Urban Environment Management: an Application of Carrying Capacity to Solid Waste Disposal

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1. Waste: Solid Waste

This section devotes in the first part to the explanations of waste generation and its definition. Solid waste is a part of waste and residential solid waste or refuse is the largest portion of solid waste to be disposed of. The reasons for ever-increasing domestic solid waste which usually enters municipal solid waste management system are given in the later part of the section. The statistical data of solid waste are presented both on the basis of per capita per day and on annual basis.

As population increases and more people are concentrated in urban areas, waste problem grows more acute. As standards of living goes up, the public demand better waste disposal service. At the same time, the higher standards of living complicates the problem by increasing the amount of waste produced and the cost of properly disposing of it. In large metropolitan areas particularly the disposal problem has reached serious proportions in recent years due to the steady exhaustion of available landfill areas, the impact of more rigid air, water, and land pollution controls, and the decline of markets for major salvage items such as ferrous metal and paper products (American Public Works Association 1970, P. 1).

Waste comes from human activities of production and consumption. As shown in the

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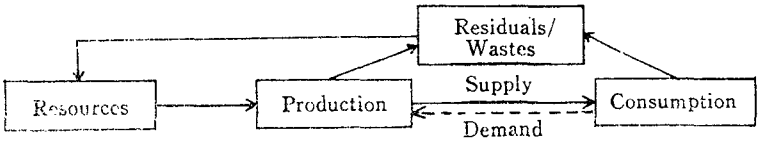


Source: A.B. Bishop et al., *Carrying Capacity in Regional Environmental Management*, Washington: EPA, 1974, p. 10.

Fig I-1. Schematic Diagram of Wastes Generation

following diagram, production activities generate residuals and wastes which are discharged to the environmental resource base, and likewise consumption goods themselves produce or become residuals and are imposed on common pool resources as externalities (A.B. Bishop et al., 1974, p. 10).

The word waste refers to useless, unused, unwanted, or discarded materials. Waste includes solids, liquids, and gases. The gases are principally industrial fumes and smoke; the liquids consist mainly of sewage and the fluid part of industrial waste; the solids are classed as refuse. The term "refuse" refers to solid waste and the two are used more or less synonymously (American Public Works Association, 1970, pp. 11-12). Solid waste may be defined as any solid matter that is discarded or thrown away. The U.S. Environmental Protection Agency defines the term as follows:

> Solid waste should be defined to include garbage, rubbish, and other discarded solid materials, materials resulting from industrial, commercial, and agricultural activities, and from community activities and should not include solids or dissolved material in domestic sewage or other significant pollutants in water resources, such as silt, dissolved or suspended solids in industrial wastewater effluents, dissolved materials in irrigation return flows or other common water pollutants (National Association of Counties Research Foundation, 1971, p. 20).

The component materials of solid wastes are classified by its kind and composition as shown Table I-1. Although the Table includes dead animals, abandoned vehicles, and special wastes of many types, these account for only a minor portion of all solid wastes and generally must be handled with specialized procedures. Various types and quantities of industrial and agricultural wastes are managed by the waste producers themselves and do not enter general municipal solid waste management systems (Schmalensee, et al., 1975, p. 177). Especially, commercial/industrial establishments which generate large volumes of waste and require daily collection service are usually served by private haulers(The Office of Solid Waste Management Programs, 1970, p. 4). In this context, the

Table I-1. Wastes by Kind, Composition, and Sources

	Kind	Composition	Sources
Refuse	Garbage	Wastes from preparation, cooking, and serving of food, market wastes, wastes from handling storage, and sale of produce	Households, restaurants, institutions, stores, markets
	Rubbish	Combustible: paper, cartons, boxes, barrels, wood, excelsior, tree branches, yard trimmings, wood furniture, bedding, dunnage	
		Noncombustible: metals, tin cans, metal furniture, dirt, glass, crockery, minerals	
	Ashes	Residue from fires used for cooking and heating and from on-site incineration	
	Street Refuse	Sweepings, dirt, leaves, catch basin dirt, contents of litter receptacles	Streets, sidewalks, alleys, vacant lots
	Dead Animals	Cats, dogs, horses, cows	
	Abandoned Vehicles	Unwanted cars and trucks left on public property	
	Industrial Wastes	Food processing wastes, boiler house cinders, lumber scraps, metal scraps, shavings	Factories, power plants
	Demolition Wastes	Lumber, pipes, brick, masonry, and other construction materials from razed buildings and other structures	Demolition sites to be used for new buildings, renewal projects, expressways
	Construction Wastes	Scrap lumber, pipe, other construction materials	New construction, remodeling
	Special Wastes	Hazardous solids and liquids: explosives, pathological wastes, radioactive materials	Households, hotels, hospitals, institutions, stores, industry
	Sewage Treatment Residue	Solids from coarse screening and from grit chambers; septic tank sludge	Sewage treatment plants; septic tanks

