol



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.

My Waste



This is an application on managing household waste in communities. The app provides 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. Finally the 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.

Urban Spectra

With the contribution of citizens and the cooperation of local authorities, the Urban Spectra application enables direct recording of the daily



problems municipalities are facing, and informs service departments in real time. This allows for a better management of problems from the relevant authorities.

This application can be adapted to any waste management problem. When a user identifies a problem of municipal responsibility, he activates the application, takes a photograph and sends it through this application to the competent authority. The photograph is sent accompanied by its data (coordinates, label, and text) to a predefined reception center in the form of a website with controlled access.

The data is transferred in real time (2-10 sec) and are stored in a database special designed to the specific task of the application. Then, the administrator of the reception center manages the received data selecting one of the two alternative forms of data visualization, between a) a categorized list with a time line of incoming data, and b) map visualization with exceptional spatial precision in a suitable mapping background.

MBT Mass Balance

MBT MassBal is an application that gives the opportunity to the users to have access to the mass balances and processes of the main types of Mechanical & Biological Treatment (MBT) facilities. It also provides estimates of the products of every chosen treatment scenario. The calculation and the results are customized to every user taking into consideration the waste characteristics (quantity and composition) as they are entered by the user.



Recycle for Greater Manchester



This 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:

- Maps and routes to local Recycling Centers 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

4. Mobile Apps & The Challenge of Behavioral Change

During the last years, waste management is becoming more and more linked to resource management and so, it has evolved in a global complicated network of material and recyclable flows, affecting in various aspects the environment and the life of the citizens, raising questions on practices that need to be deeply explored, and managed in a sustainable way. Part of the sustainability agenda seems to be more self-reliance cities, trying to contain waste flows, reduce energy and resource consumption and increase local and global recycling and reuse of materials. Consequently, waste prevention is becoming an increasingly important trend worldwide. On the other hand mobile phones have become enablers of a more sustainable way of living, and more particular for a better waste and resource management.

4.1 A Changing World

Until recently, we faced waste management as a matter of appropriate storage, collection, transfer, treatment and disposal, and the main effort was to minimize environmental and health impacts, so engineering and logistic tools were sufficient to plan and implement waste management systems. But today resource management and social behavior are becoming an organic 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.

In the above framework, the challenge of behavioral change becomes crucial for any policy related to waste prevention, circular economy and zero waste. And this is a field in which waste management mobile apps can have an important contribution.

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.

As President Bill Clinton claimed in an article published in TIMES magazine in October 2012, “Smart phones help restart the lives of many individuals, but they also help millions of individuals help restart the lives of others. We’ve seen how technological advances have democratized charitable giving as never before, allowing people to make a difference even if they don’t have much time or money to give”⁸.

Ezio Manzini⁹ from his side has suggested 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. According to his point of view, 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”.

⁸ Bill Clinton, 2012, “5 Ideas that are changing the world (for the better)”, Time. Available at: www.time.com

⁹ Ezio Manzini, 2002, “Context-based well being and the concept of the regenerative solution: a conceptual framework for scenario building and sustainable solutions development”, The journal of Sustainable Product design, vol2, pp141-8

In that way, mobile phones are at the center of any discussion regarding social and economic changes, something which is particularly true in developing countries. However, very few things have been written for the sustainability related to content that can be provided through mobile apps and the social changes that might be triggered.

Castells¹⁰ and Urry¹¹ have shown that mobility of people, information, media and objects is a key feature of an emerging social paradigm. In this point of view, the "virtual" does not replace the "real" but actually supplements it, enabling new ways of communicating and experiencing what we need or want, or think we do. The mobile phone's dramatic rise to prominence is both reflecting this ongoing social transformation and shaping it.

Horst and Miller¹² have declared that although it is predictable that a technological innovation may be used firstly to fulfil "pent-up" desires, such as just the plain advantage of mobile - phoning "on the run", what is less predictable is the way the new device will be used by a particular group, in a particular place, for a particular purpose that derives from a specific local context.

