IMPORTANCE WEIGHTING OF IMPACTS IN ENVIRONMENTAL IMPACT STUDIES

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ABSTRACT: Environmental impact studies typically compare and evaluate many impacts covering a wide range of considerations including socioeconomic, human interest, geoenvironmental, and political factors. Therefore, evaluation of the importance of impacts in the decision-making process is not an easy task. Information on the environmental impacts of the investigated action and its alternatives can often best be presented in a comparative form. Such a comparison not only defines the issues, but also provides a clear basis for decision making. This study presents systematic methods used for comparing and evaluating impacts using the cesspool system in the city of Jeddah, Saudi Arabia, as a case study. A structured importance weighting approach relying on a ranked paired-comparison technique and an unranked paired-comparison technique has been used in this study. These decision-analysis techniques basically involve a series of comparisons between impacts and a systematic tabulation of the numerical results of these comparisons. An Environmental Evaluation Systems (EES) and an Unranked Decision Matrix (UDM) have been developed for comparison and evaluation of 17 impacts of the cesspool system. The results of the study provide the necessary guidelines for Jeddah Municipality and Jeddah Water and Wastewater Department to deal with the current problems and future planning of the sewage system in the city.

INTRODUCTION

Jeddah is one of the largest cities in Saudi Arabia. During the last 25 years the city has undergone tremendous expansion and development. However, in the process of rapid development, the future impact of some of the civic amenities introduced in new suburban areas was not considered. The case in hand is that of cesspool systems used in many areas of the city for domestic and commercial wastewater disposal. The long-term use of cesspool systems has caused the ground water table to rise rapidly in many areas of the city and has caused contamination of potable water generally stored in underground reinforced concrete tanks for buildings. In some areas the water table has reached the ground surface, thus, creating sewage pits which become breeding grounds for mosquitoes and other insects. The effect of ground water on pavements and the foundations and walls of buildings is also visible in some areas. This has resulted in a decline in property value in the affected areas.

In an earlier study, the writer identified 17 environmental impacts (Table 1) caused by the use of cesspool systems in Jeddah (Mohorjy 1996). These impacts were formulated by using the Delphi technique to gather the views and opinions of some 450 individuals with knowledge of the sewage system in Jeddah. It took four steps and three rounds to conduct a comprehensive Delphi Survey. The survey started by forming a contact network as a sample population, and then proceeded with two iterations of the Delphi survey. It was completed with a consensus-building workshop.

The main objective of this study is to compare, evaluate, and rank the 17 impacts identified in the first study using ranked and unranked paired-comparison techniques for importance weighting. It is hoped that the results of the study will help the city's decision makers to formulate future plans for the sewage system.

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DETERMINATION OF IMPORTANCE WEIGHTING OF IMPACTS

Importance weighting of impacts in an environmental impact study is done via decisions on the relative importance of existing environmental conditions and environmental impacts. In most studies these decisions are made on an ad hoc basis without using available formalized techniques to provide a documented record of the considerations and rationale.

In an importance weighting approach the weight of each impact relative to every other impact is considered, and the resulting information on each impact (qualitative, quantitative, or ranking, rating, or scaling) is presented in terms of the relative importance of the impacts. Because this approach is used in decision making, the critical issue is the use of an effective method to assign importance weights to individual impacts, or, at least, to arrange the impacts in rank order of importance. In the present study, two structured importance weighting and

TABLE 1. Identified Impacts of Cesspool System in Jeddah (Not in Priority Order)

