Handbook

for Estimating the Socio - economic and Environmental Effects of **Disasters**

Economic Commission for Latin America and the Caribbean
ECLAC

Section Three

Infrastructure

Introductory note: Three main infrastructure sectors are included in this section: energy (both the electric power and oil segment), drinking water and sanitation, and transport and communications.

I. ENERGY

A. INTRODUCTION

Energy, like all other sectors, sustains direct damages and indirect losses during and after disasters, and their macroeconomic impact must also be ascertained. Direct damages refer to the immediate damage or destruction of physical infrastructure and inventories available at the time of the disaster. Indirect losses refer to the costs of satisfying demand for energy during the recovery period, as well as the net income or profit that is not received in said period. These indirect losses are used to separately assess the macroeconomic effects.

One must determine the repair or reconstruction costs required to reestablish pre-disaster operating capacity. A decision must be taken as to whether the new operating capacity should be equal to the one in place prior to the disaster or incorporate updated efficiency and security standards. Valuation criteria at current replacement cost –including technological innovations– will provide a more accurate cost of the works to be carried out in practice and the financial resources they will require.

The cost estimate must take into consideration the time needed for repair work to be completed and the costs of meeting temporary needs, as explained below in the section on indirect losses.

It is much easier to estimate stocks of equipment, materials and raw materials that were damaged or destroyed by the disaster, with replacement costs at current market prices. If at the time of the assessment, there are no equal goods available in the market, it is necessary to use the cost of the most similar goods in order to obtain equivalent or approximate results.

The quantification of indirect losses is a more complex task because it is based to a greater degree on estimates. On the one hand, the behavior of supply and demand during the rehabilitation period must be estimated; on the other, the financial results that will actually be obtained over the same period must be compared to those that would have been obtained if the disaster had not occurred. In the projection of what will happen after the disaster, results will clearly be lower than those estimated before the disaster, because large consumers will have reduced their energy demands. Though it is less likely, energy demand could increase if large amounts of energy are required for repair works. Both situations may actually occur concurrently, in which case a quantification of the net results must be made.

Once the analyst has determined post-disaster demand –which can be equal to, smaller than or greater than normal demand– the means to properly meet it must be identified. As a general criterion, assume that demand for energy will be met somehow. Then estimate the required capital and operating costs, based on how long it takes to rehabilitate all facilities. Capital costs essentially refer to the purchase of equipment, while operating costs consist of labor and materials. Personnel costs should include salaries of plant personnel temporarily laid off for any reasons arising out of the disaster.

Finally, indirect losses must be estimated. Begin by estimating the net income that can be obtained during the rehabilitation period. Then subtract the cost of temporary energy supplies in addition to the company's operational costs during the rehabilitation period from estimated income from energy sales in the same period. Keep in mind that net income thus estimated might be negative depending on the post-disaster purchasing capacity of consumers. Second, estimate the net income that would have been obtained had the disaster not occurred by subtracting total cost from gross income, just as was done in the previous example. This information is often available in the records of companies that manage the sector, especially in their respective short- and medium-term planning departments. The amount of total indirect losses can be determined by the algebraic difference –applicable in cases of real negative income– between the two previously estimated net incomes. These indirect losses would already include the additional costs of temporarily meeting demand, as well as the income that will not be received because of the disaster.

The previous estimates of costs stemming from direct and indirect damage should be broken down, on the one hand, into local and foreign currency components so that they may be used for the overall balance-of-payments calculations. On the other hand, distinctions must be made with regard to damage and losses corresponding to the public sector and to private enterprises, with a view to their utilization in subsequent estimates of national accounts for the calculation of macroeconomic effects.

We recommend the following assessment methodology for the electricity and oil sectors.

B. ELECTRICAL SECTOR

1. Direct damage

Direct damages in the electrical sector usually affect the following three major components of the system: electricity generation plants; transmission lines and distribution grids; and power distribution centers.

a) Electricity generation plants

Electrical energy is generated by hydroelectric and geothermal power plants, as well as by conventional thermal power plants driven by steam, diesel and gas turbines. For the purposes of this Handbook and in light of their special characteristics, consideration is given first to civil works required for the generation of the hydroelectric and geothermal energy. Second, we deal with the power generation plants, where the equipment to transform raw energy into electricity is located.

In connection with hydropower generation, water resource development may require a wide range of works such as diversion and storage dams, channels, tunnels, oscillation chambers and pressurized pipelines. Damage to these facilities must be repaired in order to restore the water supply required for electricity generation; failure to do so would result in the power plant becoming non-operational, and the entire electrical system would be affected. The aforementioned facilities are often located some distance from the main communication routes, so access can be difficult, at least during certain times of the year. In these cases, the direct effects should include any additional costs to repair communication routes; this should not be included in the damage quantified for the transportation sector to avoid double accounting.

