EXECUTIVE SUMMARY

With anticipated population growth, especially in urban regions with high consumption and disposal rates, timely and effective material and waste management (MWM) is a critical and growing challenge of local governments. Planning agencies have key roles to play in meeting this challenge.

Sustainable MWM needs to achieve environmental responsibility, economic efficiency, and social accountability (Ai 2011). It needs to justify local efforts for global environmental benefits, balance economic and social goals, develop data-driven and community-specific MWM programs, and address both short-term and long-term impacts that include local MWM independence as well as minimal environmental footprints.

Sustainable MWM is not a narrowly defined environmental planning challenge. It spans spatial and temporal boundaries and can involve all aspects of planning, including job creation, public health, routing planning, congestion management, land-use zoning, infrastructure planning, and social welfare and justice.

OVERVIEW OF MUNICIPAL SOLID WASTE IN THE U.S.

Municipal solid waste (MSW) loosely refers to nonhazardous waste generated from residential, commercial, institutional, and some industrial activities. MSW often comprises both inorganic (e.g., glass, metals, and many synthetics) and organic (e.g., food, yard trimmings, paper, cardboard, and timber) components. Construction and demolition debris (C&D) is increasingly managed separately. MSW can include toxic materials such as fluorescent lamps, paint, batteries, and other electronics. "Solid" waste, as regulated by the U.S. EPA, can also include liquids, semisolids, or gases.

Local definitions of MSW can be highly variable. The composition and volume of MSW varies by geographic location, economic structure, the extent of urbanization, and the socioeconomic status of individual communities. It can also change over time due to changes in MSW regulations (e.g., landfill bans for certain materials), recycling programs, and citizens' lifestyles, as well as population and economic growth.

According to national estimates by the U.S. EPA (2016a), Americans generated 258 million tons of MSW in 2014, which is nearly triple the mass generated in the 1960s. At present, over half of MSW is landfilled. Another 13 percent is combusted for energy recovery, and the remaining one-third is recycled. Food scraps are the largest single component in the MSW disposal stream.

Drivers of MWM Paradigm Change and Challenges

MWM involves all stages of material storage, collection, transfer, treatment, and disposal. Its historic, political, and economic contexts are key to understanding current management practices (Andrews 2002, 542). Factors such as priority goals, the role of the public sector, the involvement of private sectors, the market structure, financing strategies, and the transformed view of waste residuals have evolved greatly over time.

Drivers of MWM changes include health and environmental concerns, waste disposal capacity shortages, resource constraints and scarcities, the significant growth of the waste management industry, and social injustice concerns. Challenges include tensions between local efforts and global impacts, efficiencies versus equity and environmental justice in facility siting decisions, limited local data and regional variability of waste streams and disposal practices, and short-term actions versus long-term impacts.

MWM fundamentally interacts with local planning through the sources of waste discards: people and the built environment. Planners' involvement in MWM, however, has been largely limited, with a focus on infrastructure development and facility siting in particular. There does not appear to be a standard approach to addressing MWM in plans, and solid waste elements are often overlooked by planners when making comprehensive plans.

The common focus is to find solutions to the "end-of-pipe" effects of socioeconomic activities. But focusing on waste removal and disposal, instead of examining the sources of waste generation and the entire life cycle of waste materials and products, has left out many unutilized strategies that planners can and should employ for a more economically prosperous, environmentally sound, and socially equitable society.

ENVIRONMENTAL AND SUSTAINABILITY PLANNING FOR MWM

The environmental impacts of MWM activities can occur locally (e.g., noise and land-use changes), while other associated impacts can be regional or even global (e.g., water contamination, air quality, and climate change).

All MWM activities generate negative impacts that need to be mitigated, but the magnitude of environmental stress and pollution from final disposal activities (landfills and incinerations) are far greater than methods such as composting and recycling. Of the 188 toxic air pollutants regulated under the Clean Air Act, 30 may be emitted during the waste decomposition process in landfills (U.S. EPA 2006). In addition to air emissions, landfill leachate can contaminate groundwater that may migrate offsite. Waste collection and transportation also create negative impacts; they generate pollution, impair the aesthetic value of the natural environment, and increase traffic accidents (Wright and Boorse 2011). Recycling facilities, despite reducing landfill disposal and raw material extraction, can also have local impacts on the environment and surrounding communities.