Impact identification number (1)	Environmental impact (2)
I1	Contamination of potable water by cesspools
I2	Spread of odor and bad smell from sewage pits
I3	Marine and coastal pollution due to disposal of untreated sewage to the sea
I4	Frequent overflow of cesspools
I5	Cost of cesspool construction and its periodical dewatering
I6	Spread of insects from sewage pits
I7	Aesthetical and nuisance impacts
I8	Flooding of basements and deterioration of foundations
I9	Rutting of asphalt pavement
I10	Increase in costs of construction, operation and maintenance of underground public services
I11	Losing opportunity cost of not reusing and recycling wastewater
I12	Settlement of soil layers
I13	Traffic problems due to sewage accumulation in streets
I14	Decline in land value in affected areas
I15	Decline in housing value in affected areas
I16	Soil contamination
I17	Reduction in tourist and recreational activities

ranking techniques have been used to evaluate the importance of impacts due to the use of cesspool systems in Jeddah. These two techniques are ranked and unranked paired-comparison techniques which have been used extensively in decision-making efforts including numerous examples related to Environmental Impact Statements (EIS) (Canter 1996). These techniques basically involve a series of comparisons between impacts and a systematic tabulation of the numerical results of the comparisons. It represents adaption of multiple-criterion or multiple-attribute decision-making techniques used in other fields; such techniques are also called "decision-analysis techniques" and "decision-support system" (Lohani, unpublished paper, 1996).

RANKED PAIRWISE-COMPARISON

The key feature of this technique is that an initial ranking of all impacts is required. The general methodology developed for water resources projects is called Environmental Evaluation System (EES). The relative importance of the impacts is expressed in commensurate units called Impact Importance Units (IIU), by quantifying subjective value judgments of several individuals. The weighting technique used by the method developers, Battelle, Inc., was based on environmental scaling techniques and a modified Delphi procedure (Dee et al. 1972, 1973; Linstone 1975). The importance weighting technique in the EES forces a systematic consideration of the impacts, minimizes individual bias, produces consistent comparisons, aids in the convergence of judgment, and evaluates significance of findings.

In ranked pairwise-comparison, the list of impacts to be compared is ranked according to their importance, and then successive paired comparisons are made between contiguous impacts to determine for each impact pair the degree of difference in importance.

The following eight steps are used in the ranked weighting technique (Canter 1996):

Step 1: Select a group of individuals for conducting the evaluation, and explain to them in detail the weighting concept and the use of their rankings and weighting.

Step 2: Rank the groups and subgroups of impacts that are to be evaluated.

Step 3: Assign a value of 1 to the first group on the list. Then compare the second group with the first to determine how much the second is worth compared to the first. Express this value as a decimal ($0 < x \leq 1$).

Step 4: Continue with these pairwise-comparisons until the list has been evaluated (compare the third with the second and fourth with the third, etc.).

Step 5: Multiply out ratios and express terms over a common denominator, using the average values for all individuals in the experiment.

Step 6: In weighting the groups or subgroups, adjust the decimal values from Step 5 if an unequal number of impacts exist in the groups of impacts being evaluated. Adjustments are made by proportioning these decimal values in proportion to the number of impacts included in that grouping.

Step 7: Multiply these averages by the number of IIU to be distributed to the respective grouping.

Step 8: Repeat Steps 2–7 for all groups and subgroups of impacts in the EES.

The application of this stepwise procedure in this study is explained here in detail, and the resultant EES is shown in Fig. 1.