To assess the cost of rehabilitation and/or reconstruction of the affected facilities, first an estimate must be made of the following units involved: cubic meters of earth to be removed, including specifications of the type of material involved; amounts of concrete that may be required, broken down by type and strength; the length and other characteristics of water conveyance lines; and the main mechanical components and special facilities. Then an estimate of costs should be made based on current unit values for each type of component. Alternatively, depending on the basic information available, a more detailed procedure can be followed that would consider labor needs by specialty, the amounts of raw materials, the time of use of construction equipment and the unit costs for each of these components. In both cases, the type of damage sustained by the facility, access to basic construction materials -earth, sand and gravel- and the availability of both unskilled and specialized labor will have a direct bearing on the estimation of direct costs. In this regard, cost estimates and bidding proposals made by contractors that have had recent experience in the affected area or in regions with similar conditions will be a valuable source of information.

When considering geothermal power generation, resource extraction and management includes deep wells, conveyance pipe systems and specialized equipment for the processing and collecting of steam. Any estimate of damage to the availability of geothermal power falls outside the scope of the present Handbook and will require the assistance of experts and field research. However, the electrical sector specialist might try to make order-of-magnitude estimates based on updated average costs of drilling deep wells in the area under consideration or in other areas having similar geological characteristics. The alternative procedures that have already been described for hydropower plants should be followed to estimate costs for any remaining generation facilities.

The remaining components for electricity generation refer to the power plants themselves, including the building and a wide array of mechanical, electrical and electronic equipment. An analyst should first focus on equipment and machinery that deliver power to the generator; this basically covers equipment to collect hydraulic energy in hydroelectric power plants and equipment that uses heat energy through boilers, pressure tanks and steam and gas turbines. The former are individually designed to match the characteristics of the hydroelectric site, and their replacement must follow a similar procedure. However, their costs can be estimated by updating the original investment using indexes that reflect the trend in international prices of similar equipment. Manufacturers' catalogues and statistics that show the costs of equipment to collect hydraulic energy in hydroelectric power plants by range of water height (meters) and flow (m^3/sec) of the water resource may also be used.

Equipment used for the mechanical processing of energy obtained from steam and from burning oil derivatives is more standardized, although it has specific characteristics depending on the size and type of facility. This includes geothermal as well as conventional power plants classified –depending on the fuel used– as steam-, diesel-, and gas- driven plants.

Their replacement costs can be estimated following the general procedures mentioned above for hydroelectric power plants, which normally are easier to estimate because the equipment is more standardized. Power plants use a range of largely electromechanical equipment to convert raw energy forms –hydraulic, geothermal and those derived from oil derivatives– into electricity. This equipment is generally similar for different types of power plants, but it may vary depending on how up-to-date the plants are and on their specialized functions. The determination of replacement costs first takes into account investments for the original purchase –especially if this was done recently– updated to account for international inflation. A second alternative is to consult cost catalogues published by the manufacturers of this equipment or costs statistics available in specialized publications.

The above comments refer to cases in which installations must be totally replaced. When damage is less severe and only repairs or rehabilitation are required, the cost estimate must be preceded by a technical assessment of the scale of the damage and the real chance of repair. This work will require the participation of specialized personnel having wide experience in the repair and maintenance of this type of equipment. Laboratory tests of the affected equipment will be required to obtain more exact estimates, something that cannot be done in the relatively short time usually available to the disaster assessment team.

The buildings that house all generating equipment must also be assessed. The assessment of their direct damage will follow the same procedures as described for other buildings, as explained below.

b) Transmission and distribution systems

This heading includes transmission, subtransmission and distribution lines and grids, as well as all electrical substations that may be directly related to transporting the electrical power from the generation plants to final consumers.

High-voltage lines that use large and expensive pylons should be assessed first. To do this, field surveys will be required, making use of fast means of transportation such as automobiles when the lines are near to passable routes and light aircraft or helicopters in the case of cross-country lines. It is necessary to estimate the number of damaged pylons, the different types of pylon, and the length of affected electrical cables. In the case of lines that use uniformly distributed posts, only the number of kilometers of affected lines will be needed, with an indication of whether the damage is limited to the pylons or whether it also includes considerable lengths of cables. In addition, transformers and other equipment located along affected distribution lines must also be determined.

