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The Objectives of Waste Management in India: A Futures Inquiry

H. D. SHARMA, A. D. GUPTA, and SUSHIL

ABSTRACT

Future objectives of waste management in a developing country such as India will be different from those in developed countries for various reasons. This paper describes a futures study into the objectives of waste management in India at the aggregate as well as sectoral levels. It employs consensus methods to generate and analyze present and future objectives of waste management in India. The objectives have been classified depending on their driver power and dependence using indirect relationship MICMAC analysis. Interpretive structural modeling has been carried out to develop a hierarchy of actions required to achieve the future objectives of waste management.

Introduction

The most important objective of waste management in developed countries is to protect the environment. All other objectives are, by far, less important. For a developing country like India, the situation with regard to the objectives of waste management is not so simple. Environmental protection, productivity improvement, employment generation, resource recovery, welfare needs of a huge population, and so on are also important with respect to waste management. Thus the problem of ascertaining the objectives of waste management in such cases is many faceted. There can be many objectives of waste management at aggregate and sectoral levels, which have relationships among each other and hence a structure associated with them. Many relationships are subtle and indirect and hence not decipherable by structure alone. They require further analysis.

This paper describes a study that employed consensus methodologies [1, 2] in an integrated manner to generate a comprehensive list of objectives of waste management for the present as well as future, both at aggregate and sectoral levels in India. The objectives so obtained were organized to develop structures. The developed structures were utilized to obtain a hierarchy of actions required to achieve the objectives thought

H. D. SHARMA is an Assistant Professor in the Mechanical Engineering Department, College of Technology, G.B.P.U.A.T., Pantnagar, India.

A. D. GUPTA is an Associate Professor in the Mechanical Engineering Department, Indian Institute of Technology, Hauz Khas, New Delhi, India.

SUSHIL is a Professor with the Department of Management Studies, Indian Institute of Technology, New Delhi, India.

Address reprint requests to Professor A. D. Gupta, Indian Institute of Technology, Delhi Hauz Khas New Delhi 110016 India.

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to be desirable. The developed structures were also subjected to further analysis to reveal the impact of indirect relationships among objectives.

Intent Structure

Goals and objectives are thought to be two different concepts, but what constitutes the difference is not clear. The most general distinction is in terms of measurability. Objectives are thought to be measurable, whereas goals are not and vice versa. Warfield [3] has dealt with this semantic confusion.

One consequence of the semantic confusion concerning goals and objectives is that when a group assembles to discuss goals and objectives, the discussion may get waylaid in the confusion. While introducing the concept of "intent structure" Warfield [3] points out that there are many schools of thought regarding goals and objectives:

1. Invisible Intent: People and organizations have "invisible intents" and any visible portrayal of intent is at best incomplete and hypocritical.
2. Inadequacy of Language: Language alone is inadequate to convey the meaning in any useful way.
3. Alternative Focuses: There is no need to discuss goals and objectives. Operational alternatives or action plans alone should be discussed.
4. Questions of ownership arise in goals and objectives setting.

The concept "intent structure" deals with these confusions and problems. It is a methodological tool to help overcome the various inhibitors described above. It is a hierarchical structure that goes a long way toward setting objectives in context. The objectives in the lower portion of an intent structure are often essentially indistinguishable from action plans.

An objective is a statement expressed in the form; "to (action word) (object) (qualifying phase)." For example, "to ensure sanitation" is an objective. It is not the most general definition that can be given. It is not sufficient, but it does several things. It enables one to distinguish objectives from events or activities simply by the semantic format; use of an action word, an object, and a qualifying phrase usually provides enough information to convey at least what is being said, and it removes the semantic confusion between goals and objectives because in this format both can be used synonymously.

Objectives may or may not be available in written articulated form as described above. If not, they would have to be generated by using a suitable consensus methodology. For developing intent structure, Warfield has given a brief description of a rearrange and tape method [3] and a matrix method [4]. Presently developing an intent structure is done most accurately by using interpretive structural modeling [ISM] described in [5, 6, 7]. It is a structural modeling technique; Linstone et al. [8] describe its use in technology assessment. Structural modeling with special reference to ISM is described briefly below.

Structural Modeling

Structural modeling employs graphics and words in carefully defined patterns to portray the structure of a complex issue, system, or a field of study [1]. Mathematical quantification, as and where needed, can be added to make this qualitative geometric representation semi-quantitative. But the process of structural modeling essentially highlights the geometric, rather than the algebraic features. Structural models describe form and structure rather than measure quantitative output. Linstone et al. [8] state that they

provide a sense of the geography of a complex system, a rough map that can shed considerable light on the potential consequences of links between system elements.

Generating Tools

A structural model is a collection of elements and their relationships. Thus a set of elements that describe the system or issue must be known before any structuring (based on given relationships) can be done. Defining the elements that describe the system and creating an exhaustive list of such elements are critical parts of the structural modeling process of complex sociotechnical issues, such as the causes of system waste. Generating tools are those that deal with stimulation, extraction, and/or representation of ideas/knowledge from the mind of a person or a group of persons [9] so that a representative list of elements of the issue to be structured can be obtained. The key assumption underlying the generating tools is that some sort of (experience-based) intuitive knowledge or understanding of a given problem context exists in minds of certain individuals. Another assumption is that an effort is being made to elicit this knowledge or understanding and to represent it in a useful way. Generating tools have been discussed in detail [9]. Because knowledge regarding ill-structured sociotechnical issues can not be resident in a single individual or professional, it is always advisable to use a knowledgeable group in such situations. In this study the list of objectives was generated by a Delphi study [10].

Structuring Tools

Structuring tools are used to structure the set of elements into a structural model. The emphasis in this step is on the relations among the elements. All structuring tools consider only pairwise relations among the elements, though research is going on to enhance the capability to consider more general relations. Structure is depicted graphically by points (or nodes) and connecting lines (or arcs). These two define a graph. If an ordering or direction is specified for each connecting line, the graph becomes a directed graph or a digraph. Weights and/or signs for the arcs may be added to make signed digraphs. A graph or a digraph may have two elements connected by more than one line (cycle). Harary et al. [11] discuss at length the basic principles and mathematical properties of digraphs as a fundamental structure diagram. They develop equivalences between digraphs and matrices and elaborate on the concepts of adjacency, reachability, and connectedness of digraphs and matrices. Warfield has made numerous contributions and developed the structuring tools used in this study. Lendaris [9] provides a list of nine structuring tools and compares them on the basis of a number of characteristics. The list has been prepared from 100 odd candidate methods. Linstone et al. [8] have compared and contrasted these tools. All of them are fully implementable and available for use; can be understood and used by persons skilled in mathematics; are general in their applicability; are cheap and less time-consuming [8]; and permit using subjective data. Out of these ISM, ELECTRE, SPIN, IMPACT, KSIM, XIMP, QSIM are the most frequently used structuring tools. All require using a computer. Linstone et al. [8] have also explained the process of selecting an appropriate tool for a particular use.

Interpretive Structural Modeling

Interpretive structural modelling [ISM] was introduced by Warfield [1, 2, 6, 7, 12] and he provides detailed descriptions and operating procedures. Malone [5] presents a brief overview. Moore [13] mainly discusses organizational and group-process aspects. ISM is a computer-assisted, interactive learning process whereby structural models are produced and studied. Structural models so produced portray the structure of a complex

issue, a system, or a field of study in carefully designed patterns employing graphs and words. It is a means by which a modeling group can impose order on the complexity of relation among items. The method is interpretive in that the group's judgment decides whether and how the items are related, and structured in that, on the basis of relationships, it extracts an overall structure from the complex set of items, and it is modeling in that it portrays the specific relations and overall structure in a digraph (directed graph) model. ISM is primarily intended as a group-learning process but it can also be used by individuals working alone.