Step 1: 450 individuals with knowledge of the sewage sys-

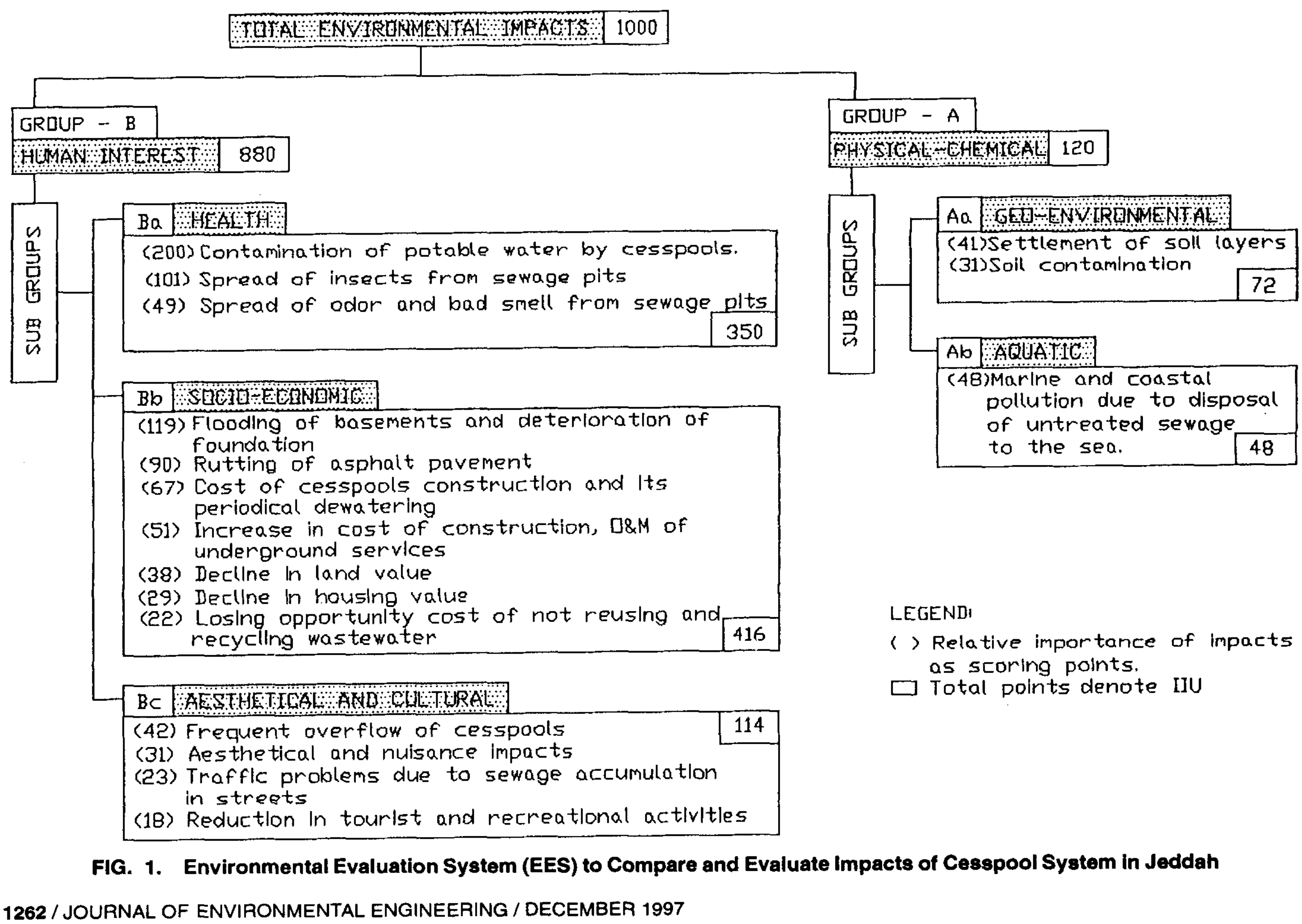

FIG. 1. Environmental Evaluation System (EES) to Compare and Evaluate Impacts of Cesspool System in Jeddah

tem in Jeddah were selected to compare and evaluate the 17 predefined impacts. The weighting concept and the use of ranking and weighting were explained to them in detail. The impacts were weighed using the following criteria:

1. Importance based on institutional recognition: The importance of impact is acknowledged in the local legislation, adopted plans, and other policy statements of public agencies.
2. Importance based on public recognition: Beneficiaries of the sewage system as a segment of the general public recognize the importance of the impact. Public recognition may take the form of controversy, support, conflict, or opposition, and may be expressed formally, as in official letters, or informally.
3. Importance based on technical recognition: The importance of impact is based on scientific or technical knowledge or professional judgment.