Source: Institute for Solid Wastes of American Public Works Association, *Municipal Refuse Disposal*, Chicago: Public Administration Service, 1970, p. 13.

bulk of municipal solid wastes, namely the general garbage, rubbish, and so forth are usually applied to solid waste management systems.

One of the primary causes of the increase in the volume of domestic solid waste is the rise in packaging materials (Skitt, 1972, p. 2):

If one considers the form in which we receive our household and personal needs, and compares this with even one or two decades ago, the statistics begin to make sense.... in fact everything is now sold in paper, cardboard, plastic, glass, or metal containers. Nor is this all. A vast quantity of garments are also sold in individual packs, and disposable paper underwear, sheets, tablecloths are now appearing in even greater numbers on the market.

Regardless of any variation of intake of potential refuse into the household, more waste is finding its way into the dustbin, as more and more smoke control orders, high rising dwellings, and central heating appliances appear. Higher living standards are also likely to lead to more food being thrown away as waste. As the number of wage earners in the family rises, there is neither the time nor the economic pressure to produce economical home cooking. Similarly there is less time to spare for the cleaning of bottles, jars, tins, and other food containers prior to disposal. Thus the putrescible content of house refuse remains increased (Skitt, 1972, p. 2).

Everyman, woman, and child in the United States now generates about 5.3 pounds (1967 data) of solid wastes per day in the form of garbage, bottles, tin cans, waste paper, plastic containers, used appliances, junked automobiles, etc. (Southwick, 1972, pp. 33-34). Of this, approximately 3 lbs. is estimated to be residential in origin, 1 lb. commercial, .59 lb. industrial, .18 lb. demolition and construction, and .55 lb. other (Schmalensee, et al., 1975, p. 179). Another source of information, Associated Press Survey, shows that consumer waste products include on an annual basis four million tons of plastics, more than 30 million tons of paper, 48 billion cans, and 26 billion bottles and jars. To this, science has added aluminum foil, nonreturnable bottles, disposable diapers, and that ultimate contribution to the culture: the tray that comes with the TV dinner (Einstein, 1970, p. 102).

II. Solid Waste Management: Disposal

Section II intends to make a foundation for applying the concept of carrying capacity to solid waste management. Solid waste management systems are generally divided into four processes: collection, transport, processing, and disposal. The application of carrying capacity is very related to the last step in the solid waste management, ie., final disposal of solid waste. The esssential operations of each diposal method are described: sanitary landfill, central incineration, on-site incineration, grinding refuse, feeding swine, composting, salvage and reclamation, and open dumps.

Schmalensee's prediction on thn quantity of wastes is impressive: assuming the U.S. population of about 210 million, roughly 268 million tons of solid waste are collected annually. In an uncompacted state (density of 8-10 lbs/cubic foot), this quantity of wastes could easily cover the State of Delaware to a depth of one foot. These figures exclude 10-15 per cent of household and commercial wastes and 30~40 per cent of industrial wastes that are self-collected and transported, as well as 3.1~3.7 billion tons of agricultural waste and crop residues, animal wastes, and mineral wastes. This huge quantity of municipal refuse is subject to four stages in the management process: collection, transport, processing, and disposal. Many different alternatives can be employed at each system:

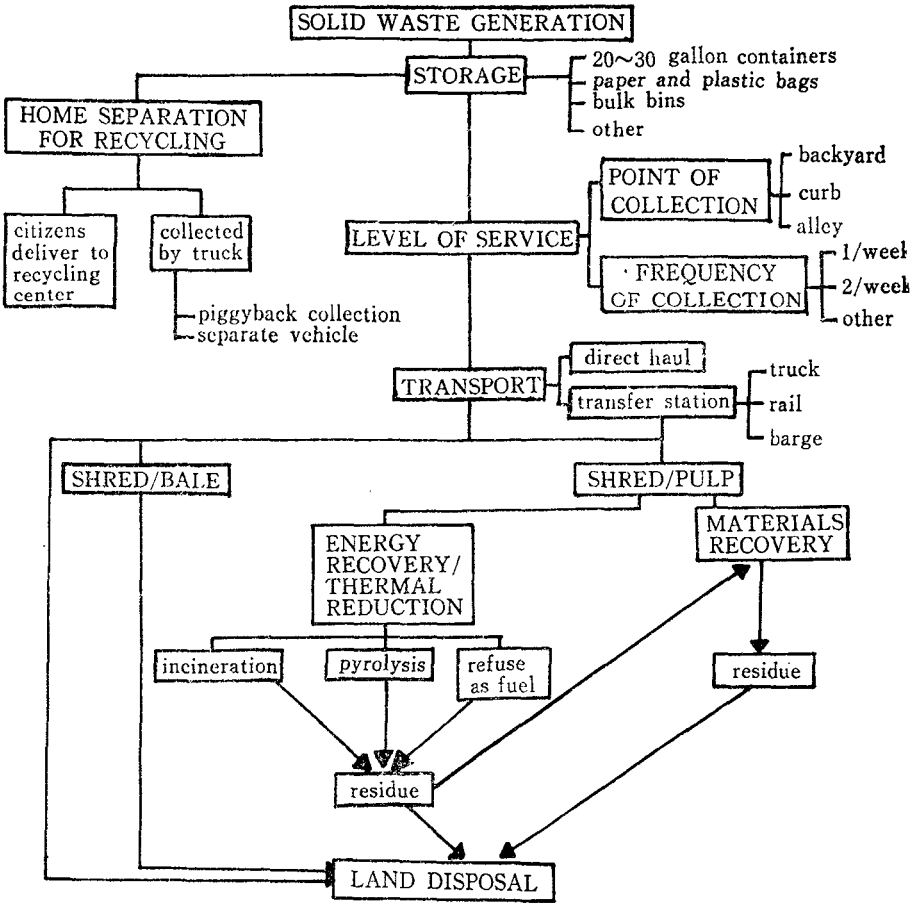
> Refuse in New York City, for example, is stored in plastic bags, collected at the street curb, transported by compactor trucks to large multi-chamber incinerators for processing, and the incinerator residues finally dumped at sea. In case of Humphreys County, Tennessee, refuse is stored in containers, collected by an open truck, and transported to sanitary landfill (Kruth et al., 1972, pp. 1-14).

Consequently, the impact of the overall management system is radically affected by the particular management techniques which are employed. The following flowchart of Figure II-1 illustrates the alternative decisions which are made from the point of generation to the ultimate disposal of municipal solid waste.

Refuse is usually stored in containers at its source prior to collection and transportation. The choice of containers is influenced by factors of economy, socio-economic conditions, convenience, climate, and municipal regulations. In terms of employment and capital expenditures, refuse collection is by far the most important phase of solid waste management (Schmalensee et al., 1975, p.182);

> It has been reported that of the total management budget, 80 per cent was spent on collection and 20 per cent on processing and disposal. About 90 per cent of municipal refuse is collected by crews of men working in conjunction with trucks. In 1968, 337,000 men were employed in the United states in collecting and transporting refuse, using 93,000 compactor trucks and 179,000 other collection vehicles to transport the refuse to disposal facilities.

After collection more than 90 per cent of the municipal refuse is transported to final disposal facilities, primarily dumps and sanitary landfills; the other 10 per cent is processed. The purposes of waste processing are volume reduction, resource recovery or the separation of waste components. The waste processing techniques include: various types of separation



Note: Collection includes storage, level of service, and the separation of materials for recycling; processing includes volume reduction through shredding and or baling and resource recovery.

Source: The Office of Solid Waste Management Programs, *Decision-Makers Guide in Solid Waste Management*, Washington: U.S. Environmental Protection Agency, 1976, p. ix.

Fig. II-1. Solid Waste Management Decision Alternatives

processes, chemical processing methods, mechanical densification and size reduction techniques, composting, and experimental resource recovery methods for metals, glass, and paper. Most of these processes have been rejected as financially or technically infeasible for widespread use, but research and development work continues on many techniques, notably pyrolysis, composting, baling, air classification, and gravity, mechanical, or magnetic separation (Schmalensee, et al., 1975, pp. 184-185).