OPERATIONAL PROCEDURE

At the outset an element set that is composed of elements that are relevant to the problem or issue is generated. Any suitable group process can be used. Next, a contextually relevant subordinate relation is chosen. It should be subordinate in the sense that a direction should be attached to it. It should be so phrased as to lead to paired comparisons, for example, "Is objective A more important than objective B?" Having decided on an element set and the contextual relation, the modeling group assembles at a place under leadership of a skilled facilitator who is well versed in ISM theory and application. Two elements are picked and a pairwise comparison is made. Group judgment on the paired comparison is determined by consensus majority vote after discussion. The vote is recorded and stored in a computer, which is available at hand and which has ISM software in its memory. Many versions of the software are available and the one developed by Tata Consultancy Services (TCS), New Delhi, India was used in this study. On the basis of pairwise comparisons entered in the computer, it infers the transitivity of the contextual relations and calls for replies to certain other paired comparisons. Thus, as input data in the computer memory builds up, the software generates a sequence of a limited number of queries that the modelers have to provide, the remaining being inferred due to transtivity. (Transitivity of the contextual relation is a basic assumption in ISM; it states that if element A is related to B and B is related to C, then A is necessarily related to C). When necessary input information is available to the computer, it generates a structural model in the form of a digraph, which is supposed to reflect the collective features of the group thinking. The digraph is then examined and if there are amendments that may be needed due to learning that has occurred in the process, they can be incorporated in it. The interpretive structural model in the form of digraph is called a map. Some software generates maps automatically while in some applications, it has to be constructed manually based on computer output. Similarly, some ISM softwares need no amendment whereas others do. The TCS software used in this study generates the map on the computer and has amendment facilities to a certain extent.

Depending on the needs of the modeling group and the requirements of the problem at hand, many kinds of structural models (for example, intent structure, priority structure, etc.) can be generated in ISM.

A computer is used in ISM to expedite the process because the mathematical calculations are tedious, repetitive, and time-consuming if done manually. But it should not limit the discretion of the modeling group or control its decisions. It is also not necessary for the modeling group to understand the mathematical basis of the method, even though ISM is based on relatively complex mathematical rules that should not be violated. Facilitators are to ensure this.

Maps produced in ISM are categorized into various types according to their structural features [14]. If the map contains a single element not connected to anything else, it is called an isolated element. A map having many isolated elements is called an array. A

cycle has two or more elements related to each other in both directions. A hierarchy is a map that has walks but no cycle (a walk is a prose statement associated with a map and the total number of walks on a map is countable). Thus a hierarchy has no feedback. Finally a map that has hierarchy(s) and at least one cycle will be called a mixed structure.

A mixed structure, which is the most commonly encountered structure in applications, can be converted into a hierarchy by replacing cycle(s) by a proxy element. Such a representation is called a box-bullet form and it has been used in this work as most structures generated in the study were mixed structures and the box-bullet form was preferred because we did not desire to study cycles in detail. Cycles were used, however, at the matrix level in carrying out the relationship analysis.

Analysis of Relationships

DIRECT RELATIONSHIP ANALYSIS

The structure developed by a structuring tool in the form of a digraph shows only the direct relations among the elements that can be seen in the digraph. A more systematic method of examining the digraph would be to examine the relations among elements since these affect the problem under analysis. The most common example of the relations among elements is that the potential power of an element to drive other elements and conversely, the dependence of an element on other elements. Elements that affect many others or that are affected by many elements should be identified. Structuring tools consider only direct relations among elements. Hence the digraph can serve to analyze direct relations. For this, a direct relationship matrix [14] is obtained by examining the direct relations between elements as depicted by the digraph, ignoring transitivity and making the diagonal entries 0. This direct relationship matrix is different from the minimum edge adjacency matrix as it takes into account feedbacks also. The driver power of an element is derived by summing up the number of interactions in the rows and its dependence by summing up the number of interactions in the columns. Thereafter, driver power and dependence ranks are worked out by giving highest ranks to the elements that have the maximum number of interactions in the rows and columns, respectively.

INDIRECT RELATIONSHIP ANALYSIS

In complex societal problems, indirect relations greatly influence the system behavior through influence chains and reaction loops, but they can not be represented in the direct relationship matrix. The number of these chains and loops could be so large that it may be difficult to interpret the relations without the help of a computer. The MICMAC method is a system of manipulating matrices that is used in this indirect relationship analysis. It was developed by Duperrin and Godet [15] to study the diffusion of impacts through reaction paths and loops for developing hierarchies for members of an element set. Two hierarchies, one based on driver power and the second based on dependence, are usually developed. The method of calculating the driver power and dependence, as well as the driver power and dependence ranks at each step is the same as given in the last section.

Matrice d'Impacts croises-multiplication applique an classement (cross-impact matrix multiplication applied to classification) is abbreviated as MICMAC. The MICMAC principle, based on the multiplication properties of matrices, states that if element A directly influences element B and B directly influences element C, then any change affecting A can have repercussions on C. Thus, there is an indirect connection between A and C that can not be shown on a direct relationship matrix. But when that matrix is squared using Boolean algebra, second-order relations are revealed such as A to C. Proceeding in the

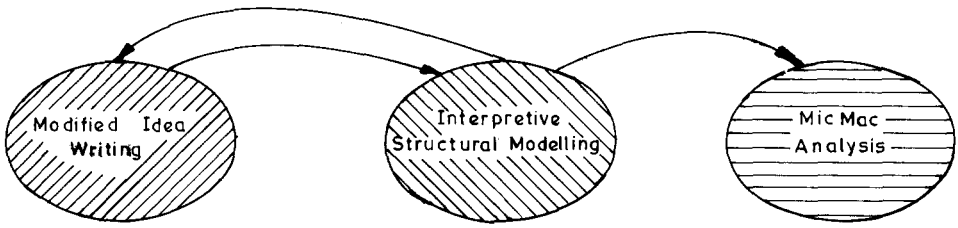

Fig. 1. The schematic diagram for the study.

same fashion if 3rd, 4th, 5th, . . . nth powers of the direct relationship matrix are obtained, then 3rd, 4th, 5th, . . . nth order indirect relationships will be revealed. Each time the process is repeated, a new hierarchy among elements can be deduced. When raised to a certain power, if this hierarchy repeats in the next stage of multiplication both in the hierarchy of rows and columns, then such a stage is considered a stable stage. This hierarchy is the MICMAC classification and is used to study indirect relations minutely.

Study Design

This study used consensus methodologies in a sequence to generate and structure the present and the future objectives of waste management at aggregate and sectoral levels in India and to develop a hierarchy of actions required to achieve the intended objectives. Relationship analysis was employed to reveal indirect relationships among objectives. Such integration of systems methodologies is also advocated by Sushil while proposing flexible system methodology [16].

The study was conducted in the following steps:

1. Generating the objectives of waste management (WM): A modified idea-writing process was used for this step. The panelists of the idea-writing group consisted of persons at the helm of policy making and administration, eminent environmentalists, engineers, educationists, industrialists, future researchers of national eminence, social workers, etc.
2. Developing intent structures for WM: Eight intent structures of objectives of WM at the aggregate and sectoral levels were created using interpretive structural modeling (ISM).
3. Developing a hierarchy of actions for WM: Some of the developed intent structures were sent to the panelists as a feedback and also to get a list of actions that were structured into a hierarchy using ISM.
4. Relationship analysis: Direct and indirect relations among objectives were studied using the developed structures and a MICMAC analysis was done to identify the key objectives that drive the system in various categories.
5. Finalizing and discussing the results: Figure 1 gives the integrated schematic diagram of the study.

Generating the Objectives of WM

It was decided to generate the objectives of WM in the following eight aggregate and sectoral categories.

1. WM in general at present.
2. WM in general in the future.
3. WM of rural waste at present.
4. WM of rural waste in the future.
5. WM of industrial waste at present.
6. WM of industrial waste in the future.
7. WM of municipal waste at present.
8. WM of municipal waste in the future.

The target time for future objectives was 2010 A.D.