Table 2 contains the relevant information on the 17 impacts, given as background for comparison and evaluation. The 17 impacts were grouped into two main groups: (A) physical-chemical; and (B) human interest. Group A contains two subgroups, geoenvironment and aquatic. Group B includes three subgroups, health, socioeconomic, and aesthetical and cultural.

Step 2: The initial ranking of importance for the two main groups was based on the consideration of the following three criteria relative to each impact:

1. Spatial and temporal consequences
2. Reliability of information
3. Sensitivity to changes in the environment

The result of the ranking of the two main groups indicated that human interest impacts were more important than physical-chemical effects.

Step 3 and 4: Based on professional judgment the following weights were assigned to B and A:

$$B = 1$$

$$A = 1/5 = 0.2 \quad \text{the importance of B}$$

Step 5: Multiply ratios and express terms over a common denominator. The average values of the two groups of impacts are given

$$B = 1/(1 + 0.20) = 0.83$$

$$A = 0.2/(1 + 0.20) = 0.17$$

Step 6: Adjust for unequal number of impacts in each group.

The hierarchical system shown in Fig. 1 has an unequal number of impacts in each group of the two main groups, A and B. To be mathematically correct, all levels of the EES hierarchy should have an equal number of impacts. However, at the present time, this difference in the number of impacts from group to group must be taken into consideration when assigning IIU in the ranking and weighting. Therefore, in the ranking and weighting procedure (Steps 1–5), it is assumed that an equal number of impacts exists in the groups being compared. These value judgments were adjusted in proportion to the number of impacts in each group as follows:

$$B = 0.83 \times \frac{3}{5} = 0.50$$

$$A = 0.17 \times \frac{2}{5} = 0.07$$

Using the new total, the group values are

$$B = 0.50/(0.5 + 0.07) = 0.88$$

$$A = 0.07/(0.5 + 0.07) = 0.12$$

and the average values for the impacts in A and B are

$$A = 0.88/3 = 0.29$$

$$B = 0.12/2 = 0.06$$

Step 7: Multiply these adjusted values by the appropriate IIU, which in this case are assumed to be 1,000 for Total Environmental Impacts (TEI). Therefore

$$B = 1{,}000 \times 0.88 = 880 \text{ points for human interest impacts}$$

$$A = 1{,}000 \times 0.12 = 120 \text{ points for physical-chemical impacts}$$

In this case of EES, a total of 1,000 IIUs are assigned to the impacts by first distributing to the two groups: (A) physical-chemical impacts; and (b) human interest impacts, then to the five subgroups of impacts, and, finally, to the 17 individual impacts. That is, for the two groups of impacts, the participating individuals determined which of the two was more important and then assigned appropriate weights as mentioned previously.

Step 8: The process is continued until all of the IIUs are reviewed and distributed among all subgroups and individual impacts in a reliable estimate based on several iterations of the technique.

Evaluating the Importance of Subgroups

For human interest group (B), the following weights are assigned:

B_a = health impacts = 1

B_b = socioeconomic impacts = $\frac{1}{2}$ = 0.50 the importance of B_a

B_c = aesthetical and cultural = $\frac{1}{4}$ = 0.25 the importance of B_a

For physical-chemical group (A), the following weights are assigned:

A_b = aquatic = 1

A_a = geoenvironment = $\frac{3}{4}$ = 0.75 of the importance of A_b

Using the technique discussed earlier and the specific IIU values which were calculated at Step 7, the points for each subgroup are

- B_a—350 points for health impacts
- B_b—416 points for socioeconomic impacts
- B_c—114 points for aesthetical and cultural impacts
- A_b—48 points for aquatic impacts
- A_a—72 points for geoenvironment impacts

All of the weighting and feedback were performed via formal feedback statements, thereby avoiding undesirable direct interchange of judgments of the individuals in the study.