The last step in solid waste management is final disposal of waste material. The sheer quantities of solid waste to be disposed of daily makes the problem of what to do with

the waste, once it has been collected, among the most difficult problems confronting municipal officials. A crisis situation can develop very quickly, e.g., in the case of an incinerator or land disposal site forced to shut down because of failure to meet newly passed environmental regulations, or it can build gradually over a period of time if needed new facilities are not properly planned for and put into service (The Office of Solid Waste Management Programs, 1976, pp. x-xi). In the disposal stage, several alternative ways of disposal exist. The essential operations of each disposal method are given here. The methods to be introduced, however, are not mutually exclusive: one can be a complement of the other,

Sanitary landfill: sanitary landfill operations are usually conducted by depositing refuse in a natural or man-made depression or trench or dumping it at ground level, compacting it to the smallest practical volume, and covering it with compacted earth or other material in a systematic and sanitary manner.

Central incineration: A central incineration plant is one in which combustible refuse is reduced to ash by high temperature burning. Refuse from collection trucks is charged into furnaces where it is burned under carefully controlled drafts, temperatures, and conditions of agitation to insure combustion as complete as possible; and the ashes and noncombustible residues are removed for possible salvage of metallic components and subsequent final disposal, usually in a landfill. Heat recovery may also be practiced through generation of steam, with a potential for some operating advantages as well as for some revenue to offset part of the cost.

On-site incineration: on-site incineration is that used inside and outside houses, in apartment buildings, stores, etc., to burn refuse produced on the premises. On-site incineration has two favorable reasons: 1) it is often desirable to dispose of refuse as soon as possible after it is produced to eliminate the need for storage facilities, 2) it does not require collection services.

Grinding refuse: Garbage can be disposed of by grinding it and flushing it into sewers. There are home grinders; grinders used in restaurants, produce terminals, and supermarkets; and grinders for centrally located stations operated by a municipality. The principle of operation is the same for all. Garbage is kept or collected separately from other refuse, it is ground or shredded in the grinder as water is added, and it is flushed into the sewers.

Feeding swine: Garbage can be disposed of by feeding it to swine. It is collected separately, the inedible refuse is separated out, it is cooked to destroy disease organisms, and it is fed to hogs on farms usually especially built for garbage feeding. In most places, garbage is collected by private haulers who make their own arrangements with restaurants and institutions.

Composting: Composting is sometimes defined as a rapid but incomplete decomposition of

moist, solid organic matter—in this case, primarily garbage—by the use of aerobic microorganisms under controlled conditions. The result is a sanitary, nuisance-free, humus-like material that can be used as a soil conditioner but is ordinarily not rich enough in the vital elements to be classed as a fertilizer.

Salvage and reclamation: The term "salvage and reclamation" covers a number of disposal processed: sorting of refuse, either manually or mechanically, for metals, tin cans, glass, paper, rags, and other materials that can be resold; rendering of animal wastes for fats; dehydration of garbage to be used for hog feed; composting; and landfills that reclaim otherwise unusable land.

Open dumps: Open dumps for garbage and other refuse are the place where the criteria for sanitary landfills do not meet. An open dump is simply a plot of land, frequently a ravine, natural depression, marshland or other site, where refuse is dumped in either a controlled or uncontrolled manner.

The selection of the proper disposal method suitable to a specific urban area is dealt in relation to carrying capacity in the later section. Before getting into the applicational problems, it may be relevant to examine the concept of carrying capacity in the next section.

III. Carrying Capacity; A Tool for Urban Environmental Management

Ecological concept of carrying capacity can be expanded to human context. This human-oriented carrying capacity has been used as a tool for regional environmental management. This section is designed to apply this regional concept of carrying capacity to urban settings. The carrying capacity-based planning process tries to make trade offs to get the socially and economically viable and environmentally sound decisions: the model constructed in the later part of this section reflects the above considerations.

The concept of carrying capacity is originally derived from natural ecology in which this concept describes the biological or physical relationship between a given resource stock and its maximum sustained yield. Southwick defines carrying capacity as the ability of landscape to support any given animal or plant species or groups of species (Southwick, 1972, p. 308).

The general goal implied (in this context) is to maximize the productivity of the system, e.g., to maximize the number of cattle marketed from a given range, or to maximize the number of board feet of lumber harvested from a given forest, or to maximize the number of user-days of recreation at a particular site, subject to the constraint of nonimpairment or nondegradation of the supporting environmental system

(Bishop et al., 1974, p. 16).

When this biological or physical definition of carrying capacity is applied in the urban context, the concept of carrying capacities is in need of an enrichment in definition and interpretation:

> The concepts associated with the term carrying capacity must be greatly broadened to find appropriate application in the realm of human activity. ...the determination of carrying capacity rests upon desired human and environmental quality levels which are circumscribed by a wide variety of political/institutional, physical/biological, and social/cultural constraints (Bishop et al., 1974, p. 30).