This particular characteristic should be of special interest for those who want to enable the benefits of mobile phones as a means of achieving a more sustainable way of life, and more specifically of improving waste management, waste prevention and recycling activities. Actually, this is more than realistic not only for the main stream users of smart phones, who already may have access to essential services or information, but also for those groups that were previously excluded from such an access.

4.2 The Role of Mobiles

Projecting people's life

Mobile phones are gradually becoming a means 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.

¹⁰ M. Castells , 2000, *"The rise of the Networked society"* (2nd end), Blackwell Oxford

¹¹ J. Urry, 2002, *"Globalisation the tourist gaze"*, Cityscapes Conference, Graz, Available at: www.aughty.org/pdf/glob_tourist_gaze.pdf , and 2007, *"Mobilities"*, Polity Press, Cambridge

¹² H. A. Horst & D. Miller, 2006, *"The cell phone: An Anthropology of Communication"*, Berg, Oxford

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, 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, is very representative of the potential involved in the new mobile universe.

Connecting People, Time & Space

Through mobile phone and social media networks we can get data regarding large-scale human behavior patterns. Though studying data deriving from those systems, in combination with geo-visualization methods, we can come up with a better understanding of urban systems in general, and its inherent social dynamics regarding activity and mobility in particular. Nowadays the sample may be still inhomogeneous, as the penetration of smart phones and internet connection is still limited in some places, but it is anticipated, from various examples in still developing countries that in the future it will develop to a global phenomenon. Mobile phones are becoming an instrument that pictures human behavior, attitude and mood while using phones in time, and space¹³.

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 behavior, 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 behavior patterns.

Mobile phones also can influence personal behavior with respect to environmental consciousness. Pervasive monitoring and analysis can improve environmental sustainability by revealing inefficiencies in the waste removal chain, and can also monitor compliance with environmental regulations¹⁴.

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 above¹⁵. 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 behavior in great detail.

¹³ Gunther Sagl, Bernd Resch, Bartosz Hawelka, & Euro Beinat, 2012, *"From social sensor data to collective human behavior patterns: Analysing and visualizing spatio-Temporal dynamics in urban environments"*, Available at: [http://gispoint.de/index.php?id=5&tx_browser_pi1\[newsUId\]=682&cHash=208290d911](http://gispoint.de/index.php?id=5&tx_browser_pi1[newsUId]=682&cHash=208290d911)

¹⁴ A. Boustani, L.Girod, D.Offenhuber, R.Britter, M.I.Wolf, D. Lee, S.Miles, A. Biderman & C. Ratti, 2011, *"Investigation of the waste removal chain through pervasing computing"*

¹⁵ Peter Ondiege, 2010, *"Mobile Banking in Africa: Taking the Bank to the People"*. Available at: http://www.afdb.org/fileadmin/uploads/afdb/Documents/Publications/John%20brief%201_John%20brief%201.pdf

4.3 Worldwide Applications & Interconnectivity

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.

For smart phones users, there are already hundreds of apps available allowing them to get connected with people of similar green interests, to locate environmental or urban problems, to measure their carbon footprint, to adapt their diets to local farming and organic food suppliers etc.

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 a better and more responsible consumer behavior, 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 neighborhood.

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

Last but not least, they can be used to create recycling networks and local context competitions in each and every neighborhood, promote waste exchange initiatives and involve citizens in decision - making regarding major waste management and recycling issues. This will also result in behavioral change since it will allow a more participatory approach to take place.

But a successful mobile application does not mean that it can replicate itself in another "audience" without considering the dimensions of the other community, it is essential to take into consideration, the local characteristics (habits, ethics, religions, etc) of each community it addresses to. 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 and waste management.

5. Mobile Apps & Recycling

Recycling is a characteristic platform upon which patterns of human behavior 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 behavioral human patterns, and the high demand for communication and interactions, mobile technologies can find significant application to this field.