Thereafter, a list should be made of affected electrical substations, using the most precise indications possible of all equipment that has sustained any damage, including open-air facilities and equipment located in the main substations.

Estimates of the corresponding costs should be made on the basis of the results obtained from the inspection of the facilities described above. These should take into account all information available on affected power companies or those in neighboring areas. Because these data are frequently used, they should be readily obtainable. As in the case for electrical generation facilities, overall or broken-down costs could also be used, such as data from local or international contractors with experience applicable to the affected area, lists of equipment costs and catalogues.

The above comments on estimating damage in partially affected installations, in contrast to those that must be totally replaced, are also applicable to power transmission and distribution facilities.

c) Energy distribution centers and other works

Electricity measurement and dispatch centers and buildings for administrative offices are also of relevance in the electrical sector. The former are buildings that house a whole range of equipment to monitor and control electricity flows between power generation plants and the main consumption areas. These facilities may range from the most elemental, using manual controls, to the most sophisticated, employing modern remote-measuring and electronic computing systems with a high degree of automated and optimized basic functions. When total reconstruction of these facilities is required, cost estimates should be based on the comprehensive estimates of the energy distribution enterprise. An inventory of the respective parts and an estimate of the extent and magnitude of the damage are necessary in the case of partially damaged equipment and structures; experts should be engaged when specialized equipment is involved.

Damage to administrative buildings and other facilities that might be affected by a disaster can be assessed relatively easily because the characteristics of such structures and constructions are well known. Average prices by unit of floor area or total horizontal space should be ascertained. For a more accurate estimate, unit prices should be estimated for the main elements that comprise such buildings, such as panels, walls, ceilings, window frames and so on.

2. Indirect losses

As previously noted, indirect losses include the additional cost of meeting interim energy demands during the rehabilitation period when affected installations are under repair; they also include net income or profits not received by the power companies during the same period.

a) Temporary supply of electricity

The calculation of the additional cost involved in the temporary supply of electricity will first require an estimate of the time required to rehabilitate the damaged infrastructure. The length of this period will essentially depend on the extent and magnitude of the disaster, and it must be determined on the basis of the assessment of direct damages. Next, it is necessary to estimate electrical demand during the rehabilitation period.

This involves determining the effect that the disaster had on the power company's main customers (generally consisting of industry, commerce and the residential sector). Residential demand projections should contemplate the number of unaffected dwellings; projections of industrial demand should reflect the number of facilities that are in a position to continue operating (including estimated demand for their products); and commercial demand estimates should take into account the operating capacity of the establishments in the affected area. Assumptions must be made for all sectors as to the purchasing power of customers in the period after the disaster to anticipate that potential source of demand constraints. These factors should make it possible to calculate the magnitude and characteristics of the total demand for power.

The electricity sector specialist should then examine alternative ways of supplying the estimated temporary demand. As was said above, this will generally be lower than if the disaster had not occurred, although some customers may tend to increase their use. This review should also contemplate possible solutions for ensuring a rapid re-establishment of electrical service.

In the case of systems in remote locations, all-in-one equipment solutions that can be mobilized and installed quickly in the main load centers should be considered. Their cost can be obtained relatively easily from specialized catalogues or based on recent purchases of such equipment for special needs, such as backup generators for industrial centers or for isolated populations not connected to the national power grid.

Operating costs can be estimated on the basis of specific fuel consumption requirements and the cost of delivery to the area that may be chosen for the temporary generators, which should preferably be located as close as possible to the centers of demand. Estimates of operational costs should be completed by adding labor and materials expenditures, which are normally obtainable from the cost accounting maintained by power companies for the operation of equal or similar equipment.

In the case of damaged systems that are not connected to the national power grid and that are located close to neighboring undamaged systems, the cost of temporarily providing electricity can be estimated quite easily. First, a determination must be made as to whether the undamaged neighboring systems have the capacity to provide the additional power and energy requirements. The cost of interconnection must then be calculated, including the cost of items such as lengths of transmission line, substation equipment and so forth. The rates at which the required power could be provided should be estimated next. If there are no existing agreements established for such emergencies, a reasonable rate based on the additional operating costs to be faced by the system chosen to temporarily provide the power supply should be estimated. In other cases, neighboring systems might be capable of supplying only part of the demand. In this case, the procedures indicated above for isolated and stand-alone systems should be used, in proportion to each one's contribution. Note that because the intention is to establish the additional costs of the provisional service, any reduction in operating costs compared to those the company incurs under normal conditions (such as the variable expenses of generating units that cease to operate because of the disaster) must be deducted from the aforementioned estimates for all alternatives considered.

b) Other indirect losses

Profits not received by the electrical utility during the rehabilitation period (after which demand would tend to normalize) are also indirect losses. It may be assumed that during this period the post-disaster reduction in income will limit the payment abilities of many consumers who need energy to speed up the recovery of their activities; such considerations can be reflected in a provisionally lower rate. It is possible to use such a provisional rate to estimate the gross income and real demand discussed in the previous section. Total costs during the interim period, including additional charges implied by interim service and the company's costs under normal conditions, should be deducted from the gross income thus calculated. This will yield an estimate of the net income during the period in question, which could be negative if there is an increase in expenses along with a reduction in income.