From this it should be clear that a human oriented carrying capacity cannot be developed in a simple, single, numerical measure. It is not only a multidimensional concept but it is subject to constant change and modification particularly as technological improvements are made and as rules change due to pressures from the region's residents.

In dealing with carrying capacity, two properties are important to note: one is the role of stability and the other is resilience. Stability is inclined to seek for the state of equilibrium; adaptation is one example of approaching the steady state. Resilience is associated with the limits or domain of stability of the system. A crucial point is that the size and configuration of the stability domain can be altered as a result of perturbations of the system. In effect, then, resilience is a measure of the ability of the system to withstand shocks or perturbations. While the current state of the art precludes any formal mathematical treatment of the resilience concept, its use as a factor in defining carrying capacity shifts attention away from optimum or maximum toward stability and instability. Any definition of carrying capacity also incorporates such boundary-oriented concerns as limiting factors and trigger factors (Bishop, et al., 1974, p. 15).

If the goal of planning can be seen as an effort to provide a desired array of "quality of life" elements through physical and social design of the human environment, the planner should examine not only what is engineeringly and economically feasible and what is socially, politically, and legally acceptable, but also the degree to which physical and functional plans are tied to ecological systems for resource supplies and for residuals assimilation. The carrying capacity concept recognizes that in order to improve the quality of life relative to both natural and human environments, the pattern and level of production and consumption activities must be compatible with the capabilities of the

natural environment, as well as with social preferences (Bishop et al., 1974, pp. 105-106).

In developing environmental management strategies for urban settings, planners and decision makers must continually assess the social and environmental implications of various proposals. Recognizing and establishing the limits or capacities of urban activity support systems along the lines of the carrying capacity provides decision makers with a workable approach to assessing the natural and human viability of proposals. Indices are an efficient means of providing a working knowledge of human and environmental quality. Indicator research has been undertaken as a means of organizing technical and particular-information into more generally understandable and practically useful information:

> One of the most effective ways to communicate information on environmental trends to policy makers and the general public is with indices. An index is a quantitative measure which aggregates and summarizes the available data on a particular problem.··· The use of a limited number of environmental indices could illustrate major trends and highlight the existence of significant environmental conditions (Bishop et al., 1974, p. 114).

Some basic problems are likely to plague most efforts to apply carrying capacity to urban environmental management. Odell's comments are quoted:

> The use of the carrying capacity approach can lead to what has been called accommodation planning, under which growth is assumed and the only question becomes how to accommodate and distribute it. ... Since all regions are part of a larger, indeed global, system, a carrying capacity assessment limited to specific boundaries is apt to be arbitrary and inadequate. ... It is important to decide how long a given level of carrying capacity is to be maintained. ... The carrying capacity of a region is likely to be highly flexible due to constant modification by outside forces of man and nature (Odell, 1975, pp. 26-27).

One environmentalist says, "It's been an obscure concept since it was taken from biology." Yet it seems to have considerable promise, not only for identifying physical capabilities, but for supporting constraints on urban driving forces in line with public perceptions of need.

The carrying capacity concepts discussed so far are fundamental information with which this section intends to build an urban envionmental management model. In the following Figure III-1, endogenous carrying capacity is that determined by the ecological relationship between resource utilization and environmental assimilative power, given an urban driving