Modified Idea Writing

Idea writing was chosen as a consensus method for the generation of objectives in various categories as it is particularly useful in generating ideas with respect to a focused question. But the method requires that the group participating in idea writing must assemble at one place. The purpose of the study was to structure the objectives of WM in various categories and to develop a hierarchy of actions. Keeping this in view, we intended to invite senior persons at the helm of policy making and administration, eminent environmentalists, educationists, industrialists, futures researchers, etc. as participants in the group. It is very difficult, however, to assemble such a group at one place even for a very short time. To harness the expertise of such a group at the helm of affairs in various fields in the country, the idea-writing method was modified to suit a geographically dispersed group. This was done by designing the questionnaire suitably. In the idea-writing method, a focused question is provided in writing or visually displayed before the group. In the modified method used in this study, a questionnaire was sent to the participants that included the following information:

1. The background information of the research study.
2. A brief and focused write-up on WM.
3. A semantic form in which the participants have to provide the objectives and a few examples of it.
4. Eight focused questions and one open-ended question.

Examples of objectives were provided to reduce the duplication of the same ideas over and over again. This drawback is immediately overcome in a group assembled at one place, because the ideas are collated and edited as soon as they are written. But in the modified idea-writing process, it was thought necessary to provide a brief write-up on the study and some obvious objectives at the outset to stimulate creative effort by the participants. Appendix I gives the write-up and the questionnaire.

Forty persons from the above-mentioned categories were invited to participate in the study. Care was taken to request an adequate number of persons in each category in order to have a balanced group. Twenty-four persons responded to the questionnaires. Table 1 gives the profile of participants.

GENERATING LISTS OF OBJECTIVES FOR WM:

The objectives as given by the panelists were listed separately for each category. Items on these lists were collated for duplication, similar meaning, inclusiveness,

TABLE 1
Participants Profile

1.	Senior government officials
2.	Representatives of various groups in the national waste-management council
3.	Industrial consultants
4.	Director and scientists associated with the National Environmental Engineering Research Institute
5.	Chariman, members, and scientists associated with National Pollution Control Board
6.	Owners and professionals of mass production heavy industry
7.	Eminent researchers in the area of WM
8.	Policy researchers
9.	Chief engineer of the National Research Development Corporation
10.	Director of Environmental Control of the largest steel plant in India
11.	Eminent future researchers of national eminence
12.	Nonofficial environmentalists
13.	Engineers associated with public sector companies
14.	Educationists

and ambiguity. Then the lists were edited and certain items combined without changing the actual objectives provided by panelists.

Finally, the comprehensive lists of objectives of WM under various categories were prepared for further analysis.

Development of Intent Structures

Objectives lists prepared in the last step of the study were used as the element sets for developing intent structures for objectives of WM at the aggregate level, as well as at the sectoral levels.

"Will help achieve" was taken as the contextual relation for developing the intent structures using ISM. Interpretive structural models prepared by computer were converted to box-bullet form.

The following intent structures were developed:

1. Intent structure for WM in general at present (Figure 2).
2. Intent structure for WM in general in the future (Figure 3).
3. Intent structure for WM of rural waste at present.
4. Intent structure for WM of rural waste in the future.
5. Intent structure for WM of industrial waste at present.
6. Intent structure for WM of industrial waste in the future.
7. Intent structure for WM of municipal waste at present.
8. Intent structure for WM of municipal waste in the future.

The research team conducted the ISM process because the geographically dispersed group could not be assembled at one place for the purpose of a structuring exercise. Because the provided objectives were very well defined and because the contextual relationship was clear cut, the digraphs produced by the research team reflect reality within the inherent constraints of the ISM process.

Development of a Hierarchy of Actions

GENERATING A LIST OF ACTIONS

The panelists were again contacted to help in formulating certain actions that should be taken to achieve the future objectives of WM as depicted by the intent structures.

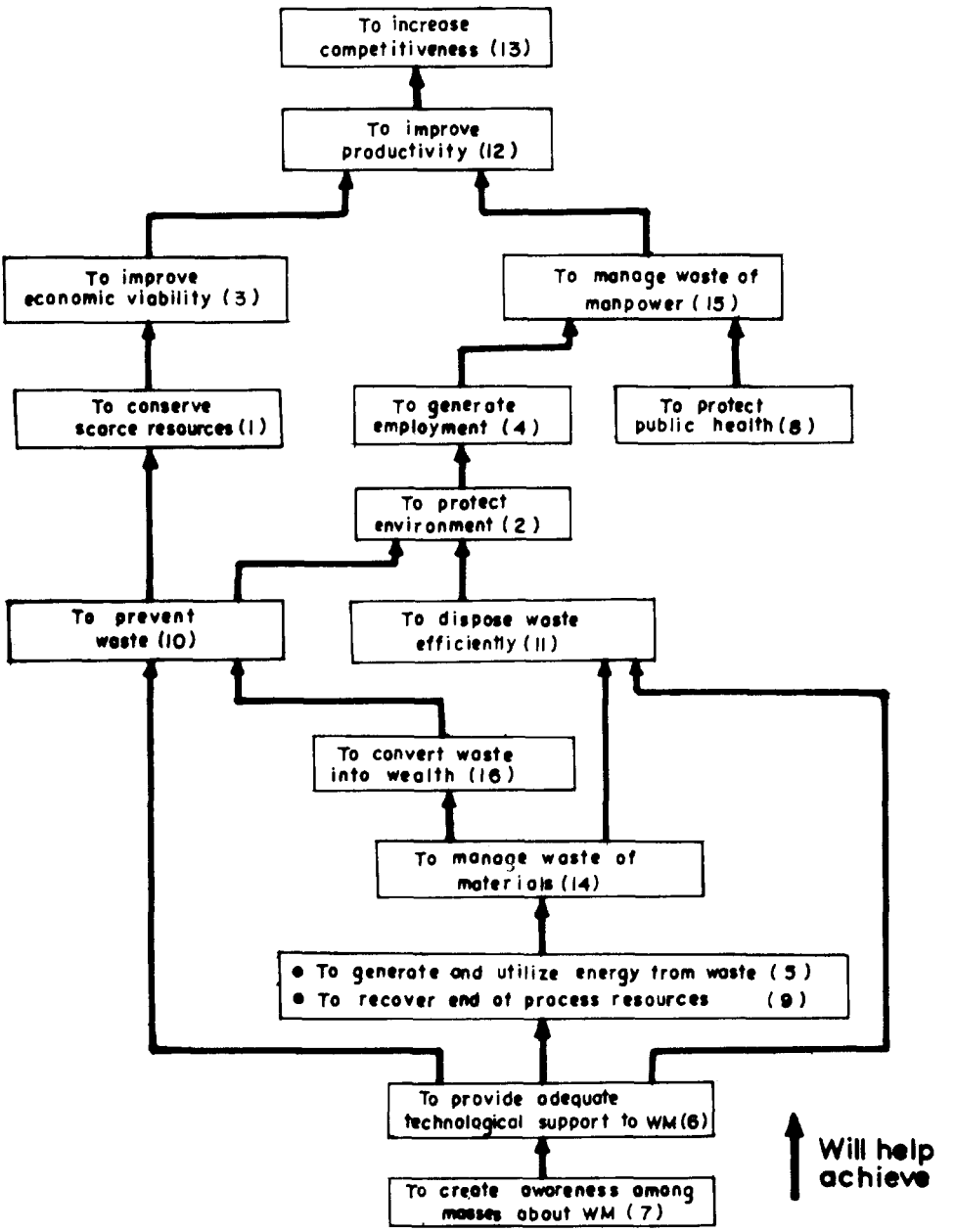

Fig. 2. Intent structure for waste management at present.

For this purpose a modified idea-writing process was again employed and information feedback was given to the panelists to guide their creative thinking.