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. More specifically, they can participate in social media discussions, and be a part of pro environmental and recycling groups that promote sustainable living and recycling culture. From their side, children and students can change their behavior by playing special games on mobiles, internet and tablets.

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.

Active and real time participation of people is a dominant characteristic of our era. Never in the past it was witnessed such an extensive interaction among people with different ideas, who live in different part of the world, and belong to different social groups as the interaction we experience in our days. Networks of different groups of professionals, practitioners, ethnic, social and religious groups are interacting through technology. And technology can stream behavior and attitudes in a great degree.

5.1 Citizens

As stated above, recycling requires a series of actions from people, some conscious and other unconscious. Some of them are the following:

- Get information on why should someone recycle (is it a choice, obligation, trend?).
- Develop a desire/will to recycle.
- Acquire information on how to perform the action (e.g. which material to recycle, how to separate materials depending on their nature, how to create space in the house for materials to be stored, when and where to recycle, and where to get recycling materials after gathering).
- Have the equipment to recycle (separate bin(s), different bags, special municipal bins).
- Cooperate with the local waste management authority, usually municipal, and follow the recycling routine it applies (whether it is something simple or sophisticated).
- Be later informed on the results of the recycling actions in order to repeat and improve them.

Of course all these would be possible if a market for recycling materials is in place in order the recycling scheme to be sustainable and last in time.

All the aforementioned actions compose a field where mobile phone technologies could intervene, improve techniques and achieve better results.

Mobile phones can synchronize recycling projects of public authorities with locals, providing in that way a valuable tool for recycling campaigns.

Through mobile phones technology information could be spread to citizens. Special tools can be developed for recycling programs, platforms for interconnectivity and information exchange can be provided. Also, mobile phones can communicate results and educate citizens regardless their background through informative applications, games for children, and much more.

Finally, as it is widely known, in recycling it is important to focus on specific groups that have a key role in recycling activities. Some of these stakeholders are the “active recyclers”, who lead to their “minor” communities recycling efforts, been ambassadors of recycling trends. Those people could use technology in great extent, could be members of networks, could seek innovation, and get organized, gain access to information and special tips in order to improve their recycling performance. Technology and mobile phones can be great allies to those efforts.

There is no doubt that communication plays a vital role in recycling. At the same time mobile phones can bring information to the people, effortless, in a cheap, and fast, with results that can be easily grouped and evaluated.

5.2 Local Authorities

Provision of waste and recycling infrastructure and services is a daily challenge for public authorities. Many municipal authorities focalize on their recycling performance, mostly because of the fact waste management and recycling correspond to a major part of their role for their local societies.

Local authorities have the responsibility to coordinate and execute recycling programs, to educate workers and residents, to inform schools, and public authorities, and deal with questions, problems,

and occasional complaints of inhabitants. Also satisfaction of the residents is of political importance for the local authorities' decision makers. Local authorities and public bodies can find a working partner in modern technologies, smartphones and applications.

Mobile phones and digital applications are easy means to get in contact with people, disseminate information, engage the young individuals in participating, and organizing campaigns and recycling programs fast and easy. There could be for example, a service that interacts with locals, accepting pictures, texts, emails, providing on line help, (ex. pictures of a damaged bin that need to be changed, a problem of waste picking from recycling trucks, an application that indicates schedule of recycling collection, etc.).

Several mobile applications already exist that facilitate the cooperation between citizens, recycling schemes and authorities. Some have been already presented in the Chapter 3.3 of this report.

5.3 Informal Sector

The role of informal sector is many times vital for accomplishing waste recycling targets, especially for countries that their formal waste management schemes are still at an early stage.

Informal sector dominated recycling market in several, especially developing countries. Its contribution could also be greater if it could integrate new technological innovations so as to improve its actions.