The known environmental impacts of MWM have led to multiple federal regulations. The passage of the Solid Waste Disposal Act in 1965 prohibited open dumping, set minimum safety requirements for landfills, and required states to better control their solid waste. Its 1976 amendment, the Resource Conservation and Recovery Act (RCRA), was passed as a cradle-to-grave approach rather than an end-of-pipe management of solid waste. Waste management hierarchy priorities were established by the Pollution Prevention Act (PPA) in 1990. Other regulations relating to MWM include the Clean Air Act (CAA), which controls emissions from both waste transportation and incineration facilities, and the Clean Water Act (CWA), which prohibits pollutant discharge into navigable water bodies. The Interstate Commerce Clause of the U.S. Constitution applies to waste transport.

While federal regulations mostly target hazardous waste, nonhazardous municipal solid waste is largely the responsibility of local and state governments. Household waste, which accounts for 55 to 65 percent of MSW, is still underregulated in the U.S. (U.S. EPA 2015a). Presently, there is no U.S. federal regulation that mandates residential recycling, nor a national plan that sets goals for MWM. All states are required to implement plans to maximize waste reduction and recycling, but efforts at the state and local levels vary greatly.

Regions on the west coast and in the northeast play a leading role in environmentally proactive policy making and have voluntarily enforced stringent standards, such as zero-waste programs that aim to minimize landfill disposal by transforming the cradle-to-grave model of MWM to cradle-to-cradle processes. Zero-waste goals are often accompanied by plans promoting recycling and composting programs, as well as the economic considerations of disposal fees and the recycling market.

Local decision makers have various options for MWM. For planning purposes, there are many trade-offs between the availability, cost, and environmental implications of various MWM strategies. The same MWM strategy may lead to various implications when it is applied at site-specific scales within the local "mix" of technologies determined by local stakeholders (e.g., community officials, planners, technical or financial partners, and regulators) (Bogner 2016).

INFRASTRUCTURE PLANNING FOR INTEGRATED MWM

Sustainable MWM infrastructure planning involves at least five considerations: the capacity and size of needed infrastructure for the regional MWM volume; the type(s) of infrastructure suitable for the municipality or region; the perceived and potential environmental hazards and risks in conjunction with that infrastructure; locations for the requisite MWM facilities; and financing of the construction, operation, and maintenance of new, existing, and closed MWM facilities.

All activities along the logistics chain of MWM necessitate infrastructure support. According to a national facility survey by the Environmental Research & Education Foundation, the U.S. had 9,028 MSW facilities in 2013, comprising 3,913 recycling facilities, 3,494 composting facilities, 1,540 MSW landfills, and 81 waste-to-energy (WTE) plants (EREF 2016). MSW management also requires collection and storage bins, collection and transportation fleets, and mobile facilities (e.g., for waste pickup or exchanges).

Planning Considerations for MWM Infrastructure

Recycling and disposal should be key components for planners when considering proposals for renovation, demolition, or residential, commercial, or industrial development (Daniels 2014, 238). In addition to assessing the infrastructure needs for waste residual collections, waste diversion and recycling infrastructure should also be examined and supported.

For MWM planning at the community level, a common approach for estimating future waste generation volume is to multiply the projected population growth by a uniform per capita waste generation rate. While most current practices are based on the assumption that waste volume increases in proportion to economic and population growth, it may be necessary to decouple these trends.

What research has been performed on the health impacts of MWM infrastructure has found that landfills and incinerators may have adverse health impacts on nearby residents, such as certain cancers and birth defects (Aydin 2016; Mattiello et al. 2013). Planners should help minimize environmental hazards and community nuisances from MWM facilities by strategically siting MWM facilities and working with communities and partners, such as health professionals and researchers, for more effective educational programs, technical assistance, and pollution prevention programs.

A complementary and well-balanced combination of MWM infrastructure types can improve the efficiency of waste management services and help achieve cost savings. Instead of focusing on end-of-pipe disposal solutions, MWM infrastructure planning should cover all life cycle stages of MWM, from waste reduction to long-term monitoring and management of disposal facilities after their closure.

STRATEGIC FINANCING FOR FULL COSTS AND EXTERNALITIES

Sustainable MWM necessitates the support of sustainable funding. Waste material collection, sorting, recovery, recycling, and final disposal services, as well as community education programs, all create demand for infrastructure and labor and therefore incur costs. Traditionally a public service, solid waste management is one of the largest items on the municipal budget for many cities, exceeded only by schools and roads (Daniels 2014; World Bank 2012).

Revenue is primarily generated from the property tax millage that typically covers waste collection and disposal services. Other revenue can include landfill tipping fees and energy recovery from landfill gas if those facilities lie within the jurisdiction. Revenue can also come from fees tied to recyclable materials, waste infrastructure, and vehicle permits.