A questionnaire was constructed in which background information on intent structures together with the two intent structures for WM in general at present and for the future (Figures 2 and 3) were sent to the panelists. The questionnaire requested the panelists

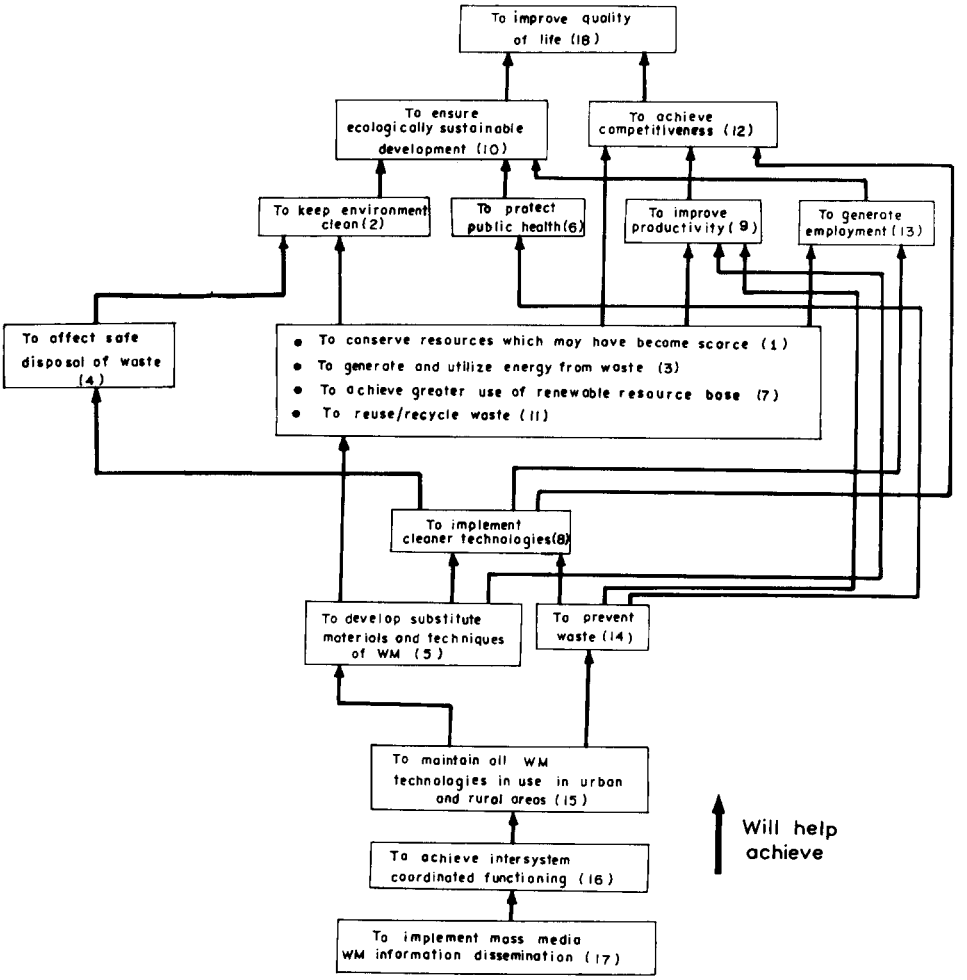

Fig. 3. Intent structure for waste management in future.

to recommend three actions that they deem most important to achieve the intended objectives in the future. The panelists were also requested to suggest the agencies they thought should be charged with responsibility of carrying out the actions they suggested.

A total of 16 panelists provided lists of actions. They were collated with the agencies recommended in each case to check for tie-up. Items on the lists were also collated for duplication, similar meaning, inclusiveness, and ambiguity. Finally the list of actions was merged with the list of agencies with due care and edited to create a comprehensive list in which no unique item provided by any of the panelists was left out nor the real purpose of any action recommended changed.

DEVELOPMENT OF A HIERARCHY

Using ISM, the research team structured the list of 15 actions developed in the last step of the study. The actions list was taken as the element set and "should precede" was selected as the contextual relation.

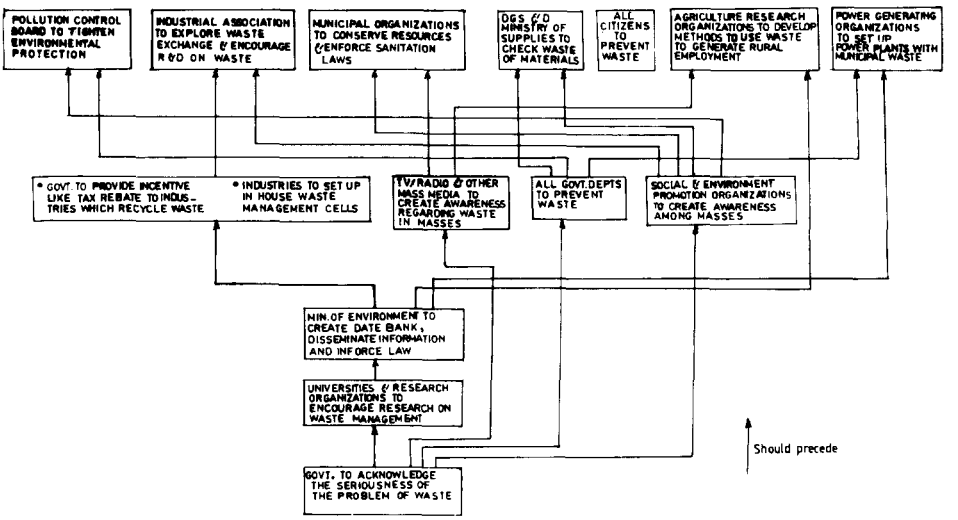

Fig. 4. Hierarchy of actions for waste management.

The interpretive structural model produced by the computer was converted into box-bullet form, this is given in Figure 4.

Relationship Analysis

DIRECT RELATIONSHIP ANALYSIS

The digraphs of the intent structures developed for the various categories of WM were used to study the direct relations among the objectives. Visual examination of digraphs brought out certain facts, whereas comparison of driver power of objectives in direct relations with those in indirect relations also clarified certain other items.

INDIRECT RELATIONSHIP ANALYSIS

Indirect relationship analysis was carried out using the MICMAC principle. As a first step in this analysis, direct relationship matrices of the digraphs of intent structures were prepared. As required for indirect relationship analysis using MICMAC principle, these matrices were raised to powers and checked for stability. The stabilized matrix was

TABLE 2
Stabilization of the Matrix in Indirect Relationship Analysis

S. Number	Intent structure	Stage of stabilization
1.	General (Present)	M^{10}
2.	General (Future)	M^{7}
3.	Rural Waste (Present)	M^{13}
4.	Rural Waste (Future)	M^{7}
5.	Industrial Waste (Present)	M^{10}
6.	Industrial Waste (Future)	M^{6}
7.	Municipal Waste (Present)	M^{6}
8.	Municipal Waste (Future)	M^{5}

M^n stands for the nth power of the Direct Relationship Matrix M.