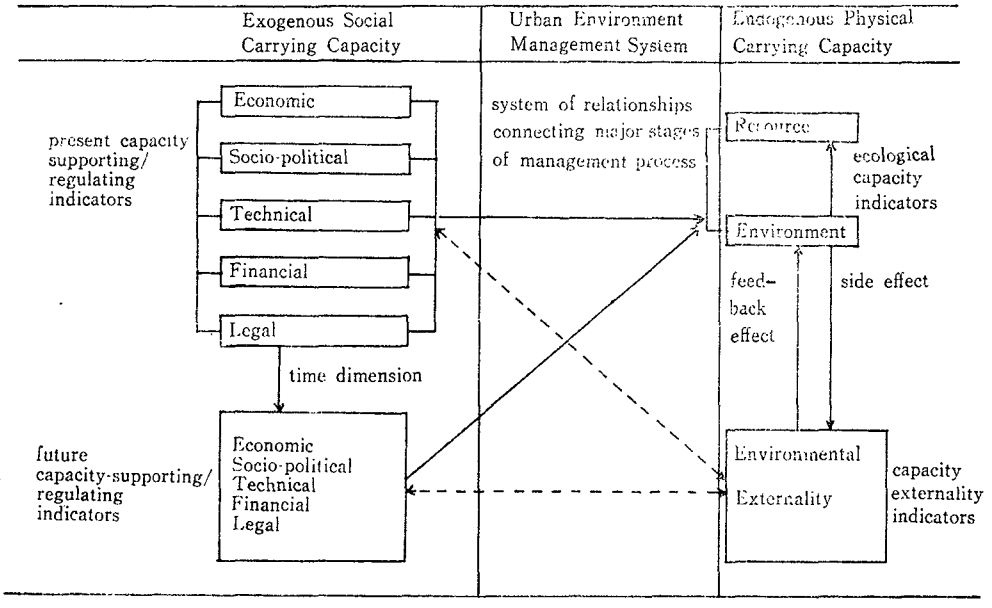


Fig. III-1. Application of Carrying Capacity to Urban Environment Management

force within a specific urban area. This capacity is so-called physical or biological capacity and deficient capacity in one indicator affects carrying capacity in the other. This endogenous carrying capacity is equivalent to that of four indicators suggested by Bishop, et al.: resource, production, infrastructure, and environmental assimilation. Within the class of endogenous physical capacity, ecological capacity indicators and capacity-externality indicators are distinguished: ecological capacity indicators define the conditions of physical capacity being measured; and capacity-externality indicators those generated from the deficiency of ecological carrying capacity under consideration.

Exogenous capacity is a kind of supporting or regulating one along the lines of the endogenous capacity. This capacity comes from the social contexts and is called social capacity. Within the class of exogenous social carrying capacity, the present and future capacity-supporting/regulating indicators are separated: the present capacity-supporting/regulating indicators are those which are instrumental at present by policy makers in the process of urban environmental management, and the future capacity-supporting/regulating indicators are those which are not manipulable at present by policy makers.

Relating these four sets of indicators, a model or system of relationships is constructed. The main relationships determining carrying capacity are indicated with solid arrows: the present and future social carrying capacity along with physical carrying capacity are the

management decision factors of urban environment. When the deficiency of carrying capacity appears, it generates environmental externalities as a side effect and the externalities in turn have feedback effect toward carrying capacity. The present and future social capacity affect the generation of environmental externality and the externality in turn stimulate the future social capacity. These relationships are expresed with broken arrows. The study on the impact of environmental externality on social and physical capacity is one of urban environment impact study. Here, the boundary of urban environmental management is functional in nature: depending upon the urban driving force considered, the boundary is subject to change.

IV. An Application: Urban Solid Waste Disposal

The disposal methods which have been used thus far in the practices of municipal solid waste management can be grouped into three alternatives: direct disposal, pyrolysis, and resource recovery. The selection of the proper disposal method which is not only engineeringly and economically feasible and socially, politically and legally acceptable, but also ecologically sound in terms of resource supply and waste assimilation is of utmost importance. Carrying capacity can be utilized as an insightful tool for the selection of the proper disposal method. As a means of clearifying further applicational procedures, the case of Llangollen and Tybouts Corner landfills is examined.

The disposal methods described in the later part of Section II can be abstracted by three basic disposal alternatives (Office of Solid Waste Management Programs, 1976, p. xi): direct disposal of unprocessed waste in a sanitary landfill; processing of waste followed by land disposal; and processing of waste to recover resources (materials and/or energy) with subsequent disposal of the residues.

Direct haul to a sanitary landfill is usually the cheapest disposal alternative in terms of both operating and capital costs. It may not always be the best from an environmental standpoint because of danger of water pollution from leachate. This alternative is also wasteful of land and resources. With the second alternative, processing prior to land disposal, the primary objective of the processing is to reduce the volume of wastes. Such volume reduction has definite advantages since it reduces hauling costs and ultimate disposal cost, both of which are, to some extent, a function of waste volume. However, the capital and operating cost to achieve this volume reduction is significant and must be balanced against the savings achieved. An additional consideration is the environmental benefits which might be derived from the volume reduction process. The third category of disposal

alternatives are those processes which recover energy or materials from mixed solid waste. In terms of economics, there are significant capital and operating costs associated with all these energy and/or materials recovery systems. Revenues from the sale of recovered products will reduce the net costs of recovery, however. Not only do resource recovery system achieve the goal of resource conservation, but the residuals of the processes require much less space for land disposal than unprocessed wastes.