This process is continued until all the units are distributed among all individual impacts in each subgroup of impacts in a systematic, reliable estimate based on several iterations of the technique. The ranked pairwise-comparison evaluates not only the importance of main groups, but also those of different impacts in each group. In Fig. 1, the results of the comparison are presented by arranging the groups, subgroups, and the impacts in the descending order of the ranking in terms of IIU.

In the group of human interest impacts (B), the subgroup

TABLE 2. Relevant Information on Impacts of Cesspool System in Jeddah (Not in Priority Order)

Impact identification number (1)	Identified impact (2)	Nature of impact (3)	Description (4)
I1	Contamination of potable water by cesspools	Public health	Pollutants found in Jeddah municipal wastewater are suspended and dissolved solids consisting of inorganic and organic matter, nutrients, oil and grease, toxic substances, and pathogenic microorganisms. Since this human waste is not properly collected, carried away, treated, and disposed of, it will be mixed with potable water through seepage from cesspools or crossconnection with water supply networks, thus pose risks of parasitic infections (through direct contact with fecal material) and hepatitis and various gastrointestinal diseases, including cholera and typhoid through contamination of water supply. Because water supply flow in Jeddah is not continuous but may come to a certain district once a week, and the ground water tables rise sharply at an alarming rate of 0.5 m/year, domestic water supply may be mixed with the contaminated ground water as the latter overlays the domestic water network (pipe lines). This means that drinking water which is used directly by humans is exposed to contamination.
I2	Spread of odor and bad smell from sewage pits	Air quality/public health	The sharp rise of water table and inundation of low lying areas forming pits and pools of untreated sewage spread odor and bad smell all around these areas. There is a probability of emission of volatile organic compounds from raw sewage.
I3	Marine and coastal pollution due to disposal of untreated sewage	Marine environment at out fall diffuser, beach, and coral reef erosion and loss of fisheries productivity	When wastewater is collected from cesspools by trucks but not treated before disposal or reuse, the same public health hazard as in impact I1 exists at the point of discharge, if it is a wadi east and south of Jeddah. If such discharge is to receiving Red Sea at Al-Khomra site, additional effects will occur (e.g., habitat for aquatic and marine life is impaired by accumulated solids, oxygen is depleted by decomposition of organic material; and aquatic and marine organisms may be further harmed by toxic substances, which may spread to higher organisms through bioaccumulation in food chain). If the discharge enters confined water, such as nearby Salman bay at the south of Jeddah coast, its nutrient content can cause eutrophication, with nuisance plant growth which can disrupt fisheries and recreation activities.
I4	Frequent overflow of cesspools	Public health/aesthetics	If cesspools are not periodically cleaned and sewage trucked away, it will frequently overflow causing inundation of low lying areas and form sewage pits.
I5	Cost of cesspool construction and its periodic dewatering	Socioeconomic	It is estimated that to construct what is called publically a bricks box, sized 3 m × 3 m × 3 m cesspool, it will cost the individual household owner 9,000–10,000 Riyal; and to clean it periodically by trucking the sewage, it will cost 10–12 S.R/m^3 of sewage trucked twice a month on average (U.S. $ = 3.75 S.R).
I6	Spread of insects from sewage pits	Public health	The formed sewage pits become breeding environments for flying and crawling insects.
I7	Aesthetical and nuisance impacts	Human interest	Nuisances, aesthetics, and public health hazards from cesspool overflow, backups, and formed sewage pits. These pits are unpleasant sights. It develops a proper climate for the growth of uncontrolled and unattractive plants. In public and private green areas (parks) the rising of the ground water table causes the deterioration of plants. It turns beautiful recreation areas into swamps.
I8	Flooding of basements and deterioration of foundations	Socioeconomic	The basement of many affected buildings were not designed to cope with the significant hydrostatic pressure, nor were they protected from the chemical attack associated with a high water table. Damages to structural elements of buildings results from hydrochemical attack to concrete and reinforcement by sulphate ($SO_4^=$), chloride (Cl^-) and nitrate NO_3^-), which are available in local ground water in Jeddah. The main risk occurs at water table by capillary zone. The damage may occur due to weathering of concrete through sulphate infiltration of steel reinforcement as a result of chloride attack. Corrosion may lead to expansion of reinforcement and subsequent spalling of concrete. Foundation placed on rocks may also be exposed to damage due to weakening and softening of porous weathered rocks. Solution of cavity in fill materials or washout of lines from cavities may cause settlement and collapse of foundation.
I9	Rutting of asphalt pavement	Traffic safety and socioeconomic	Bearing capacity is reduced almost to one half when water table rises to surface of ground. The intrusion of water in as-