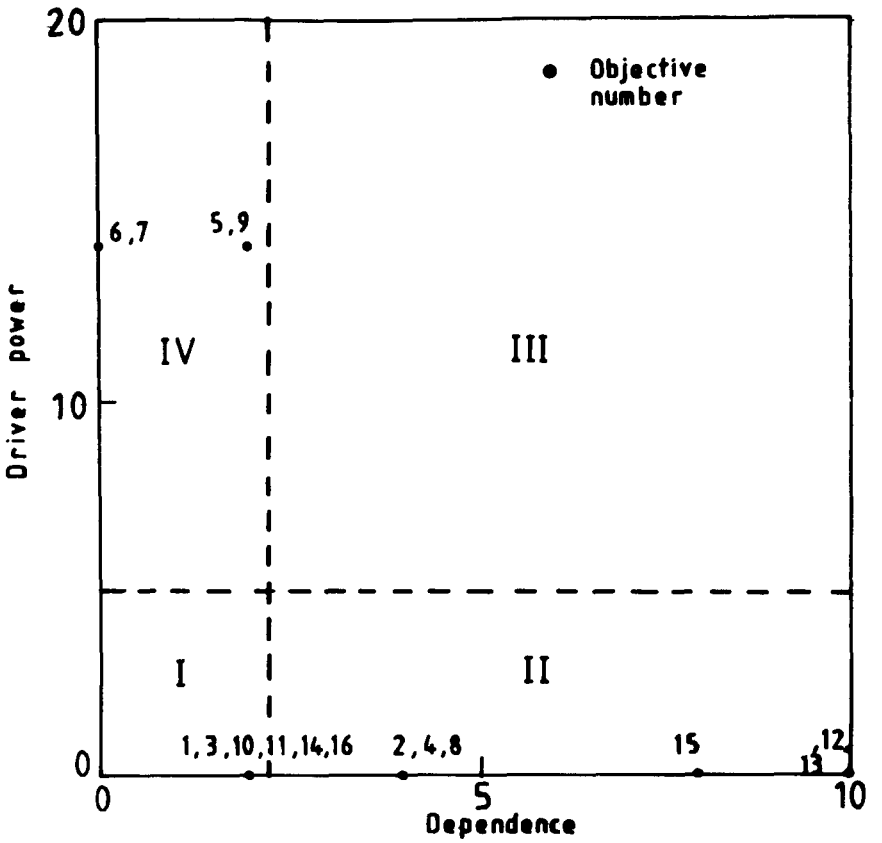

Fig. 5. Driver power dependence matrix: WM in general at present (Indirect Relationship).

used for determining driver power and dependence of elements in indirect relationship analysis. Table 2 gives the stabilization stages of all direct relationship matrices.

DRIVER POWER AND DEPENDENCE

The stabilized matrix of each digraph of the intent structure was taken as the basis for determining driver power and dependence of various objectives in each case. The indirect relationship driver power and dependence were calculated from stabilized matrix while direct relationship driver power and dependence were determined from the direct relationship matrix in each case.

Indirect relationship driver power-dependence matrices (based on MICMAC) are given in Figures 5 and 6 for the objectives of WM in general for the present and the future, respectively.

COMPARISON OF DRIVER POWER RANKS

Driver power ranks of objectives in various intent structures were then calculated. They were calculated for both direct and indirect relationships. Driver power ranks were used for deciding the hierarchy of elements and identifying key elements in each case.

Direct and indirect relationship driver-power ranks of various intent structures were plotted with indirect relationship driver power ranks on the x-axis and the same in direct

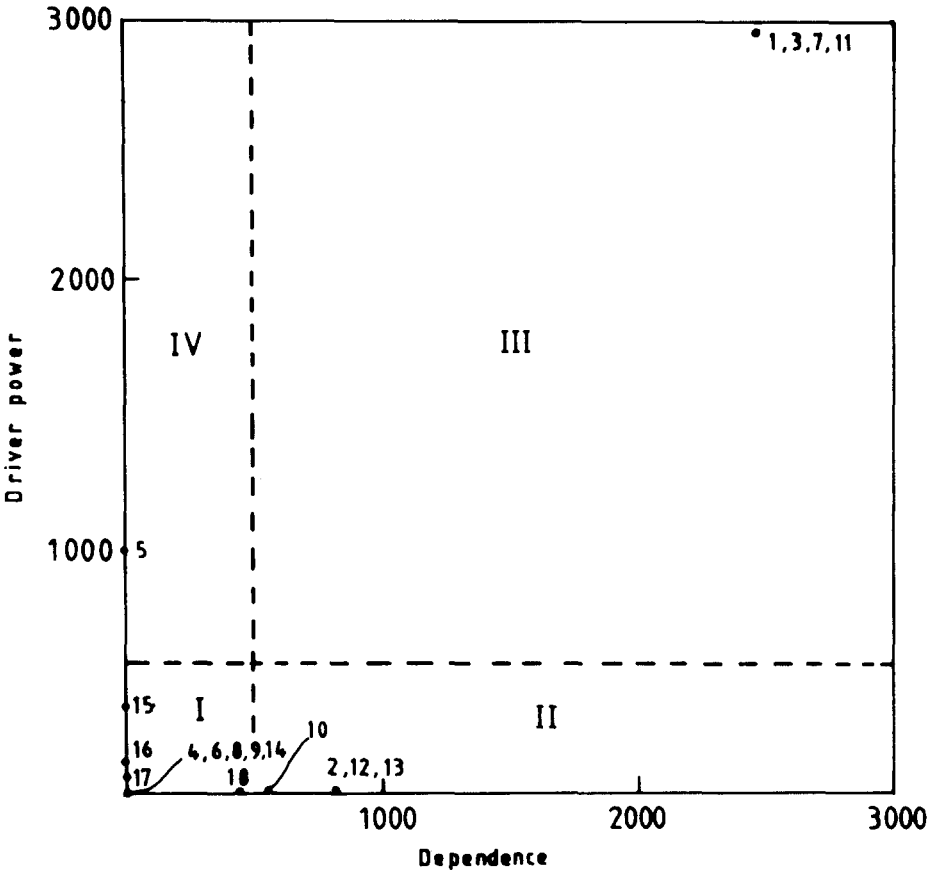

Fig. 6. Driver power dependence matrix: WM in general in future (Indirect Relationship).

relationship on the y-axis. These are shown on Figures 7 and 8 for the objectives of WM in general for the present and the future, respectively. Table 3 gives a summary of this comparison and Table 4 gives the key objectives of WM.

CLASSIFICATION OF OBJECTIVES

Objectives were classified into four categories: Autonomous (sector I), Dependent (sector II), Linkage (sector III), and Independent (sector IV) based on the driver power dependence matrix in each case, and the classification has been shown in Figures 5 and 6 for the objectives of WM in general for the present and the future, respectively, for the indirect relationships.

CHANGES IN CLASSIFICATION OF OBJECTIVES

Classification of objectives of various intent structures based on the driver-power dependence matrix constructed on the basis of direct and indirect relationships shows many changes. The classification based on indirect relationships is more important as it reflects the impact of indirect chains of relations. Table 5 lists the objectives classified on this basis and Figure 9 shows the changes in the classification occurring when indirect

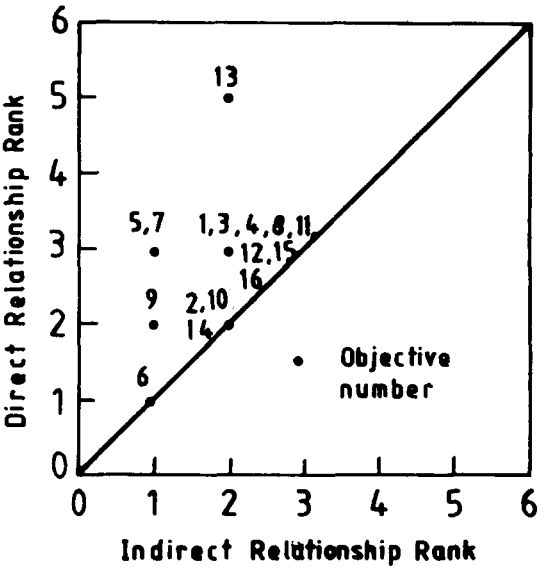

Fig. 7. Comparison of ranks: WM in general at present.

relationships were taken into consideration for the objectives of WM in general for the present and the future.

Study of Structures

INTENT STRUCTURE OF WM IN GENERAL AT PRESENT

The intent structure reveals the following: "To create awareness among masses" about WM is the bottom level objective while "To increase competitiveness" is the top level objective of WM at present. There is one cycle in the structure and "to generate and utilize energy from waste" and "to recover end-of-process resources" affect each other in both directions.

The indirect relationship analysis reveals that the key objectives of WM at present are "to provide adequate technological support to WM," "to generate and utilize energy from waste," "to recover end-of-process resources," and "to create awareness among masses about WM." The second finding of the indirect relationship analysis is that 75% of the objectives have higher driver-power rank in the indirect relationship analysis. Third, the comparison of the classification of objectives reveals that only one objective retains its classification in both direct and indirect relationship analysis and that there is no linkage objective in the indirect relationship, whereas there are nine such objectives in the direct relationship analysis.

