

CHAPTER XVIII. MANAGEMENT INFORMATION SYSTEMS

A. Introduction

Information management is the process whereby data are collected and analysed for the purpose of planning, evaluating, and monitoring systems. Management information systems (MIS) play a critical role in the planning and operation of solid waste management services. One of the primary reasons for this importance is that several activities in solid waste management are empirical and do not follow a set of theoretical principles. Another reason is the fact that the quantity and composition of the wastes vary substantially as a function of time, as well as among types of generators. These variations further complicate attempts to not only evaluate but also predict the performance of a solid waste management system. Therefore, data acquisition and analysis become the principal steps for describing the operation and performance of solid waste management systems.

As a general rule, those responsible for the management of solid wastes in economically developing countries do not pay adequate attention to the use and importance of information management. Typically, evaluations of performance and effectiveness of the solid waste management system are limited to visual observations of primarily streets and disposal sites. Inadequate coverage by the collection services, uncollected solid waste, and fires and unpleasant odour generation at the disposal site typically are blamed on a lack of equipment and human resources. Rarely is a more fundamental problem considered, i.e., inefficient utilisation of available resources. Invariably, one of the most serious problems that is identified by those involved in the management of solid wastes in developing countries is an insufficient level of funds.

Acquisition of vehicles and hiring of additional employees do not necessarily result in efficient and effective utilisation of available resources. In order to establish efficient solid waste management systems, the efficacy of existing systems and subsystems must be thoroughly assessed. The results of the assessment can be used to plan and implement improved, more efficient systems.

Each of the planning and operational phases of the process requires that accurate information be collected and processed. The emphasis here is on accurate information and proper processing of the information. Unfortunately, on the rare occasions where some type of MIS has been implemented, the accuracy of the data is seldom evaluated and a large amount of data are not analysed. Consequently, the entire effort simply is wasted. In order to facilitate the collection, processing, storage, and utilisation of the data, it is necessary to implement an MIS.

The basic data for the MIS should be obtained not only from the solid waste management system but also from a variety of other sources, such as land use and economic development. In order to be useful, the data collected should be catalogued and filed in a manner that allows easy retrieval and utilisation.

During the planning process, information is utilised to establish solid waste management goals for the planning period, to determine resource requirements; and to make decisions on investments for collection, processing, and disposal services. Information on current and future population, commercial and industrial development, quantity of solid waste generated, land use, and other topics is used to estimate the levels of demand for the solid waste system and to set goals. The information is then used to develop various options to meet the goals. Based on an analysis of the options, a particular alternative is selected using criteria such as level of recycling,

waste diversion from landfill, or cost effectiveness. Using the selected option, resource requirements are determined and an investment schedule is developed.

With respect to the management of operations, information is used to evaluate the efficiency of the service and to improve the performance of the entire system. The types of data that are required include operation and maintenance history of vehicles and equipment, productivity of both equipment and workers, and expenditures.

If available, personal computers should be used to collect, process, store, disseminate, and utilise the information in planning and operational management. Information generated from actual operation of the services should be collected regularly (preferably on a daily basis) and stored on computer. Socioeconomic information relevant to solid waste management should also be collected and stored. These data are then processed to provide information in a useful form for subsequent utilisation. The processed information should be stored on magnetic media (computer disks) and printed on paper for use in planning and operational management. The use of personal computers also allows for online access to the processed information.

In addition to the operational data on solid waste management and socioeconomic statistics indicated in the preceding paragraph, information from technical publications; legal documents; and environmental data such as those required for environmental impact assessment of collection, processing, and disposal facilities should be obtained. This information should be used in planning, designing, and operating solid waste management systems. However, this type of information can be managed more effectively by a system similar to that used for the operation of a library. Therefore, it is advisable that the system for the management of literature should be developed separately from the basic MIS.

B. Evaluation of performance

The performance of a solid waste management system is a function of the amount and quality of resources allocated to carry out the services, as well as on the socioeconomic development and physical characteristics of the service area. The performance can be expressed mathematically as follows:

$$O = f(I, D)$$

where:

- O = the performance of the service,
- I = the resource inputs to the service, and
- D = the socioeconomic development and physical characteristics of the service area.

The variables related to the socioeconomic development and physical characteristics of the service area normally cannot be controlled by the authority. For instance, the width of a street could not be changed to allow passage of solid waste collection vehicles. Instead, the authority must modify its collection fleet to existing conditions in order to perform the required services.

On the other hand, the variables associated with resource inputs can and should be controlled by the authority. In fact, the success of a solid waste management system depends largely on how wisely available resources are utilised. Consequently, in order to improve the performance of its services, the waste authority should allocate available resources optimally. Resource allocation

should take into consideration the nearly continuously changing service demands and constraints due to socioeconomic development and physical characteristics of the service area.

Decisions on operational management usually are made based on the level of socioeconomic development, physical characteristics of the service area, and a predetermined total resource input. In small municipalities in developing countries, the resource input generally is dictated by the central government. Under these conditions, the authority must operate the system such that maximum performance is achieved. Based on the information presented in the equation, this becomes an optimisation problem; that is, O is to be maximised, having I and D as constants. Therefore, the authority must select a set of collection, processing, and disposal methods, among various alternatives, such that O is optimised.