TABLE 2. (Continued)

(1)	(2)	(3)	(4)
			phalt pavement materials may cause particle rearrangement which, in turn, increases pavement distresses, which lead to rutting of asphalt pavement materials. A recent study by Zahran and Fatani (1995) showed that rehabilitation cost per kilometer of pavement in Jeddah is S.R. 111,300 or S.R. 11.3/linear meter for 5 cm stripping thickness and a width of 6 m roads, which is equivalent to U.S. $30/linear meter. It is estimated that 30–40% of roads in Jeddah are affected by rise of water table and need to be rehabilitated periodically.
I10	Increase in costs of construction, O&M of underground public services.	Socioeconomic	Due to lack of a proper sewerage system, the sewage has been seeping into the ground through the cesspools. As a result, it is estimated that the ground water levels are rising through Jeddah at an estimated approximate rate of half a meter per year which make it difficult to layout, and maintain underground public utilities because of the difficulty of digging and tunnelling and the need for continuous dewatering which is expensive, needs certain experience, and has some side effects if not properly done.
I11	Losing opportunity cost of not reusing and recycling the wastewater	Socioeconomic	More than 50% of wastewater generated in Jeddah is not being collected, treated, and reused properly which lead to lost opportunity to get benefit of treated wastewater. Such benefits as increased water availability to support development in the region, the opportunity to diminish landscape irrigation demands on potential public water supply source as expensive desalination, reduced need for chemical fertilizers, and using treated sewage for industrial purposes as water for cooling towers, etc. These beneficial uses of wastewater can often be measured, most of them by calculating avoided costs.
I12	Settlement of soil layers	Geoenvironment	Bearing capacity is reduced almost to one half when the water table rises to surface of the ground. The intrusion of water in soil voids and between particles may cause soil particle rearrangement, which in turn lead or result in collapse. Collapse may also be caused due to loss of cementation and/or leaching of salts. Solutions of cavity infill material or washout of lines from cavities may cause settlement and collapse. Such considerations were not taken into account when buildings in Jeddah were designed and constructed. Due to this, and as the ground water rises, heave settlement or soil collapse takes place. Heave may also occur due to soil expansion as it becomes saturated with water.
I13	Traffic problems due to sewage accumulation in the streets	Traffic safety	Roads in affected areas may be closed for through traffic or at least speed has to be lowered due to sewage ponding. This creates, to a great deal, an uncomfortable feeling and may cause some contamination from moving vehicles.
I14	Decline in land value in affected areas	Socioeconomic	The identified environmental and socioeconomic detrimental impacts due to the use of cesspool system in some areas of the city make people uncomfortable which causes land value to decline.
I15	Decline in housing value in affected areas	Socioeconomic	The greatest damage is being done to buildings in areas of the city where the water table was historically low which badly affected housing values.
I16	Soil contamination	Geoenvironment	The frequent overflow of cesspools and inundation of low lying areas forming pits of sewage causes continuous contamination of soil layers, posing risks of public health hazard through direct contact or through plants planted in these contaminated soil.
I17	Reduction in tourist and recreational activities	Human interest	Real or perceived nuisances and adverse aesthetic impacts in affected areas and dumping untreated sewage to the sea results in reduction of tourist and recreational activities for citizens, visitors, and tourists.

of socioeconomic impacts has 416 points (IIU), while the subgroup of health impacts follow with 350 points, and lastly, the subgroup of aesthetical and cultural impacts has 114 points.