Even in this stakeholder category, mobile phones can play a major role for the better organization of the sector. Mobile phone is listed in the most essential equipment of a person, no matter his income or social status.



Clockwise from top-left: prototype of a pickup request website; mapping workshop with cooperative workers; pickup request mobile app for residents; GPS traces of a week of collection activity, showing routes of manual pull-cart (orange) vs. truck collection (blue).

Figure 6: Using mobile technologies for waste pickers in Brazil

[Source: Dietmar Offenhuber et al., 2010]

Smart phones on their part are not just phones; they are tools that incorporate modern applications and offer access to information at any time, at any place. Smart phones serve the democratic need of all people to reach information, and organize their life in new ways, no matter their background.

In just few years, mobile applications that suit everyday necessities will be the norm. Looking on how the world is evolving, it will not be a surprise to see that in the near future informal sector will also take advantage of the applications and functions that smartphones offer.

There have been already case studies that examine the use of modern tools (special software, GPS, web mapping, mobile applications, etc.), in informal waste sector. In a case in Brazil, there has been an effort to map the internal of special organization of waste collection of informal pickers using

such devices¹⁶ (See Figure 6). Through mobile phones there has been an effort to map the special organization of waste collection, and to develop software tools for coordination between waste pickers, clients and planning operations. Through GPS tracking, web-based mapping, and mobile applications, informal pickers are supported with the aim to collect, manage, and interpret spatial data by themselves, and to redesign their own system collaboratively with others. Despite of the difficulties and obstacles that the program faced, due to the particular characteristics of how informal workers work and think, results showed that the experiment was successful.

In Brazil self-organized informal recyclers have a long history. Their sector is so big across the country (500 cooperatives totaling 60,000 members), that they constitute an essential recycling infrastructure for the country. Local public waste policies incorporate the contribution of informal recyclers, and in 2010, the federal government adopted a new national solid waste law, recognizing for the first time the work of waste pickers, and requiring cities and private companies to partner with them. As a result new opportunities are arising for the informal sector through this new scheme. It is a great opportunity for them to stop living and working in the margin, to integrate into the formal system and, improve their social, financial and health status. Informal sector faced new demands by this new scheme, and new technologies are here to assist them. Being away from traditional, inflexible norms, technology can offer information, organization and management patterns that can be adapted to the special needs of the informal sector.

Use of mobile phone could have many benefits for informal sector form organizational and coordinating issues to schedule of meetings with customers. So, as technology is becoming a norm for the new societies, even waste pickers cannot be left out.

Private firms can learn from informal sector's experience and gather information on how their system works in order to improve their services (routes, waste quantities recovered in specific areas, best practices for collecting, sorting, handling and selling, especially in underserved areas that waste pickers have established longstanding networks of connection with local residents and other waste pickers).

Table 1 presents how modern mobile technology can address several issues for waste pickers, and informal waste sector in general.

¹⁶ Dietmar Offenhuber, David Lee & MIT Senseable City Lab, 2010, *"Putting the Informal on the Map - Tools for Participatory Waste Management"*. Available at: http://senseable.mit.edu/foragetracking/PDCpaper_final.pdf