Annual local government finance surveys by the U.S. Census Bureau (2013) show that the revenue-to-expense ratio of waste management services ranges from less than 1 percent to more than 95 percent. For municipalities that have achieved a high revenue-to-expense ratio, the most important contributor has been the successful implementation of recycling programs. By promoting recycling, reuse, and recovery, cities reduce landfill tipping costs while receiving revenue from selling recycled materials.

Accounting for Full Costs and Externalities of MWM

To ensure financial viability and efficiency, short-term, long-term, private, and social costs should all be included in MWM planning. The U.S. EPA (1997) has suggested a full cost accounting (FCA) approach that includes not only upfront and operating costs, but also long-term monitoring and maintenance costs. The environmental and social costs in the FCA framework are still largely overlooked in current practice and in pricing MWM services. The negative externalities of landfill disposal and the positive externalities of recycling both need to be factored into pricing and budgeting for waste management services.

One way to compensate for the negative social and environmental costs of MWM services is through market-based instruments (MBIs), which can be used to provide economic incentives for environmentally conscious activities (such as waste reduction and recycling), and disincentives for polluting activities (such as littering and disposal). These include Pay as You Throw (PAYT) systems, where users are charged rates based on the amounts of waste presented for collection, and recycling rewards programs that provide financial incentives for good recycling habits.

Balancing Environmental and Economic Goals

In response to the financial challenges brought on by the economic recession, municipalities have adopted a wide range of changes in waste management programs without increasing fees or interrupting services in response to reduced revenue for waste management (Ai and Grande 2012).

A common strategy to reduce the costs of landfilling by diverting waste from landfills is expanding the scope of recycling by accepting more recyclable materials and promoting composting (Tresaugue 2010). Reorganizing waste collection methods can save cities money through efficiency. Some cities, such as Seattle and Portland, have found that trash only needs to be collected biweekly instead of weekly, which saves significant operating costs (CBC News 2011; Hunt 2011). Many cities have resorted to private services for waste management (Church 2011; Paperny 2011).

While a single approach can be beneficial, multiple programs can be combined for even greater impacts. For example, several cities have reduced the frequency of garbage collection and promoted recycling at the same time by increasing the size of recycling bins, adding to the number of recycling drop-off sites, and expanding the types of recyclable materials accepted, as well as other approaches. Strategically planned economic incentives for waste reduction and recycling, coupled with disincentives or penalties for waste disposal, can improve both the environmental performance and financial strength of municipalities.

FOSTERING ECONOMIC DEVELOPMENT THROUGH WASTE DIVERSION

It is an underappreciated fact that waste diversion, whether regulatory or market induced, creates new businesses and jobs. More jobs are created by recycling material than disposing of it into landfills because once material has been collected, hauled, and placed into the landfill, its value becomes nearly zero. Reuse, recycling, and remanufacturing (R3) activities provide a range of opportunities to create value and jobs from further material handling, sorting, processing, manufacturing, distribution, research and development, marketing, sales, and related administrative and support activities. Further, conventional waste collection is occurring in an increasingly concentrated waste management industry, while waste diversion provides opportunities to create jobs and businesses at the local level.

While the need to address long-term unemployment and the challenges of the hard-to-employ may be greatest in our largest cities, all local and regional economies may wish to explore the business and job creation potential from implementing waste diversion and waste-to-profit strategies that will grow the R3 industry.

Reuse, Recycling, And Remanufacturing (R3)

One significant way the R3 industry can be stimulated is through legal mandates at the state or local levels that require general waste diversion from landfills. R3 development can be industry driven because of sustainability objectives or fear of legislative response, as in the Carpet America Recovery Effort (CARE) of the major U.S. carpet manufacturers. The recovery of valuable or rare materials can be a strong motivator of R3 development, and is a key impetus for the zero-waste and waste-to-profit movements. Zero-waste programs seek to eliminate waste by designing products and processes such that discarded materials become resources for other uses. The waste-to-profit movement matches local generators of wastes and byproducts with local businesses interested in recycling the materials as substitutes for raw materials, making waste a significant economic resource.

Both for-profit and nonprofit firms are engaged in R3 activities. The for-profit sector includes large and sophisticated firms, some of which process very high-value materials (e.g., medical instruments and precious metals). There are also many small and medium-sized businesses engaged in R3 activity. The U.S. used merchandise stores industry, made up of nonprofit and for-profit resale shops, consignment shops, thrift shops, and antique stores, has 25,000 stores and a combined annual revenue estimated at $17 billion (NARTS 2010). Some nonprofits engaged in R3 activity have a goal of providing employment to ex-offenders or the homeless.