In the group of physical-chemical impacts (A), the most important impact is the aquatic impact which stems from the marine and coastal pollution due to disposal of untreated sewage to the sea (see Table 1, I3).

For the subgroup of socioeconomic impacts, the most important impact is the flooding of basements and deterioration of foundations due to the rise of the water table (see Table 1, I8), and for the aesthetical impacts, the most important impact is the frequent overflow of cesspools (see Table 1, I4).

The results show that, although the subgroup of socioeconomic impacts has more points than that of the subgroup of health impacts, the contamination of potable water by cesspools (Table 1, I1) gets the maximum points in terms of IIU, and, therefore, turns out to be the most important impact. The points of this impact exceed the total points of group A and subgroup B_c. This method of comparison, therefore, indicates not only a comparative ranking of impacts, but also a ranking

TABLE 3. Unranked Decision Matrix (UDM) to Evaluate and Rank Importance of Impacts of using Cesspool System in Jeddah

Impact	SUM	I.I.C	RANKING
I1	17	0.111	1
I2	13.5	0.088	4
I3	13.5	0.088	5
I4	15	0.098	3
I5	8.5	0.056	9
I6	16	0.105	2
I7	10	0.065	8
I8	12	0.078	6
I9	11	0.072	7
I10	8.5	0.056	10
I11	2	0.013	17
I12	6	0.039	11
I13	6	0.039	12
I14	2.5	0.016	15
I15	2.5	0.016	16
I16	4	0.026	14
I17	5	0.033	13
I18 (DUMMY)	0	0.000	18
TOTAL	153	1	

Legend:
Impact # I_1–I_{17} are described in table 2
I.I.C.=Impact Importance Coefficient
$SUM = \frac{N(N-1)}{2}$, N = Total number of impacts

of different impacts with other impacts or groups/subgroups of impacts.

UNRANKED PAIRWISE-COMPARISON

Another technique usefully employed for importance weighting of impacts is the unranked paired comparison technique. This comparison technique is developed by statisticians and operation researchers and has been widely used for environmental analysis since the last decade (Dean and Nishry 1965). A major study was conducted in India to evaluate alternatives for a major water project south of the city of Calcutta using this technique (Bose 1995). This technique can be used by an individual, an interdisciplinary team, or a group, and involves the comparison of each identified impact to every other impact in a systematic manner. This weighting technique consists of considering each impact relative to every other impact, on a pairwise basis. In each pair a value of 1 is assigned to the impact considered to be more important, and a value of 0 to the other impact.

Seventeen impacts in the present study were identified earlier (Table 1), the weighting technique consisted of considering each of the 17 impacts relative to every other impact. In each pair of impacts, the most important impact was assigned a value of 1, and to the less important of the pair, a value of 0 was assigned according to the professional judgment of the individuals participating in this study. The rationale for each decision depended on the detailed relevant information on the impacts given in Table 2. The use of this unranked paired comparison technique for using cesspools as an effluent control system is shown in Table 3 which is called Unranked Decision Matrix (UDM). It should be noted that the assignment of 0 to a member of a pair does not denote "no importance"; it simply means that in the pair considered, it is of less importance (least environmentally disruptive in the pair). Therefore, this technique involves both interval and ordinal scaling.

A "dummy impact" (see Table 3, I18) is included to preclude the net assignment of 0 value to any basic impact (I1–I17) in the process of each paired comparison. Therefore, the dummy impact is included as a "place keeper" to avoid skewing the process. The dummy impact is assigned a value of 0 when compared to any basic impact.

In paired comparison, if two impacts are considered to be of equal importance, when a value of 0.5 is assigned to each impact.