In waste management planning, the desired performance (O) generally is fixed as a future goal of the plan, with the estimated level of socioeconomic development and physical characteristics of the service area (D), and the level of resources required to achieve the goal (I) at a minimum cost. Thus, the problem becomes one of optimisation of I having O and D fixed at a certain time. The minimisation of I is, therefore, a decision criterion used in the planning process.

In addition to these criteria for evaluation, a ratio of the service performance to the resource input or vice versa (i.e., O/I or I/O) can also be used for evaluating the efficiency of solid waste management systems.

In order to make these evaluation processes possible and analytical, the variables in the equation must be determined and measured. These variables generally are called indicators. The indicators typically are divided into: service performance (used to describe O); resource input (used to describe I); efficiency (O/I or I/O); and socioeconomic and physical conditions (used to describe D) [1,3].

C. Indicators

In the previous section, information required for solid waste collection and disposal services was classified into the following major categories: socioeconomic and physical condition indicators, service performance indicators, resource input indicators, and efficiency indicators. The classification was based on evaluation and decision-making processes used in planning and operational management. Unfortunately, the information required for planning is not always the same as that required for operational management. For instance, day-to-day operational instructions require timely information with respect to specific location, personnel, and equipment involved. Additionally, the instructions do not necessarily coincide with the evaluation framework discussed in the previous section. The design of solid waste processing and disposal facilities requires site-specific information that does not fit into the evaluation framework. The general indicators described in this chapter are intended mainly for use in the planning and monitoring of solid waste management systems, as well as for operational management.

A discussion of the indicators, divided by the various key phases of a typical solid waste management system (i.e., generation, storage, collection, transfer and transport, processing and resource recovery, and final disposal), is provided below. A list of specific indicators is presented in Appendix C [2].

C1. GENERATION

The indicators in this phase of the solid waste management system primarily are focused on socioeconomic and physical conditions. These indicators represent the type and level of demand for solid waste management services.

In the list (Appendix B), the indicators (excepting those that describe the administrative area and its corresponding population) represent the generators that require the collection service. Some of these wastes can be disposed properly without utilising the formal public or private collection infrastructure. For instance, the waste generated by some commercial establishments can be privately collected and transported to the disposal facility. In industrialised countries, industrial waste (particularly hazardous industrial waste) is collected, transported, and disposed of separately from other sources of waste. Consequently, as was indicated in previous chapters, it is important to clearly define the types of waste that are collected and disposed of by the municipality, or by individual households, institutions, commercial establishments, or factories, before appropriate indicators are selected.

The quantity of waste generated by each one of these sources (waste generators) is an indicator of primary service demand. These indicators can be used to estimate the quantity of waste generated under different conditions, such as a different population size and increased levels of commercial or industrial activities. Therefore, the indicators are also useful for estimating the demand for collection, treatment, and final disposal.

In addition to the quantities of wastes generated, the characteristics of the wastes (i.e., physical and chemical) provide essential information for determining appropriate management methods.

C2. ONSITE storage

As previously discussed, onsite storage is the point at which the solid waste generated is stored for eventual collection by the municipal authority or by its contractor. Onsite storage can be classified under two general categories: 1) individual storage serving the occupiers of a single dwelling, shop, or office; and 2) communal storage serving the occupiers of multiple houses, apartments, shops, or offices.

Normally, the responsibility for the acquisition and maintenance of individual storage containers rests with the owner/occupier of each unit. On the other hand, the authority usually assumes responsibility for purchasing and maintaining communal storage containers. Indicators relating to individual storage can therefore be classified as socioeconomic and physical condition indicators, while those relating to communal storage are considered to be resource input indicators.

C3. COLLECTION and transport

Indicators for collection and transport can be classified either as service performance indicators or as resource input indicators. These two general types of indicators can be used to calculate efficiency indicators.

C4. PROCESSING and resource recovery

Indicators for describing processing and resource recovery can also be divided into performance, resource input, and efficiency indicators.

C5. FINAL disposal

Indicators that can be used for final disposal are very similar to those for evaluating processing and resource recovery activities. The indicators are also divided into service performance, resource input, and efficiency indicators.

C6. ADMINISTRATION

Administrative activities do not produce measurable outputs in the service and, therefore, the type of information generated in the administrative section is not classified as a service performance indicator. One possible exception is the information generated on the type and number of complaints. This type of information is considered a service performance indicator and normally is processed by the administrative section.

The administrative section generally is responsible for activities associated with enforcement, public education, and public relations. Although these activities do not fall directly under the category of service performance indicator, they indirectly have a profound effect on the performance of the service. The information on these activities is useful for planning and operational management of solid waste management services.

