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Technological challenges for effective development towards sustainable waste management in developing countries: Case study of Bangkok, Thailand

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ABSTRACT

One of the consequences of rapid urbanization and a growing population is an increasing amount of municipal solid waste. Cities around the world have been facing the same global waste management dilemma. The increasing amount of waste has created the needs for an effective management system that provides reliable service, as the current systems in place are failing to respond to the demand. From the service perspective, waste management is an environmental public service. Applying appropriate technology is considered a potential solution to increase waste management performance. Therefore, in this paper, technological challenges are studied as a potential way to alleviate the impacts of ineffective waste management services. The success factors to overcome technological gaps which can be occurred along management chain are identified on the basis of service concept. Bangkok is selected as an urban city in a developing country that is experiencing problems caused by ineffective waste management services. The research methods used for obtaining and analyzing data include questionnaire surveys, interviews, and literature reviews. In addition to problems with waste collection and waste transportation services, a key factor contributing to ineffective waste management is lack of participation from local residents. In this paper, ways of increasing the effectiveness of waste management services are proposed, success factors to overcome technological challenges are identified, and the implications of these challenges are discussed.

1. Introduction

An overwhelming amount of generated waste is a serious side effect of increasing consumption and production. The demand for more goods and services to meet human needs is creating a huge amount of waste that is being disposed of into the environment. The increase in waste tends to correspond with the economic development and rapid urbanization of society [1,2]. The amount of municipal solid waste (MSW) generated has been rapidly increasing in the past few decades [3]. Worldwide, approximately 1.3 billion tons of MSW is now generated per year, and this number is expected to reach 2.2 billion tons by 2025. Urban areas of Asia are conservatively forecasted to generate 1.8 million tons of MSW per day by 2025 [4]. The increasing generation of MSW is a serious problem, particularly for urban areas in developing countries with depleting landfill spaces and limited capacities [5]. This increasing waste, along with more awareness of human health, environmental impacts, social problems, and depleted natural resources has created the desires for strategies and techniques to reduce the amount of waste and sustainably alleviate MSW related problems [6].

The provision of adequate sanitation services is crucial. Proper disposal of all waste is vital to mitigate health risks [7]. Waste management is a basic public service that should be provided to all residents who will eventually make the system run itself productively and ultimately contribute to a better system to improve quality of life. However, municipal solid waste management (MSWM) is an increasingly burdensome challenge for stakeholders, particularly residents and responsible authorities in many cities around the world [8]. There have been many methods proposed for dealing with ineffective waste management systems. Supply chain management, life cycle analysis, and integrated waste management

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systems have been mapped into waste management strategic policies [9,10]. Improved MSWM is a critical component of efficient city management, but it requires a high investment in terms of workforce, equipment and infrastructure, and other operating costs [11]. This has necessitated calls for an improvement to the currently inadequate level of waste management services being provided by authorities.

MSW is in urgent need of effective solid waste management strategies that can be applied to all types of waste—not only at the national level, where guidelines, targets, and strategic action plans are set, but also at the local level, where waste management actually takes place [12]. Difficulty in providing waste management services corresponding to demand is typically due to institutional, technical, and financial constraints at the level of national to local government, as well as in the private sector [13,14]. Management systems and techniques are currently being developed to decrease the environmental burden of waste generation, but there is still a need to provide a sustainable waste management system that effectively supports residents. It is essential to apply appropriate technologies to waste management systems. In this paper, the objectives are to identify the technological challenges facing the current MSWM system and to overcome the technological gaps in Bangkok, Thailand as a representative urban city in a developing country. Technological gaps in management processes are one of the main causes of poor performance in waste management systems. To identify the success factors for a sustainable MSWM technology transition, the paper is aimed to incorporate human aspects of technology for MSWM by investigating service providers and service recipients' experiences and attitudes of MSWM.

2. Thailand waste management scenario

2.1. Overview

Waste is defined as any residual material from industrial and human activities that has no residual value [19]. According to the Thailand Public Health Act 1992, MSW includes waste generated from community activities, residential households, commercial and business establishments, fresh markets, institutional facilities, and construction and demolition activities, excluding industrial waste [16].