The process of assignment of importance to each impact relative to other impacts is completed following several iterations to be sure that each impact is being considered in a consistent manner with each other impact. The resultant Unranked Decision Matrix (UDM) is developed and presented in Table 3.

Following the previous procedure (Table 3), the individual weight assignments are summed and the Impact Importance Coefficient (IIC) is calculated. IIC is equal to the sum value for an individual impact divided by the sum for all of the impacts and is expressed as a decimal fraction. The total of the sum column should be equal to (N)(N − 1)/2, where N is the number of the impacts included in the assignment of weights. As shown in Table 3, 18 impacts were considered, including the "dummy." The sum column total should be equal to 153. The total of IIC column should be equal to 1.00.

The IIC column in Table 3 indicates that of the 17 basic impacts, impact I1 "contamination of potable water by cesspools," is most environmentally disruptive, followed by I6, I4, I2, I3, I8, I9, I7, I5, I10, I12, I13, I17, I16, I14, I15, and I11. This unranked paired comparison technique has enabled the rank ordering of the 17 impacts from most important to least important.

CONCLUSIONS

The focus of this paper is on systematic methods which can be used for importance weighting of impacts in environmental

TABLE 4. Comparison of Ranking of Impacts by Two Techniques

Impact (1)	Ranking order as per unranked pairwise-comparison (2)	IIU per ranked pairwise-comparison (3)
Contamination of potable water by cesspools	1	200
Spread of insects from sewage pits	2	101
Frequent overflow of cesspools	3	42
Spread of odor and bad smell from sewage pits	4	49
Marine and coastal pollution due to disposal of untreated sewage to the sea	5	48
Flooding of basements and deterioration of foundations	6	119
Rutting of asphalt pavement	7	90
Aesthetical and nuisance impacts	8	31
Cost of cesspool construction and its periodic dewatering	9	67
Increase in costs of construction, O&M of underground public services	10	51
Settlement of soil layers	11	41
Traffic problems due to sewage accumulation in the streets	12	23
Reduction in tourist and recreational activities	13	18
Soil contamination	14	31
Decline in land value in affected areas	15	38
Decline in housing value in affected areas	16	29
Losing opportunity cost of not reusing and recycling the wastewater	17	22

impact studies. The ranked paired comparison technique and unranked paired comparison technique have been used to compare and evaluate impacts of using cesspools as an effluent control system in Jeddah. These comparisons very clearly point out the most important impacts that must be considered by Jeddah Municipality and Jeddah Water and Wastewater Departments in improving the sewerage system in the city.

Although the two techniques allowed systematic, easier, and more straightforward comparison, evaluation, and ranking of impacts, the unranked pairwise-comparison requires fewer iterations and has a simpler procedure, since no initial rank ordering of impacts is required. The unranked paired comparison technique has enabled direct ranking of the 17 individual impacts from most important to least important without any relative importance/weights. The ranked paired comparison technique considered groups and subgroups of the impacts and calculated Impact Importance Units (IIU) for each impact. This method, therefore, shows relative weightage of each impact with other impacts and group/subgroup of impacts.

Table 4 shows a comparison of the results obtained by the two comparison techniques in the present study. In both techniques "contamination of potable water by cesspools" becomes the most important impact to be considered. This shows that if an impact has tremendous bearing on the environment, it will be identified, no matter what technique of comparison is used. The same seems to be true for the impact due to the spread of insects from sewage pits. However, for other impacts, the ranking/points by the two techniques differ quite appreciably. The impacts at 3, 4, and 5 by unranked pairwise comparison has low rating in ranked pairwise-comparison.

Both techniques depend solely on preliminary investigations and physical surveys used to analyze the potential impacts and their relevant qualitative and quantitative information. Care must be taken, therefore, during the physical surveys and other investigations, otherwise the importance weighting of impacts might be superficial and the proposed action might fail over time.

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