Table 1: Mobile phone technology solutions for waste pickers

| Problems | Solutions technology may address |
|---|--|
| Lack of internal understanding on how they operate. | By tracking automatically valuable spatial data about operations of informal pickers, those data can be utilized by the informal workers themselves, or can be forwarded to formal recycling systems. Waste pickers can visualize mistakes they do when practicing waste collection, can improve their logistics, and learn from their mistakes. Special platforms can be made particularly designed for waste pickers in order to get required information for their work. |
| Lack of infrastructure and means for working. | Mobile phones are simple in use, have a range of free, or inexpensive applications that can be used instead of expensive equipment and provide the sense of freedom for actions, outside fixed formal boundaries that informal sector members trying to avoid. They offer applications like camera, maps, location tracker, information about places to drop of their materials, calculator of distance, temperature, access to digital information, scanning of barcodes, meteorological information, etc. They can exchange texts, pictures, videos and have real time communication, by phone, video or instant messaging, it can offer coordination between partners, workers or possible clients. |
| Lack of public visibility of the service they offer to the community. | Informal sector lacks of respect regarding the services it provides to society, as its actions mostly remain hidden. Once its activities are mapped, it can help to the recognition of the sector's offering. |
| Lack of trust between informal sector and private entities. | Mobile tools can provide valuable data of informal sector activities to formal sector (public, and private), as well as register the otherwise lost information and experience of the waste pickers. Waste pickers can identify problems, and come up with solutions differently than the formal sector, based on their practical experiences. With a platform of coordination, and information exchange by using mobile technology, business and residents can work with the informal sector, while making it easier for the waste pickers to organize themselves. Gathering and utilization of data can help different partners expand and optimize their work. Waste pickers can strengthen their position towards the municipality, and support internal training of the new collectors. Also hybrid systems with the formal systems can be effective, where informal and formal sector can interact, supplementing each other's gaps where necessary. |

Nevertheless special attention should be given to the limits and obstacles that informal sector has in using new technologies. There is usually reluctance in taking over new responsibilities; some have no room for experimentation, and no time for training, neither for data entry or documentation of their daily activities. That's why technology should be applicable in the limits of informal sector's capacities.

5.4 Private Sector

The same stands for the private companies and employees working in the waste sector.

Mobile phones provide opportunities to network, get information, provide cheap infrastructure, organize work, attract customers by being a marketing tool, serve professional relationships, eliminate distance problems between partners, facilitate projects that require participation of a broader audience, save money, gain money, provide a common and understandable platform for cooperation and sharing between different stakeholders that have varied communication codes (e.g. with informal sector, simple citizens, public authorities, etc.)

Recycling professionals, and not only, can easily be guided to information and networks of knowledge and experience sharing. Practitioners, experts, even informal workers that get organized through social media. Mobile phones and modern applications offer them access to a new world of solutions and interconnectivity. Cooperation and information can be shared with informal sector as well and find a way to work through a digital platform that was never existed in the past.

It would be necessary to mention that mobile solutions could help businesses to reduce their environmental and waste footprint by eliminating unnecessary travel and energy consumption having the ability to access and at the same time interact with the company's network remotely. Relevant solutions can instantly connect a mobile workforce using smartphones, tablets, laptops and even standard mobile phones. Mobile workers are able to access the user's application whether online or off, allowing functionality even when they are disconnected from the network.

Relevant applications can also act as tools in order to complete works on location, including back office information systems, enterprise communication and network management, with a single signing in. Mobile workers avoid making unnecessary trips back and forth to central office locations, wasting time and fuel resources, as information is accessible to their hands.¹⁷

Several other examples of relevant applications exist already in the market, and many more are expecting to develop in the near future.

An interesting case study comes from a food recycling company in Coventry, UK, which is the first company using a mobile app to record its waste disposal.

Bioco Recycling's fleet of maintenance staff uses the pay-as-you-go app called My Mobile Workers to record details of any waste collected on food and catering jobs to ensure compliance with the Waste (England and Wales) Regulations 2011. These regulations came into force to make businesses that dispose of waste to measure their waste output and record all waste activity as part of an overall bid in order to reduce the amount going to landfill. The information could later be inspected by the Environment Agency.¹⁸

Nestlé Singapore and the Nanyang Polytechnic School of Information Technology, have also developed 123Recycle a free mobile application in order to help people in Singapore to recycle

¹⁷ Robert Stanley, 2012, "ClickMobile is helping businesses stay connected without waste", Online article. Available at: <http://www.greenconduct.com/blog/2012/11/22/clickmobile-is-helping-businesses-stay-connected-without-waste/>

¹⁸ Activeprofile, 2012, "Food recycling company stays green with mobile phone app", Online article. Available at: <http://www.activeprofile.co.uk/2012/02/food-recycling-company-stays-green-with-mobile-phone-app/>

waste packaging correctly. The app is supported by the National Environment Agency and the Singapore Environment Council, and can be used with both Nestlé and non-Nestlé products.