According to a study by Garrod and Willis, there are six functional elements grouped by activities associated with MSWM: waste generation, waste storage, waste collection, waste transfer and collection, waste processing, and waste disposal [20]. In order to have an effective and sustainable MSWM system, it is important that all applied and social studies be linked with a good management plan that involves all sectors at all levels. The conventional MSWM system consisting of waste trucks, waste bins, and landfills is currently still in use in many countries.

The increase of waste generation and inefficient waste management services pose serious challenges to the responsible parties, especially local authorities. One obstacle that has a significant impact on the effectiveness of MSWM systems is the use of inappropriate technologies. Appropriate Technology (AT), a term coined by Ernst Friedrich Schumacher in 1973 [26,27], refers to technologies used in the developing world. Schumacher stated in his work that AT should be small scale, low capital, energy efficient, and controlled by the local community [28,29]. This concept has now been applied in many industries, including waste management. Therefore, AT is one part of the solution in achieving sustainable and safe waste management services.

The waste situation has currently reached a threshold level, especially in many of the developing countries in Asia. According to the U.S. Environmental Protection Agency, MSW generation has increased by 2.6 times from 1960 to present [12]. This increase in the amount of new generated waste is in addition to the huge amount of waste currently sitting in numerous landfills. As stated earlier, MSWM is a public service, and effective waste management services should be provided to all people to enable them to live in a healthy environment with adequate hygiene and a high standard of living. The effectiveness of a waste management system is strongly dependent on the effectiveness of the underlying MSWM system. Unfortunately, the MSWM systems in many developing countries are more or less ineffective, despite taking a relatively high proportion of the budget. This leads to incomplete historical long-term planning, which further degrades the effectiveness of a waste management system [15].

Bangkok, the capital and the fastest growing city in Thailand, has continuously witnessed accumulating MSWM problems. As other urban cities in developing countries, the amount of generated MSW in Bangkok mainly depends on population, economic growth, and the efficiency of reuse and recycling systems. Both economic development and the higher number of population have dramatically increased MSW generation amount in Thailand, from 48 million tons in 1982 to 65 million tons in 2012. As of December 2012, the population in Bangkok was 5,673,560, or about 9% of the total population in Thailand, and there were more than 300,000 tons of MSW generated monthly in Bangkok [16].

Typically, the larger and denser a city, the more sustainable it is in terms of per capita use of resources and production of waste from the perspective of economies of scale [17]. However, the quality of the environment is a matter of growing concern. The Bangkok Metropolitan Administration (BMA), which is responsible for the city management of Bangkok and for the well-being of its residents, is aware that waste increase is causing big problems. Like other municipalities, the BMA seeks to avoid environmental pollution by encompassing various strategies, such as 3 Rs, efficient waste collection and disposal system campaigns, and effective participation in the government, public, and private sectors. Since 2004, community based solid waste management (CBM) has been applied to reduce waste generation at the source and to create mutual benefit between local communities and the BMA [18]. In addition to the need for an integrated waste management system that suits the characteristics of the city, solid waste problems specifically in Bangkok still require further attention through the involvement of related parties, a well-designed long-term master plan, and most importantly, applications of effective technologies to each management process.

2.2. Municipal solid waste management situation

Under the BMA, the Department of Public Cleansing (DPC), together with the 50 Bangkok City districts, is responsible for cleaning the city and reports the amount of waste collected from all districts. MSW is collected from receptacles in front of houses, buildings, and other designated locations on specific dates and times. The collected MSW is first transferred to one of three locations (called transfer stations)—On Nut, Nong Khaem, or Sai Mai—and then transported to one of two landfill sites in two nearby provinces, Nakonpathom and Chachoengsao. Hazardous waste from three stations is managed and transferred to an incineration plant in Samutprakarn province by a contractor. In 2013, the BMA collected an average of 8,766 tons of MSW per day, which represents 21% of the country's total waste amount. About 90% of the collected waste is disposed of at the two sanitary landfills and the remaining 10% is composted at a waste transfer station in On Nut [19].

There are four types of MSW in Bangkok: organic waste, general waste, recyclable waste, and hazardous waste [16,18]. In terms of