INTENT STRUCTURE OF WM IN GENERAL IN THE FUTURE

"To improve quality of life" is the top-level objective whereas "to implement mass media WM information dissemination" is the bottom most objective of WM in future. There is a four-element cycle in the structure. The elements "to conserve resources that may have become scarce," "to generate and utilize energy from waste," "to achieve greater use of renewable resource base," and "to reuse/recycle waste" affect each other.

All the elements of the above-mentioned cycle form the key objectives of the structure. The effect of indirect relationship reveals that 55.5% of the objectives have lower

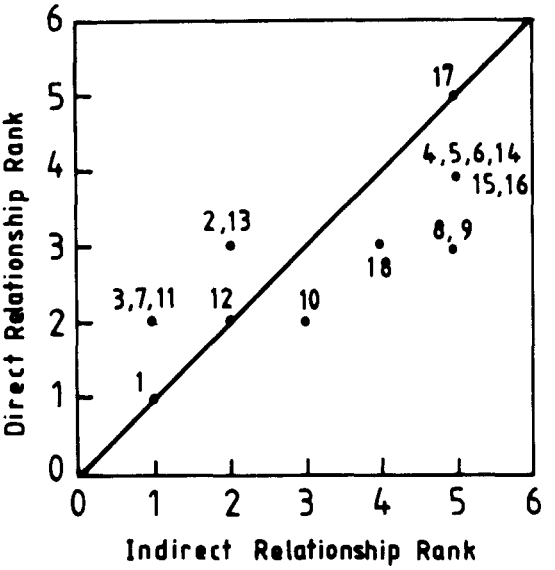

Fig. 8. Comparison of ranks: WM in general in future.

driver power rank, whereas 16.6% of the objectives have the same driver-power rank as in the case of direct relationship. Only two objectives retain their classification when subjected to the indirect relationship analysis.

INTENT STRUCTURE OF WM OF RURAL WASTE AT PRESENT

The top and bottom level objectives are "to improve quality of life" and "to create awareness using local language," respectively. There are two cycles of two elements each. The elements "to arrange for renewable resource management" and "to produce biofertilizers" affect each other. Similarly, "to generate biogas" and "to achieve cheap availability

TABLE 3
Effect of Indirect Relationships on Driver Power Ranks

Number	Intent structure	Total number of objectives	Number of objectives		
			Same rank as in the direct relationship	Higher rank in indirect relationship	Lower rank in indirect relationship
1	WM at present	16	4	12	0
2	WM in future	18	3	5	10
3	WM in Rural Waste at present	20	1	1	18
4	WM in Rural Waste in future	16	1	1	14
5	WM in Industrial Waste at present	18	6	6	6
6	WM in Industrial Waste in future	18	2	1	15
7	WM in Municipal Waste at present	15	0	2	13
8	WM in Municipal Waste in future	16	1	7	8

TABLE 4
Key Objectives (Indirect Relationship)

S. number	Intent structure	Key objective
1.	Present	(i) To provide adequate technological support to WM
		(ii) To recover end of process resources
		(iii) To generate and utilize energy from waste
		(iv) To create awareness among masses about WM
2.	Future	(i) To conserve resources that may have become scarce
		(ii) To generate and utilize energy from waste
		(iii) To achieve greater use of renewable resource base
		(iv) To reuse/recycle waste
3.	Rural waste at present	(i) To create awareness using local language
4.	Rural waste in future	(i) To collect efficiently
5.	Industrial waste at present	(i) To explore industrial waste exchange
		(ii) To obligatorily enforce environmental safety technology
6.	Industrial waste in future	(i) To achieve integrated pollution control
7.	Municipal waste at present	(i) To reduce waste
		(ii) To utilize waste
8.	Municipal waste in future	(i) To ensure sanitation
		(ii) To keep environment clean
		(iv) To generate energy

and equitable distribution of energy" affect each other. Ninety percent of the objectives have lower driver-power rank when subjected to indirect analysis, whereas one objective retains its direct relationship driver-power rank. The key objective is "to create awareness using local language." No objective retains its classification because all objectives change their classification when subjected to indirect analysis.

INTENT STRUCTURE OF WM OF RURAL WASTE IN THE FUTURE

This intent structure does not have one objective at the top-most level. It has five objectives at the top level out of a total of 16. "To generate rural employment," "to ensure health and hygiene," "to save energy," and a two-element cycle with members "to protect environment" and "to minimize waste generation" are at the top level. The bottom level objective is "to ensure awareness and education about waste." There are two cycles of two elements each in the middle levels of the structure. The element "to effect better utilization of renewable waste generated" and "to recover resources," *and* "to achieve suitable treatment and technology upgradation" and "to collect efficiently" affect each other.

"To collect efficiently" is the key objective of the structure in which 87.5% of the objectives have lower driver-power rank in the indirect relationship analysis. Classification of all the objectives also changes in the indirect analysis.

INTENT STRUCTURE OF WM OF INDUSTRIAL WASTE AT PRESENT

Three objectives, "to generate employment," "to ensure ecologically sustainable development" and "to increase competitiveness," share the top level. "To explore industrial waste exchange" and "to effect integrated pollution control" are in the cycle. There are seven intermediate levels but no other cycle. "To obligatorily enforce environmental safety technology" is the bottom-level objective.

"To explore industrial waste exchange" and "to obligatorily enforce environmental safety technology" are the key elements of the structure. One-third of the objectives retain

their driver-power rank in both the direct and indirect relationship analysis, one-third having lower and the remaining have higher driver-power rank in the indirect analysis. Classification of all but one objective changes when subjected to indirect analysis.

INTENT STRUCTURE OF WM OF INDUSTRIAL WASTE IN THE FUTURE

"To generate new technologies of WM indigenously" is at the bottom level of the structure and "to ensure sustainable development" is the top level objective. There are three two-element cycles in intermediate levels that affect each other. These are "to conserve resources" and "to develop alternatives"; "to achieve cleaner production" and "to minimize waste generation"; and "to reprocess hazardous and toxic waste" and "to reprocess nuclear reactor waste."

Of the objectives, 83.3% have lower driver-power ranks in the indirect relationship analysis. "To achieve integrated pollution control" is the key element. Only one objective retains its classification when subjected to the indirect relationship analysis.

INTENT STRUCTURE OF WM OF MUNICIPAL WASTE AT PRESENT

"To generate employment" and "to develop fail safe treatment systems" are at the top and the bottom levels of structure, respectively. There is one three-element and one two-element cycle. Elements of the three element cycle are "to reduce waste," "to utilize waste" and "to achieve safe disposal"; those of the two-element cycle are "to treat garbage and sewage water" and "to recover materials from waste."

The key elements are "to reduce waste" and "to utilize waste." Of the objectives, 86.6% have lower driver-power rank and the classification of all but one objective changes in the indirect relationship analysis.

INTENT STRUCTURE OF WM OF MUNICIPAL WASTE IN THE FUTURE

This structure has a three-element cycle at the top level. The top level objectives are "to keep environment clean," "to achieve health and hygiene for all," and "to ensure sustainable development." "To sponsor new research on WM of municipal waste" is at the bottom of the structure.

There are four key elements: "to ensure sanitation," "to keep environment clean," "to recycle excreta," and "to generate energy." Half of the objectives have lower driver-power rank in indirect relationship analysis. Classification of all but two objectives changes on the basis of the indirect relationship analysis.