As a means of selecting the proper method of solid waste disposal for an urban area, carrying capacity-based urban environmental management developed in the previous section is reapplied here. For the simplicity and convenience, only few indicators are presented in the Figure IV-1 and the practical selection of one method using this model is avoided: in fact, it is meaningless to select one method without consideration of spatial and time dimensions. Each method, however, will be evaluated in the model and the desirable disposal method suitable to any specific urban area will be chosen. The method chosen will be acceptable with respect to physical and social carrying capacity.

For clearifying the model, the cases of Llangollen and Tybouts Corner sanitary landfills in New Castle County in Delaware are quoted. In both cases, the sanitary landfill was legally determined. There was no choice but to adopt the sanitary landfill as a disposal method in Delaware:

Prior to 1960, the solid waste disposal in New Cew Castle County were incineration or open dumping often accompanied by open burning. The air pollution and health

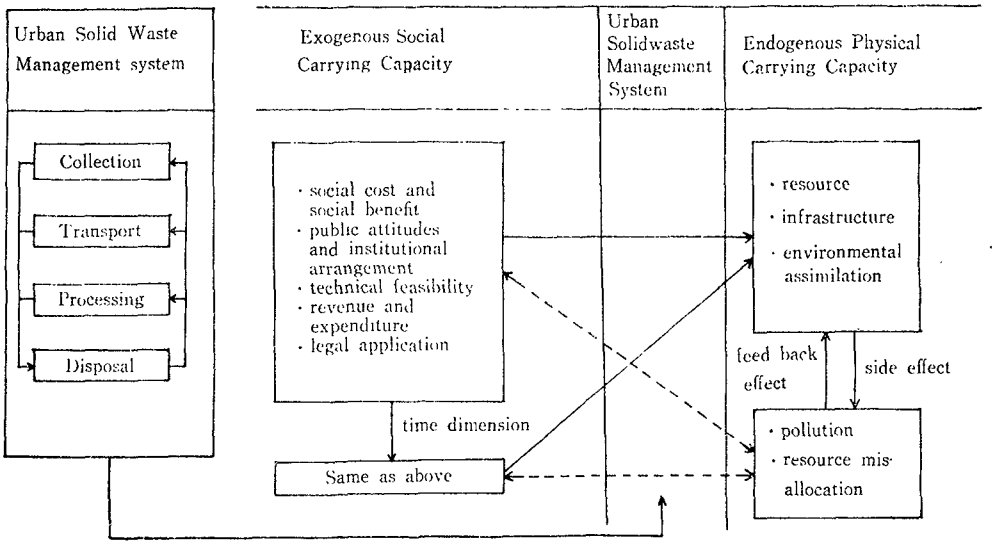


Fig IV-1. Application of Carrying Capacity to Urban Solid Waste Management

hazards from these practices became unacceptable and encouraged the development of new techniques such as sanitary landfills. A major shift in solid waste disposal practices took place in 1960 with the revision of County regulations concerning the "Control of Garbage and Rubbish Disposal Areas" and with the development by New Castle County of the Llangollen landfill. In December 1968, the Delaware State Board of Health, by the adoption of the State Solid Waste Disposal Code, absolutely prohibited open dumping or improperly operated landfill disposal. The Tybouts Corner landfill was also designed and operated according to these regulations. (New Castle County, 1975, pp. 1-5).

These two completed sanitary landfills are more or less generating leachate problem. Liangollen's problem (1960~68) is more serious than that of Tybouts Corner landfill (1968~71). Given the favorable social capacity of two landfills, the deficient physical capacity due to their mismanagement of site selection, design, operation, and completed use is wholly responsible for the leachate problem. The available data are also limited to those indicators of physical capacity, and the following Figure IV-2 is constructed with emphasis on the elaboration of the relationship between ecological capacity and its environmental exernaltty.