Planning and Policy Tools for Economic Development from Waste Diversion

The R3 industry in the U.S. is still in its infancy, and much of its economic and job creation potential has yet to be realized. Increased waste diversion and accompanying growth of the R3 industry requires widespread adoption of more supportive public policies at all levels of government.

Some states and localities have shown the effectiveness of "stick" policies and related legislation that ban specific materials from landfills (e.g., carpet, electronics, mattresses, and tires), impose consumer deposit fees for easily discarded (and easy to return) items such as beverage containers, and require recovery fees as well as producer responsibility for specific materials. "Carrot" approaches include providing start-up and small business assistance, developing career paths and apprenticeships through education and workforce training programs, and offering relevant economic development incentives to nonprofit R3 businesses.

All R3 activity needs appropriate space and infrastructure. Land-use planning and zoning that fosters the appropriate siting of recycling facilities within population centers is essential. So, too, is transportation planning and urban design that addresses the negative externalities associated with transporting and storing material.

BALANCING EQUITY AND EFFICIENCY

The siting of MWM facilities has historically been controversial because of its complex implications in economic, environmental, social, and political terms. Due to anticipated increases in road traffic, noise, air pollution, and associated health risks, MWM facilities, especially disposal and hazardous waste facilities, have historically been at the top of the list of not-in-my-back-yard (NIMBY) activities (Kraft and Clary 1991; Lober and Green 1994; Rushton 2003).

Many studies have examined the linkages between the location of MWM facilities and the demographic characteristics of their surrounding communities. Minority communities do not have the necessary financial resources or organized advocacy to sustain the long-term battle against environmental injustice. Environmental justice initiatives emerged in the 1990s aiming to "correct environmental discrimination and disparities based on race, ethnicity, income, gender, culture, workplace, and geographic location" (Bullard 1996, 497).

Local Planning Tools for Equitable MWM

Understanding and limiting the possible adverse effects of MWM are imperative not only to avoid social inequities but also to improve the environmental performance of MWM. Communicative planning, instead of the rational comprehensive model, has been advocated for more efficient and equitable MWM planning programs (Hostovsky 2006). Planners should help foster alliances among stakeholders of various interests so they can build consensus and establish cooperation for the common purpose of improved MWM systems (Anschütz, IJgosse, and Scheinberg 2004).

Compared to disposal activities that are stringently regulated at the federal level, recycling and other MWM facilities still need more policy support and guidelines. Land-use categories and design regulations have been developed to mitigate such concerns and may help reduce opposition to proposed recycling centers. Some municipalities have adopted or amended their ordinances to address community concerns and ensure business interests at the same time.

Given the complex economic, technical, and political factors, planners may face many challenges in battling for environmental justice when considering MWM facility siting or evaluating the fairness of impacts in the first place. Planners' knowledge about communities can be particularly helpful. Factors to be considered in identifying, addressing, and eliminating environmental disparities include historical land use, population density, residential housing patterns, neighborhood formation, and facility siting within neighborhoods, cities, regions, and states (Bullard 1996, 495–496).

Equity planning is not just about the distribution or redistribution of MWM costs and benefits. Assessing the fairness of MWM impacts may involve research and partnerships among many disciplines, including toxicology, geography, epidemiology, sociology, and economics. Equity planning for MWM is about education, training, and behavior changes to achieve the integrated goals of economic development, environmental protection, and social equity.

PLANNING SMART WITH COMMUNITY-SPECIFIC MWM DATA AND TECHNOLOGY

MWM necessitates a thorough understanding of waste stream characteristics, which can vary by socioeconomic conditions, climate, industry structure, development density, urbanization scale, and other factors. MWM data at refined geographic scales and shorter intervals can better inform MWM policy making and improve the efficiency and effectiveness of MWM.

An analysis of local inventory is essential for proactive and efficient MWM planning. Unlike other centralized urban services, such as metered water, gas, or electricity, solid waste and recycling materials can be difficult to track to the end user. In a "big data" era when data is becoming available in greater frequency and greater volume, MWM statistics are still rather limited, especially at refined geographic scales.

Community-Specific Waste Management Planning

While higher landfill diversion rates and lower disposal volumes are common goals of local MWM, the logistical challenges and cost implications of meeting these goals vary across communities. Waste composition is community specific and changes over time. Content analyses of landfill-bound waste streams can help planners identify missed opportunities for recycling specific types of materials in various regions. Accordingly, goal setting and policy design can be tailored to local characteristics.