Users of the app can scan a product's barcode to see clear instructions on how to dispose or recycle the different parts of the product's packaging. For Nestlé products, the app gives exact instructions on how to recycle each part of the packaging. For non-Nestlé products, it offers generic recycling instructions for the packaging.

This 123Recycle app would be useful for the public to find out how to recycle waste packaging on the go. There are also discussions on a second version that will include an interactive map of recycling points.¹⁹

Another field of the private sector that smart phones and tablets could have an important contribution is the use of Mobile Apps to trade waste online. The main concept takes advantage of use of mobiles to facilitate waste producers to post their waste on the online trading platform (e.g. <http://www.retrader.org.uk/>).

Currently, there are some various projects trying to take advantage of the Internet to set up such waste trading platforms. An example is presented in Figure 7 (e.g.). However, considerable work is needed to study the feasibility of using mobile apps as an easily-accessible tool to post waste materials online.

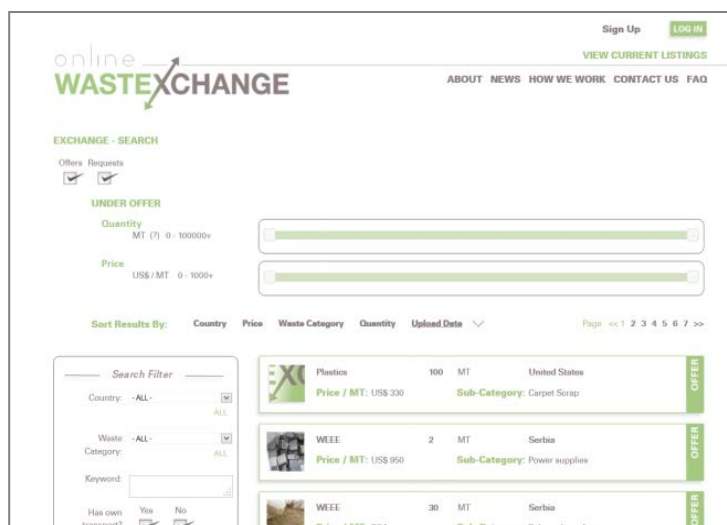


Figure 7: Example of waste trading platform

[Source: <http://www.onlinewastexchange.com/listings/>]

5.5 Scientists & Researchers

A wide range of applications can be of great use for the scientific community as well.

For example, through those modern means, scientists can get valuable information on how the informal waste sector is organized; it can help them better observe and, understand better the system and to improve waste management processes. From their side, they can assist municipalities and service operators to improve their logistics.

Conducting research with mobile tools has the advantages of gathering rapid and economically large amounts of data across a diverse population²⁰. Smart phones provide the opportunity to gain direct access to social media, at all times, exploring in that way the vast amount of data they host, and thus

¹⁹ Eugene Tay, 2011, "123Recycle Mobile App Helps People in Singapore Recycle Waste Packaging Correctly", On line article. Available at: <http://www.zerowastesg.com/tag/mobile-application/>

²⁰ Hyunkyu Lee, Pauline L. Baniqued, Joshua Cosman, Sean Mullen, Edward McAley, Joan Severson & Arthur F. Kramer, 2012, "Examining cognitive function across the lifespan using a mobile application".

studying human interaction in real time. Furthermore, data collection using mobile applications allows researchers collect a large amount of data with cultural and regional diversity, and offers high temporal resolution with built-in millisecond timing for displaying stimuli and measuring behavioral responses. Variety of sampling uncovers mechanisms of human cognition and interactions with lifestyle factors that may not easily be observed in the noise of small scale and homogeneous samples. Such technological means allow the collection of data from a various age range, education, social and cultural backgrounds.