Leachate is a highly polluted liquid which is generated by the movement of water through solid waste. Water may enter solid waste either as rainfall infiltration or as groundwater inflow. The quality of the leachate is affected primarily by the composition of the refuse, that is, the percentage of putrescible matter and/or the amount of soluble inorganics and metals present. Other important factors affecting leachate quality are the water content of the refuse, the degree of compaction attained, and whether the refuse

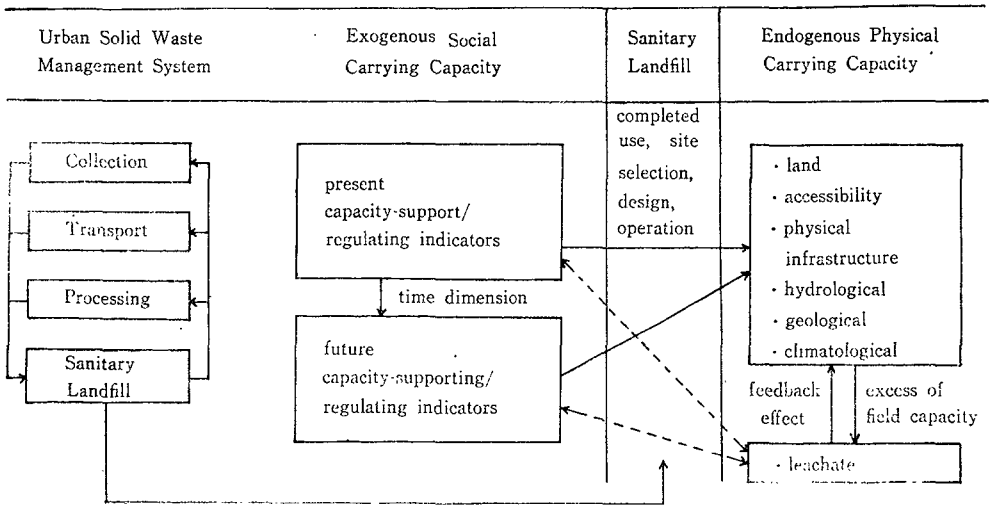


Fig IV-2. Application of Carrying Capacity to Sanitary Landfill

Table IV-1. Physical Carrying Capacity of Llangollen and Tybouts Corner

Carrying Capacity	Capacity Indicator	Sanitary Landfill	
		Llangollen (1960~1968)	Tybouts Corner (1968~1971)
Endogenous Physical Carrying Capacity	• land	56 acres	50 acres
	• cover material	sand and gravel with clay and silt (good/excellent)	
	• accessibility	U.S. Route 13 and 40	U.S. Route 13 and State Route 71
	• physical infrastructure	—	—
	• precipitation	relatively high rainfall over the last few years	
	• surface run-off	numerous subsidence depressions (ungraded)	localized depressions
	• evapotranspiration	—	—
	• ground water	large sections(below water table)	partially in the ground water zone
	• upland drainage	—	—
	• vegetation cover	low grasses and some reeds	sparse
	• water table	average two feet	average two feet

is decomposing aerobically in the presence of free oxygen or anaerobically without the presence of free oxygen. Leachate drainage from a landfill, except for direct channeling, can occur after the "field capacity," or total amount of water that can be held against gravity by the refuse, is attained. Any additional water beyond the field capacity will cause the lateral or downward movement of contaminated water. Depending upon the permeability of the cover material, the slope of the fill area, and the type and degree of vegetation cover, the climatic conditions play a very critical role in the attainment of field capacity (New Castle County, 1975, p.8). The above Table IV-1 is the further elaboration of Figure IV-2 with respect to physical capacity and leachate.

As shown in the above Table, Liangollen and Tybouts Corner are favorable locations for the sanitary landfill. The overall physical carrying capacity, however, turns out to be deficient mainly due to hydrogeological and climatological conditions of two landfills. Therefore, field capacity is reached rapidly and leachate production and movement are generated.

V. Conclusion

Carrying capacity concept which is originally derived from biology turns out to be an insightful tool for environmental management. Carrying capacity allows planners to "examine not only what is engineeringly and economically feasible and what is socially, politically, and legally acceptable but also the degree to which physical and functional plans are tied to ecological systems for resource supplies and for residuals assimilation." This paper intends to apply this regional concept of carrying capacity to urban settings and further to a specific project like sanitary landfill. The problem encountered is how to make trade offs between the conflicts of social and physical capacity, i.e., economically and technically feasible, and legally and politically acceptable, but environmentally unsound sanitary landfill.

This paper, however, emphasizes on the formation of conceptual framework of urban environmental management using carrying capacity rather than on resolving conflicts and making trade offs necessary to converge on socially and economically viable and environmentally sound decisions as to solid waste disposal as an urban driving force. The trade offs in the model may be between physical and social capacity with consideration of carrying capacity's resilience and among the sets of indicators of social capacity. System simulation model may furnish policy makers with quantitative alternatives of trade offs in which they will choose a proper one. Public or social choice theory is another conflict resolving meohanism.

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