Many states have conducted waste characterization studies and adopted them as the basis for solid waste plans, which are required by federal regulations in the RCRA. When coupled with local demographic and community profiles, the refined scale of waste characterization data can help planners identify neighborhoods that tend to throw large amounts of recyclables in the garbage and target groups for promoting recycling and education programs. Because waste characterization studies require resources and are labor intensive, however, they are not regularly undertaken.

Adopting and Investing in "Smart" MWM Technology

Emerging technologies, including information and communications technology (ICT), renewable energy fleets, and engineering solutions have been applied through the logistics chain of MWM operations. Smart MSW technologies include the use of radio-frequency identification (RFID) tagging and GPS to streamline waste collection, optical sorting to enhance automation at processing facilities, gasification of MSW into advanced biofuels, and sensors and software that remotely monitor landfill performance (Lawrence and Woods 2014, 2). The adoption and implementation of modern technologies are expected to improve the efficiency of material and waste management services, accelerate the integration of waste management operations, facilitate data collection, and offer opportunities for stakeholder participation.

Employing Planning Tools that Facilitate MWM Data Collection

Community-specific and source-generated MWM data are of critical value for waste diversion programs (Leigh et al. 2007; Lindsey and Lechner 1989). One planning approach is to incorporate the considerations of recycling and data reporting in city ordinances. San Francisco was the first U.S. city to adopt a local municipal ordinance for source separation of refuse, including organics (CIWMB 2011). Refuse collectors are required to inspect the discards in the container, collect and report information about violators (e.g., placing recyclables in trash cans), and report material-specific volumes every year. At the operational level, there are also potential opportunities to engage citizens and stakeholders to achieve the goals of efficient data collection and waste diversion from landfills. For example, Pay as You Throw (PAYT) programs not only encourage landfill-bound waste reduction, but also provide waste generation volume data at the community or neighborhood level. Increasingly, web-based tools have been developed and employed for MWM data analysis, information sharing, and policy development.

ADVANCING PLANNING'S ROLE IN SUSTAINABLE MWM

Material and waste management (MWM) activities highlight the challenges that each city faces to achieve sustainable development. The increasing pressure of achieving sustainability has been a direct result of urban population growth, land development and conversion, decreasing life span of products, and increasing intensity of material uses. A city cannot be sustainable if it generates more waste than it can assimilate. Planners need to better understand MWM to minimize hazards to the environment while improving the efficiency of economic development and promoting social equity.

Planners naturally possess the skills and knowledge needed to contribute to proactive and efficient MWM. Planners are familiar with local and regional demographics, employment characteristics, and economic structures. They are adept at using local data for dynamic estimates of infrastructure and community planning, and waste management programs may naturally fit into the long-term plan. Planners place a special focus on spatial implications of policy making and are ready to incorporate local characteristics to develop community-specific waste management policies. Additionally, planners hold holistic views of regions and are the most capable of managing the highly interdisciplinary issues of waste management. A good understanding of the complexity in MWM helps minimize the conflicts between stakeholders and planning objectives, and subsequently promotes social equity, environmental effectiveness, and economic efficiency in waste planning.

Sustainable MWM requires transparent, high-quality data for program design, implementation, and assessment. The considerable inconsistencies in the definitions of solid waste directly lead to discrepancies in waste statistics and difficulties in regional comparisons or long-term planning. Opportunities exist for the U.S. to strengthen national and regional coordinated efforts in MWM data tracking through a life cycle system perspective.

Fundamentally, sustainable MWM needs to transform the focus from minimizing pollutants to maximizing the efficiency and value of materials and resources. A few states in the U.S. and several other countries have been leading sustainable MWM practices by rethinking "waste" as "materials" and fostering the culture of 6Rs: respect the value embedded through the life cycle of all materials and refuse materials and products that we do not have to consume; reuse where possible; recycle products at the end of their useful lives; reduce waste generation at the source; recover energy or materials from the waste stream; and replenish the ecological system.

Opportunities are lost if we continue to focus on residuals disposal and examine waste materials simply as the byproducts of socioeconomic activities. MWM is complex, which demonstrates the interconnectedness of economic, environmental, and social dimensions. By highlighting some of the interconnected strategies of MWM, this report stresses the missed opportunities at the local level and the need of collaboration among all planning departments and stakeholders for sustainable MWM.