HIERARCHY OF ACTIONS FOR WM

The bottom level action of this hierarchy is: "Government to acknowledge the seriousness of the problem of waste." There are six actions at the top level. Pollution Control Board, industrial associations such as ASSOCHEM, municipal organizations, supplies ministry of the central government, agricultural research organizations, and power-generating organizations have all been charged with specific actions at the top level. There is one cycle in the structure with two elements "government to provide incentives like tax rebate to industries which recycle waste" and "industries to set up in-house WM cells," which affect each other. This structure has an isolated element, which, as is customary in ISM, is placed at the top level. "All citizens to prevent waste" is a one-element hierarchy in itself; it is totally independent of the remaining structure. This action by all citizens is deemed as important as the remaining structure.

TABLE 5
Classification of Objectives based on Indirect Relationship Analysis

Number	Intent Structure	Autonomous	Dependent	Linkage	Independent
1	Present	1. To conserve scarce resources 3. To improve economic viability 10. To prevent waste 14. To manage waste of materials 16. To convert waste into wealth	2. To protect environment 4. To generate employment 8. To protect public health 12. To improve productivity 13. To achieve competitiveness		5. To generate and utilize energy from waste 6. To provide adequate technological support to WM 7. To create awareness among masses about WM 9. To recover end of process resources
2	Future	4. To affect safe disposal of waste 6. To protect public health 8. To implement cleaner technologies 9. To improve productivity 14. To prevent waste 15. To maintain all WM technologies in urban and rural areas 16. To achieve intersystem coordinated functioning 17. To implement mass media WM information dissemination 18. To improve quality of life	2. To keep environment clean 10. To ensure ecologically sustainable development 12. To achieve competitiveness 13. To generate employment	1. To conserve resources that may have become scarce 3. To generate and utilize energy from waste 7. To achieve greater use of renewable resource base 11. To reuse/recycle waste	5. To develop substitute materials and techniques of WM
3	Rural Waste at present	1. To generate rural employment	2. To keep environment clean 3. To conserve resources 6. To maintain rural health 9. To help in village sustainability 11. To reduce waste 15. To improve productivity of farming system 18. To improve quality of life	13. To minimize waste generation	4. To generate biogas 5. To arrange for renewable resource management 7. To achieve cheap availability and equitable distribution of energy 8. To product biofertilizers 10. To utilize waste 12. To recognize waste 14. To convert waste into wealth 20. To collect efficiently
4	Rural Waste in future	4. To ensure health and hygiene for all 8. To help achieve rural industrialization	2. To generate rural employment 3. To protect environment 6. To replace chemical fertilizers	1. To effect utilization of renewable resource generated 10. To recover resources	5. To ensure awareness and education about waste 7. To produce biofertilizers

			9. To save energy 10. To recover resources 12. To minimize waste generation		11. To recognize waste 13. To convert waste into food 14. To convert waste into fodder 15. To achieve suitable treatment and technology upgradation
5	Industrial waste at present	1. To generate employment 8. To save energy 9. To recover resources 10. To convert waste into wealth 11. To effect clear production processes 13. To check ground water contamination 14. To recycle waste	2. To protect public health 4. To protect environment 5. to reduce cost 6. To increase competitiveness 7. To reduce waste 15. To convert hazardous waste into innocous/useful waste	3. To ensure ecologically sustainable development	15. To explore industrial waste exchange 16. To recognize waste 17. To effect integrated pollution control 18. To obligatorily enforce environmental safety technology
6	Industrial waste in future	6. To develop alternatives 10. To save energy 18. To generate employment 13. To ensure sustainable development 14. To improve municipal finances	1. To conserve resources 2. To protect environment 3. To achieve economic viability of industries	4. To reprocess hazardous and toxic waste	5. To reprocess nuclear reactor waste 8. To achieve integrated pollution control 11. To recognize waste
7	Municipal waste at present	1. To recover energy 3. To generate employment 4. To treat garbage and sewer water 6. To develop fail safe treatment systems 7. To maintain health and hygiene 8. To prevent diseases 13. To create facilities to make industrial water from waste 14. To improve municipal finances	2. To protect environment 9. To improve sanitation	11. To reduce waste 12. To utilize waste 15. To achieve safe disposal	5. To recover materials from waste 10. To achieve decentralized management and recovery
8	Municipal waste in future	2. To recover resources 7. To sponsor new research on WM of municipal waste 12. To achieve individual level treatment 13. To achieve individual level recycling/reuse 16. To generate energy		1. To keep environment clean 5. To achieve health and hygiene for all 6. To ensure sustainable development	3. To utilize waste 4. To generate employment 8. To improve municipal finances 9. To prevent diseases 10. to ensure sanitation 14. To introduce best of WM technology 15. To recycle excreta

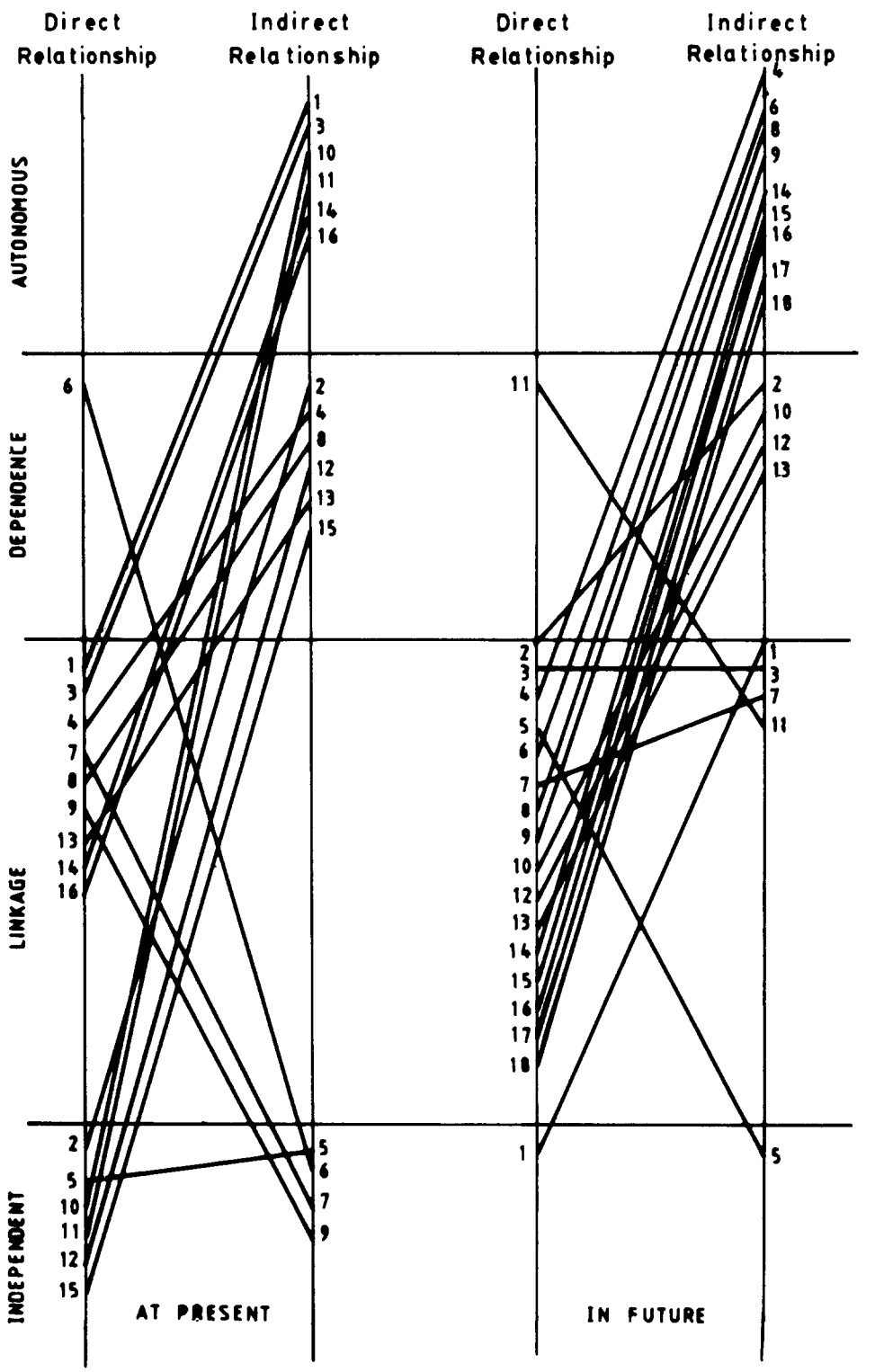

Fig. 9. Change in classification of objectives of WM in general.

