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Sustainable Solid Waste Management: Socio-economic Considerations

Evangelia N. Lakioti[a], Konstantinos G. Moustakas*[,b], Dimitrios P. Komilis[c], Asimina E. Domopoulou[a], Vayos G. Karayannis[a]

[a]Dept. of Environmental Engineering, Technological Education Institute of Western Macedonia, 50100, Kozani, Greece
[b]School of Chemical Engineering, National Technical University of Athens, 15773, Zografou Campus, Athens, Greece
[c]Dept. of Environmental Engineering, Democritus University of Thrace, 67132, Xanthi, Greece
konmoust@central.ntua.gr

In the present study, recent socio-economic aspects in solid waste management (SWM) are discussed. This manuscript considers economic viability and public support as the key factors for the implementation of SWM schemes, along with technological advancement and ecological impact. This holistic approach links society, economy and the environment, towards a sustainable development. The significance of economic issues to accelerate the implementation of innovative environmental technologies is broadly recognized, and economic drivers are considered critical parameters for policy-makers to develop effective strategies. Also, the study of social perceptions and attitudes can provide an insight into several factors that affect the shaping of public awareness on environmental actions. Much work has been reported that points out the role of relevant social and economic research for detailed plans to enhance public acceptance of emerging technologies balanced with cost-effectiveness. SWM appears to be a complicated procedure involving multiple environmental and socio-economic criteria. The influence of socio-economic status on both the quantity and composition of municipal solid waste in designing an effective SWM plan has long been recognized, and the importance of reliable information has been highlighted. Various socio-economic factors influence the recycling behavior and the willingness to pay for the introduction of recycling actions into SWM services. Decision-making in specifying realistic policy objectives and operational measures and alternatives to find appropriate solutions to SWM problems is crucial. The transition from a traditional SWM scheme to a more integrated approach often requires the encouragement of the participation of multiple stakeholders in the society: government, municipalities, industries, experts, and certainly the public. Conclusively, social acceptance and awareness should be considered along with economic issues and the evaluation of environmental impacts, to ensure the efficient implementation of sustainable SWM actions.

1. Introduction

The significance of economic issues to accelerate the implementation of innovative environmental technologies is broadly recognized. Economic drivers are considered critical factors for policy-makers to develop relevant effective strategies. On the other hand, the study of social perceptions and attitudes, which refer to citizens' understanding and favorable or unfavorable evaluations of an issue, can provide an insight into several parameters. These parameters affect and shape the public awareness of innovative actions related to the environment and energy. The social acceptability may form a factor constraining their implementation, expansion and ample use. Moreover, public support is frequently high at an abstract level, whereas the situation in a local context may be quite different. There are many different strategies for social participation; however, the public can be involved in a social project through: a) information about ongoing development (information), b) involvement in the decision-making process (planning participation), and c) financial participation in the project (Soerensen et al., 2003).

A lot of research work has been reported in the literature that highlights the role of social and economic research for detailed plans in communication and participation to enhance public acceptance of emerging cost effective technologies. For example, both social and environmental "pillars" of sustainability should be

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reconciled with the economic ones for the assessment of chemical plants (Sepiacci and Manca, 2015). The role of social perceptions, attitudes and participation in respect of the ambitious targets of deployment of renewable resources and the application of energy efficient technologies is increasingly emphasized, e.g. case studies for renewable energy technologies in Germany (Musall and Kuik, 2011) and in Finland (Moula et al., 2013), wind power (Yuan et al., 2015), pyrolysis for biomass valorization (Samolada and Zabaniotou, 2012), biofuels (Savvanidou et al., 2010), and water reuse (Hartley, 2006) are included.
Economic viability and social support are considered key factors of concern for the implementation of carbon capture and storage (CCS) technologies (Karayannis et al., 2014). Findings from relevant studies can offer insights into the best way for policy-making in order to develop CCS projects (Theeyattuparampil et al., 2013). Nowadays, the need for timely addressing climate change impacts and strengthening the adaptive capacity is increasingly recognized (Loizidou et al., 2016). Indeed, building a low-carbon economy for a transition to a low-carbon society represents an urgent priority (European Commission, 2013). Particularly, minimization of the equivalent carbon dioxide emissions generated and total cost, should be also the goal of optimization of integrated municipal solid waste management systems (Minoglou and Komilis, 2013). However, when evaluating potential carbon footprint reduction technologies, frequently conflicting objectives, such as economic efficiency and environmental impact, should be taken into account (Pintaric et al., 2015).
In the present study, recent socio-economic aspects in sustainable solid waste management (SWM) are discussed. These aspects consider economic viability and public supportiveness as key factors of concern for the implementation of SWM, along with the technological advancement and ecological impact aspects.