Recycling has to do greatly with human behavior patterns. Mobiles are trustworthy tools that can help us get valuable data and utilize them for better results.

They allow scientists and researchers to conduct cross sectional studies at low cost. Data collection is possible wherever the device is available, making it useful for cross cultural studies. Due to the fact that mobiles are portable, they provide the opportunity to gather data in regions and populations that are difficult to access, or are not equipped with technology or knowledge to handle extensive testing.

In order an application to be successful, its design and functionality should cover a wide aspect of its users' needs. For instance, it should take into consideration the need of a young mother in the "rich", developed world that wants to know at what time she should bring her bags with used glass outside of the door and the same time to cover the needs of a slam resident that gathers aluminum tins in a poor village somewhere in India, and wants to know where to find a best price for his product. Applications and smart phones can constitute the means that can bring together valuable facts that can facilitate the whole system, organize the globalization labyrinth, and transfer, even in real time, key data to those who need it.

5.6 E-Waste

Finally, there is also a different aspect that should be taken into account when considering the relation that mobile phones have with recycling and waste management. The large amount of mobile phones and tablets that are entering the market, result in greater e-waste quantities of special materials that need to be handled after use. The complex construction of such devices makes difficult their dismantling and subsequently their disposal too. Mobile devices have valuable metals and parts that need special care. The more technologically advanced a device is the more complex its waste disposal is.

Nonetheless for the first time mobile phones, and digital applications like tablets, can also have a negative impact to this harmful trend. As platforms for disseminating information, educating and supporting waste management works, actions or campaigns, mobile phones and tablets are strengthening relevant recycling or prevention policies and actions.

The marketing attitudes of the consumption era that we are leaving in, promotes over-consumption patterns. In particular, changing devices every once in a while, and exchanging it with a most modern phone with slight better characteristics is a common practice. Moreover, the life time of new devices is considerably smaller than it was in the past, and there are no sufficient alternatives for replacing defective parts or simply find other service practices. Once an appliance has a problem, it is easily replaced with a new one rather than fixed it or have it reused by someone else. This

consumption pattern should change, because of the extensive use of scarce materials, as well as the increased waste generation, not to mention dispense of hazardous materials in the environment, that need special handling²¹.

E-waste deriving from mobile phones and relevant digital appliances is creating a toxic bomb for the future.

Companies promote mobile devices mostly for free, and people consider them as they have no significant value when they abandon them for newer devices, but this is not the case. In fact, if the phone is still functioning there is a residual value. Retailers and providers, manage to gain the cost from the free products they give, with various ways, by very few consumers up front, and from complex service plans that bind consumers for up to two years²².

But devices, changed after the contract period expires, could last at least four, or five years, before showing signs of being eclipsed by innovation²³. But the provider's business model requires an accelerating cycle of purchase and disposal.

There is an alarming gap between consumer information regarding end-of-life choices for mobile-owners. Governments and regulators worldwide have shown their concern and it would be vital to take more action. Legislators need urgently to reconsider the impact of this style of marketing on the e-waste stream, particularly as this has become the norm for most of the countries in the developed world²⁴.

Also consumers should stop being ignorant about the problem and learn about proper recycling and disposal of e-waste. It is a fact that currently most mobile phones and e-tablets are sold to consumers without any coherent explanation of their internal material toxicity, potential lifespan, or end-of-life choices, except in rather distant and not visible place.

²¹ Robert Crocker, *"Getting closer to zero waste in the new mobile communications paradigm. A social and cultural perspective"*

²² Optus, 2011, www.optus.com.au/home/mobile-phones, Telstra, 2011, www.telstra.com.au/mobile/index.html, and Verizon, 2011, www.verizonwireless.com/b2c/index.html

²³ G. Slade, 2006, *"Made to Break: Technology and Obsolescence in America"*, Harvard UP, Cambridge, MA

²⁴ Same to 15

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