The hierarchy of actions was not subjected to an indirect relationship analysis because it was thought that such an analysis, though very important to study causation and intent, does not have much relevance when studying the hierarchy of actions to be taken.

Discussion of Results

LIST OF OBJECTIVES

Modified idea writing employed for the generation of the objectives resulted in exhaustive lists that needed shortlisting and edited to a small extent. The following results are highlighted:

1. The present objectives in all categories emphasized economic aspects, whereas those for the future emphasized environmental sustainability and quality of life aspects.
2. The village sustainability and quality of life aspects are on the list of rural waste objectives at present, but they are not present in the list for future. It points to the fact that participants opine that the Indian villages that will survive after 20 years will be sustainable in themselves and the main problems of WM will be to generate rural employment, to check population emigration, protect the environment, minimize waste generation, etc.
3. Industrial waste management at present has an objective calling for law enforcement for environmental protection at the bottom of the list. Economic aspects receive more emphasis than does the environment. But this is not true for the future. In this list, the emphasis is on indigenous technology development, hazardous and toxic WM, and on sustainable development of industrial/urban population centres.
4. For the WM of municipal waste at present, development of fail-safe treatment systems and economic aspects such as employment generation and improvement of municipal finances are emphasized. Future WM of municipal waste has been considered dependent on sponsoring new research, recycling of excreta, individual level treatment, and efficient collection.
5. The qualitative changes in various lists indicate that the modified idea-writing process employed has been successful in triggering creative thinking in the participants.

INTENT STRUCTURES

The following points are highlighted with reference to the developed intent structures:

1. Five intent structures have only one objective at the top level, whereas all the eight have only one objective at the bottom level. Three intent structures for the rural waste in the future, for industrial waste at present, and for municipal waste in future, have three or more objectives at the top level, which suggests that these categories have many objectives of nearly equal importance that are considered most pertinent, and a trade-off is required.
2. The intent structure for municipal waste in the future does have a three-element cycle at the top level but the elements are primarily concerned with environmental protection, which will ensure health and hygiene for all and ensure sustainable development.
3. Levels and cycles in the intent structures are logical and seem intuitively satisfactory.

4. The intent structure for rural waste in the future has five objectives at the top level, out of which two are in a cycle. This is indicative of the fact that rural waste will become a vital issue in an agricultural society such as India. The present thinking about the issue of waste management is not very clear, this may remain so in the future as well.

ANALYSIS OF RELATIONSHIPS

Analysis of interrelations among the objectives of WM in various categories carried out in this study confirm the fact that indirect relationship analysis based on the MICMAC principle is more effective in revealing the interrelationships than the direct relationship analysis based on digraph. The following points are highlighted in this context.

1. The driver-power rank of almost all objectives changed when indirect relationship analysis was carried out. In most cases, the rank in indirect relationship was lower than that found by direct relationship analysis of digraphs. This indicates that the objectives thought to be strong drivers of the intent structure were actually not found to be so when the impact of indirect relationship was taken into consideration.
2. The key elements found from direct analysis did not persist as key elements after indirect relationship analysis.
3. The classification of objectives into autonomous, dependent, linkage, and independent categories varied in direct and indirect analysis. Most objectives fell into the linkage category in direct analysis, that is, they were supposed to affect the intent structure both ways. But indirect relationship analysis altered this classification and revealed that, when the impact of indirect relations is considered, most objectives become either autonomous, independent, or dependent, and the linkage class loses its membership drastically.

LIST AND HIERARCHY OF ACTIONS

1. The list of actions provided by the respondents on the basis of feedback supplied embraced all agencies such as government, voluntary organizations, teaching, and research organizations, industrial, rural, and municipal policy planning, etc. The respondents provided a focused list of agencies that should be charged with these actions.
2. The government has been charged with the most basic action of accepting the seriousness of the problem of waste, which forms the bottom level action in the hierarchy.
3. The top level of the hierarchy has as many as seven actions, which is suggestive of the multifaceted nature of the problem of waste.
4. The isolated action at the top level of hierarchy reflects the uniqueness of the citizens' responsibility to prevent waste.
5. The top-level actions that have ensued from the study and the organizations charged with the responsibility of their implementation are:

   - Pollution Control Boards to tighten environmental protection;
   - Industrial associations to explore waste exchange and encourage research and development (R&D) on waste;
   - Municipal organizations to conserve resources and enforce sanitation laws;
   - DGS and D under the Ministry of supplies to check waste of materials;

- Power-generating organizations to set up power plants that use municipal waste;
- Agricultural research organizations to develop methods to use waste to generate rural employment.

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Appendix I

Write up

In all activities, resource inputs such as manpower, materials, energy, technology, and so on are used. Unnecessary input of these resources is called waste. Second, while producing desirable products and services, all systems also produce undesirable fumes, pollutants, scrap, residues, etc. This is also called waste.

Thus any unnecessary input and/or undesirable output is waste.

Input stage waste is usually classified according to resource categories, such as waste of manpower, waste of technology, waste of energy, waste of materials, etc.

Most commonly used classification of output stage waste is placed in three categories, namely, industrial waste, municipal waste, and rural waste.

Waste management (WM) is that multidisciplinary activity that deals with identification, reduction, collection, recycling, and disposal of waste.

Ours is a developing country and we have to increase productivity in all spheres, conserve our insufficient and fast-depleting resources, provide meaningful employment to a huge population, increase industrial and agricultural production, give meaning and shape to a welfare state, safeguard ecological balance, protect environment, etc.

All of the above place different and often conflicting demands on waste-management activities and for positive development we must evolve a rational and balanced approach toward waste and its management.

Questionnaire

Note 1: By objective, we mean the main purpose for which waste should be managed. We may say that objective is the focus around which WM should be carried out. There can be many objectives such as "to improve productivity," "to generate employment," "to protect environment," etc.

Note 2: Please *do not* take the above-mentioned objectives as suggestions or guidelines. Please formulate the objectives that *you* deem as most important.

Note 3: While answering a question regarding the future, please ponder your experience and the perceptions that you may have developed about the future of Indian economy and technological progress.

1. *Please Fill in the Gaps in the Following Items*

(a) The three most important objectives of waste management (WM) in India *in general at present* in descending order of importance *should be* to:
(1) _____
(2) _____
(3) _____

(b) The three most important objectives of WM of *rural waste* in India *at present* in descending order of importance *should be* to:
(1) _____
(2) _____
(3) _____

(c) The three most important objectives of WM of *industrial waste* in India *at present* in descending order of importance *should be* to:
(1) _____
(2) _____
(3) _____

(d) The three most important objectives of WM of *municipal waste* in India *at present* in descending order of importance *should be* to:
(1) _____
(2) _____
(3) _____

(e) The three most important objectives of WM in India *in general in 2010 A.D.* in descending order of importance *would be* to:
(1) _____
(2) _____
(3) _____

(f) The three most important objectives of WM of *rural waste* in India *in 2010 A.D.* in descending order in importance *would be* to:
(1) _____
(2) _____
(3) _____

(g) The three most important objectives of WM of *industrial waste* in India *in 2010 A.D.* in descending order of importance *would be* to:
(1) _____
(2) _____
(3) _____

(h) The three most important objectives of WM of *municipal waste* in India *in 2010 A.D.* in descending order of importance *would be* to:
(1) _____
(2) _____
(3) _____

2. Kindly Write Any Suggestions that You Would Like to Give Regarding Objectives of WM in India in the Space Below:

Name: _____
Total Experience: ( ) years
Address: _____
_____
_____