2. Socio-economic considerations in sustainable solid waste management

Recently, the amount of municipal solid waste (MSW) sent to landfills has been decreasing. Household composting has started to increase, whilst the recovery of recyclables keeps improving because of the implementation of relevant European Union legislation. Nowadays, the improvement of recovery performance and quality of materials collected by recycling is at the top of solid waste management (SWM) agenda. Nevertheless, SWM appears to be a complicated procedure involving multiple environmental and socio-economic criteria.
In order to assess sustainability in SWM technologies, models based on the principles of life-cycle cost (LCC) analysis are lately proposed. LCC can provide detailed cost items for all key technologies within modern SWM systems (Martinez-Sanchez et al., 2015). The applicability of models that are based on the multivariate econometric approach and apply statistical tools to forecast and manage the MSW was also demonstrated (Abdoli et al., 2011). Moreover, waste management pinch analysis (WAMPA) was proposed for studying the effect of recycling and cost reduction targets towards an improved waste management planning and an enhanced comprehension of SWM strategy (Tan et al., 2015). Furthermore, possible implementation of additional resource recovery from solid waste, such as nutrients from food waste, can be expected to further provide cost-recovery and to enhance MSW management financial sustainability (Amir et al., 2016). The aforementioned studies confirm that MSW generation is a complex function of socio-economic characteristics, climatic factors, as well as public policies and strategies.
For the evaluation of social sustainability in technology, the importance of social indicators engaging members of society is pointed out, and an approach to present the results along with economic and ecological indicators is suggested (Assefa and Frostell, 2007). Emphasis is placed on sustainable SWM (Wong et al., 2016). Particularly, the influence of socio-economic status on both the quantity and composition of MSW in designing an effective SWM plan for a city has long been recognized. A comprehensive study of the variables influencing solid waste production and recycling rate is considered crucial for identifying the mechanism of solid waste generation and forecasting future dynamics in the field (Grazhdani, 2016). Statistical techniques have been used to evaluate the relationship between diverse socio-economic factors and the composition of generated waste (Dennison et al., 1996a) and quantity (Dennison et al., 1996b). The importance of reliable relevant information has been highlighted in several studies: in order to assess solid waste generation, socio-economic parameters, such as education level, occupation (Khan et al., 2016), and family members and income (Suthar and Singh, 2015), should be accounted for. Moreover, factors including seasonal variation (Kamran et al., 2015), living habits, social attitudes, religious and cultural beliefs (Bandara et al., 2007), and even regional idiosyncratic features (D'Amato et al., 2015), may affect the amount and composition of waste.
The efficient citizens' participation in recycling schemes presents serious challenges for the MSW management system, and appears to be crucial for the achievement of household recycling targets. However, the so-called NIMBY (Not-In-My-Back-Yard) syndrome remains a constant impediment when procuring suitable land sites for the recycling receptacles (Byrne and O' Regan, 2014). That is although people frequently support SWM actions they oppose SWM facilities constructed close to their residences. Factors affecting participation attitudes should be confronted. Insights can be gained by responses to questions on the

type of materials that the residents are willing to recycle, the number of recycling bins or bags required at home, and the potential economic incentives to be imposed (Keramitsoglou and Tsagarakis, 2013). A study of the practices, processes and guidelines of domestic recycling at local level, as well as the problems encountered in the recycling procedure, can contribute to the understanding of the perceptions and attitudes on the recycling of different social, economic and cultural groups. Indeed, awareness raising and education campaigns, based on community-based involvement, appear to be essential for people's active participation in domestic recycling initiatives (Kotzé, 2015). In elementary schools, appropriate planning tools that document the development and performance of recycling programs seem to be limited, despite efforts to implement integrated SWM. Therefore, existing programs should be analyzed, whilst the phases required for a successful program should be identified. Successful techniques and utilization recommendations can be provided from the development of a framework for a recycling program implementation in an elementary school (Ward et al., 2014).

An extended theory of planned behavior (TRB) can be applied to investigate the main factors affecting the intention and self-reported behavior on recycling of packaging waste and printed paper. This theory is used in psychology to link beliefs, attitudes and behaviour. The findings can be utilized for the development of better recycling schemes and communication campaigns (Ioannou et al., 2013). The role of social influence and worldview (i.e., anthropocentrism) on the self-reported and observed recycling behavior, based on the self-determination theory, has indicated that self-reported and observed recycling behavior are correlated with each other (Huffman et al., 2014). Thomas and Sharp (2013) have explored what influence norms, habits, policy drivers and provision of recycling facilities had on people's recycling behavior to strengthen the supportiveness for recycling and the adoption of other sustainable behavior. Approaches on behavior change to minimize inclusion of non-targeted materials have been compared. For example, a comparison among one door stepping-based, one incentives-based and one delivering personalized feedback has been made. The personalized feedback was found to be noticeably the most cost-efficient one and also proved to be highly effective in reducing contamination (Timlett and Williams, 2008). Furthermore, for financing the introduction of new recycling actions into existing SWM services, various socio-economic factors influence the citizens' willingness to pay (Challcharoenwattana and Pharino, 2016). On the contrary, there is no guarantee that people will accept the societal risk or potential adverse effects imposed on them when giving authorization for handling or disposing hazardous substances (Geerts et al., 2016).