D. Establishment of the management information system

Once the type of information that would be useful for the evaluation of the solid waste management service has been identified, the next task at hand is to determine the procedure for collecting, storing, processing, and distributing the information. A system in which information is collected, stored, processed, utilised, and disseminated is called an MIS. Several approaches have been suggested for the establishment of an MIS. The final form of a particular system is largely a function of the quantity of information to be collected and the level of resources (human, physical, and financial) available for the development and maintenance of the system. It is safe to assume that, in most cases, a large municipality or metropolitan area will generate more data and will, therefore, require a relatively sophisticated computerised system for information management. On the other hand, a small municipality may only require a manual system. A variety of system configurations are possible, depending upon the size of the municipality and resources available. Therefore, this chapter will not suggest a single prototype MIS; instead it will provide special considerations required for designing such a system.

D1. ORGANISATION

The first step in developing an MIS is to identify and designate the personnel who will be involved in collecting, storing, processing, and disseminating the information. In most cases, personnel that are actually working in the field are requested to either generate or collect data that are obtained through some type of reporting system. The data are then stored, processed, and disseminated by staff in the administrative section. However, the personnel who will be participating in the process, and the manner by which the information is to be transmitted from one staff member to another, depend on how the solid waste management system is organised in the municipality.

Large municipalities generally are divided into districts. In turn, personnel assigned to the districts are responsible for providing waste collection services. Processing and final disposal facilities usually are sited throughout the municipality and are utilised by more than one district. Processing and disposal facilities, therefore, do not normally belong to a specific district, but are part of the entire system. In such a situation, the information generated in the field is collected, stored, processed, and utilised for action at the district offices and the information relevant to processing and disposal is assigned to the municipality's headquarters.

Small municipalities normally have only one office responsible for the management and implementation of the waste management service; that office is responsible for collecting information from solid waste collection crews, as well as from personnel at processing centres

and disposal facilities. The office also is responsible for storing, processing, and using the information in the decision-making process.

In some municipalities, solid waste management is carried out by more than one agency. For instance, equipment maintenance is performed by the operations maintenance department, while the collection system may be the responsibility of the health department. In such a case, equipment maintenance records and information on spare parts, downtime, human resources input, and others should be transmitted from the operations maintenance department to the health department for monitoring performance and for the scheduling and purchasing of collection vehicles. This information also is required to evaluate the overall efficiency of the collection service. In designing an MIS for this municipality, both departments should be required to have individual, but compatible, management information systems.

D2. DATA collection

There are various methods for collecting data. Data can be collected from existing sources, by conducting special surveys, by taking measurements, or through regular reporting mechanisms. Of the indicators given in Appendix C, the information on most socioeconomic and physical condition indicators (such as administrative area, population, the number of households, and commercial/business establishments) normally is available from the municipal departments responsible for urban planning and public works. Therefore, such information should be collected from those agencies and should be frequently updated.

Waste characterisation surveys, such as those described in Chapter III, should be carried out to collect information on generation rates, physical composition, bulk density, and storage indicators. Physical and chemical characteristics of the wastes, such as calorific value and chemical composition, are determined through laboratory analyses. If these types of data are required, it is important to determine the capabilities and experience of the laboratories such that reliable data are obtained.

Information on the indicators for collection, transport, processing, resource recovery, final disposal, and administration can be obtained from the respective services through a regular reporting system.

D3. STORAGE and processing

Storage and processing of the data can be performed either manually or electronically. A manual system consists of first labelling and cataloguing the information, followed by an accurate procedure of filing and analysing it.

The development of personal computers has been such that they have become accessible to many institutions and individuals in developing countries. The use of personal computers for information management has become practical and popular due to increases in memory and storage capacities, as well as increasingly affordable prices. In addition, there are various commercially available software packages for general-purpose data management, such as spreadsheet and database management. These packages can easily be applied to municipal solid waste services. Other advantages of using computers include the capability of producing graphs, tables, and maps, and the ease in transferring information (networking), e.g., between departments.

In a municipality where a computerised MIS has already been developed or is in the process of being developed for general accounting or other purposes, the MIS for solid waste management planning and operations should become part of the overall computerised system as a subsystem.

Once this linkage is established, information can be shared among various departments in the municipal government.

E. Conclusions

A large amount of data is used for planning, designing, and operating municipal solid waste collection, processing, and disposal services. Due to the diversity of situations throughout the world, and in many cases within a particular country, it would be difficult to design a single MIS that would be capable of satisfying the needs of all solid waste management functions. Instead of proposing a comprehensive prototype MIS that would be applicable to most situations, in this chapter we suggest that a simple system tailored to local conditions be established with available resources and information specific to the locality. The system should be flexible and capable of expanding, as more resources are made available.

Using this approach, a series of indicators that can be used to evaluate the performance of solid waste management services has been presented. In addition, a general methodology for establishing an MIS has been proposed. It must be emphasised that, due to space limitations, a number of indicators that are useful for certain decision-making processes in waste management have not been extensively covered. These indicators include literature information, environmental data, and various design parameters. As previously discussed, these indicators cannot easily be incorporated into the MIS proposed in this chapter.

Finally, this chapter presents an MIS that would be utilised by municipal government officials and does not describe the type of information that would be required by a national agency.

F. References

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