The examination of the relationship of household waste disposal with environmental concerns, citizens' awareness, and the satisfaction level for the local existing capacities, can contribute to decision making on MSW management sustainability (Al-Khatib et al., 2015). The techno-economic assessment may suggest a smoother transition from a traditional SWM system to an integrated one. This is particularly true in developing countries (Qdais, 2007). For policy makers, convenience, charges and communication are reported to be significant attributes of intervention to stimulate household cooperation in waste management (Briguglio, 2016). Furthermore, decision-making often requires the encouragement of the participation of multiple stakeholders in the society. Such stakeholders are government, municipalities, industries, experts, and certainly public (Soltani et al., 2015).

A comprehensive overview of the aforementioned studies is provided in Table 1. These studies were selected since they focus on various socio-economic aspects of solid waste generation, composition, characteristics, and sustainable management. From the economic point of view, emphasis is placed on the application of different models and statistic tools to attain cost reductions in the frame of an improved waste planning and management strategy. For evaluating the social behavior, including perceptions, attitudes, readiness, awareness, to achieve the necessary social acceptance of SWM actions, field research (survey) is usually conducted, by choosing participants/respondents from various stakeholders, applying appropriate sampling techniques, and gathering data using structured questionnaires, interviews or focus groups.

3. Concluding remarks

- The active involvement of society appears to be a key factor in improving understanding of people's behavior and establishing a high degree of confidence on SWM.
- Communication of expert knowledge and public participation should be promoted to strengthen the positive attitudes towards SWM systems. Emphasis should be given to enhance public acceptance and participation, and to encourage policy-makers to develop more effective strategies for the advancement of novel and cost-effective SWM systems.

In conclusion, social acceptance and awareness, along with the evaluation of economic issues and the environmental impact, should be taken into broad consideration, thus linking society, economy, environment and policy-making in a holistic approach, to ensure the efficient implementation of sustainable SWM actions.

Table 1: Socio-economic considerations in solid waste management (SWM)

Focus of Socio-Economic Aspects	Focus within the SWM System	Country of Study	Participants	Reference
Economic assessment of SWM	Waste management pinch analysis (WAMPA) with economic assessment	Malaysia	Case study	Tan et al., 2015
	Life cycle cost (LCC) of waste management systems	Denmark	Households	Martinez-Sanchez et al., 2015
	Multivariate econometric approach	Iran	Inhabitants	Abdoli et al., 2011
	Converting food waste into biogas on a household level	Indonesia	Household members	Amir et al., 2016
Socio-economic factors influencing MSW generation, quantity, and composition	MSW generation rate	India	Household members	Khan et al., 2016
	Factors affecting solid waste generation and recycling	Albania	Households	Grazhdani D., 2016
	Waste management and disposal	Italy	Inhabitants and annual tourist attendances	D'Amato et al., 2015
	Household solid waste generation and composition	India	In-house plan and workout of residential settlements	Suthar and Singh, 2015
	MSW management	Pakistan	Self-classified monthly income and family members	Kamran et al., 2015
	Waste generation and composition	Sri Lanka	Households	Bandara et al., 2007
	Household waste composition and quantities	Ireland	Households	Dennison et al., 1996a
Social behavior (perceptions, attitudes, readiness, awareness and acceptance) of SWM actions	Financing MSW recycling program: willingness to pay	Thailand	Household members	Challcharoenwattana and Pharino, 2016
	Hazardous substance activities	Netherlands	Inhabitants	Geerts et al., 2016
	Domestic recycling	South Africa	Women and domestic workers	Kotze et al., 2015
	Waste management plans; Household recycling	Ireland	Primary schools	Byrne et al., 2014
	Waste-reduction and source-separation plan	USA (New York)	Elementary schools	Ward et al., 2014
	Waste recycling	USA (Southwest)	Undergraduate students	Huffman et al., 2014
	Waste management policy at local level	Greece	Town residents	Keramitsoglou et al., 2013
	Household recycling targets	Greece	Households	Ioannou et al., 2013
	Dry recycling	UK	Town residents	Thomas et al., 2013
	Waste management	England	Town residents	Timlett et al., 2008
Multi-criteria decision-making (multiple stakeholders)	MSW management	Canada	Stakeholders and governments / municipalities	Soltani et al., 2015
	Waste treatment mechanism	Palestine	Individuals aged 18 years & older	Al Khatib et al., 2015
	Techno-economic MSW management	Jordan	Three main cities	Qdais, 2007
	MSW management		Households	Briguglio Marie, 2016

MSW: Municipal Solid Waste

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