Net income should then be estimated as though the disaster had not occurred. On the one hand, expected income should be considered by applying estimated average income to the normal projection of electricity demand. On the other hand, an estimate of anticipated costs based on recent historic behavior, including direct and indirect costs, should be made in order to calculate normal income for the utility. Power utilities usually employ the expected surplus to cover capital investments made to adequately and opportunely meet future demand. Any significant reduction in operational surpluses would entail new loans that will only be granted if the respective company is financially profitable. Estimates for this second scenario are normally available in power utilities, which constantly require updated short- and medium-term planning.

Indirect losses –which in this case would be equal to the profits not made due to the disaster– would be estimated as the algebraic difference between net income calculated for a normal scenario, with no disaster, and net income estimated for the disaster scenario, including any additional costs of supplying power during the rehabilitation period. Note that when net income is negative in the latter scenario, it must be added to the estimated net income for the normal scenario to obtain the total decrease in profits due to the disaster.

3. Imported content and breakdown of costs

The effects of the disaster on the balance of payments and national accounts may be ascertained from separating direct damages and indirect losses into foreign and national - currency spending requirements, on the one hand, and into public and private - sector spending, on the other. As far as direct damages are concerned, foreign-currency spending should include all equipment, materials and specialized labor that must be imported for the rehabilitation of facilities and machinery.

Local spending refers mainly to construction and repair costs, such as surveying work, earth removal, construction of structures and so forth. However, these items may also include significant foreign-currency spending on specialized equipment such as tractors, trucks and cranes that must be imported. The cost accounting records of power companies or those of contractors with recent experience in the region should prove useful for these estimations.

As far as the foreign-currency component of indirect costs is concerned, one should estimate the expense of temporarily meeting electricity demands in function of the equipment and materials that must be imported for such purposes. The costs of importing electricity from other countries should be included, when applicable.

The separation or breakdown of costs into public and private sectors depends on whether the affected power utility is state or private owned. In addition, when the government provides power services, participation by private companies in related activities, normally in reconstruction or repair contracts for the affected installations, must be taken into consideration.

C. OIL SECTOR

1. Direct damages

a) Production facilities

Oil production involves the drilling of deep wells on land or at sea and the extraction of crude oil. Oil transportation and storage, either for domestic refinement or for export to external markets, fall within the transport sector and should be estimated therewith.

Structures, equipment and facilities that are tailor-made to the needs and characteristics of the geographic environment are used to drill and operate the production wells. They include control rigs, deep drilling rigs, offshore platforms and a wide array of pipelines and equipment to handle the resulting flows of oil. When access to the underground oil deposits has been hampered by a disaster, estimation of damages requires that highly specialized personnel carry out field research.

Such activities are beyond the scope of this Handbook, which refers to estimates that can be carried out in a very short period of time. In the case of total destruction of a given well, the amount of investments already made, updated as of the date of the disaster, would provide a first estimate of direct damage. An approximation of indirect losses would be provided by the net commercial value of production lost during the rehabilitation period. This could then be refined through estimates of damage to such installations as rigs, drilling machinery and auxiliary equipment.

When such facilities have to be replaced because of total destruction, estimates can be made using (updated) standard costs that are normally available in the oil companies' files. Information on costs can also be obtained from manufacturers' catalogues in the case of industrial equipment. Contractors with relevant experience can also be approached. If damaged facilities and equipment can be repaired, it is necessary to assess the magnitude and extent of damage; such estimates require specialized experts with broad experience in repair and maintenance works, preferably familiar with the affected installations.

b) Oil refineries

Refining facilities may be simple when they only cover the stages of primary distillation, but they may be rather complex when they handle more processed products or remove harmful substances such as sulphur. Refineries generally include different kinds of processing towers, storage tanks and a wide array of pipes of differing diameters with various categories of valves and other fittings for managing fluids. Assessing disaster damage at oil refineries should follow the same or similar procedures as those described in the previous chapter for thermal power plants, as they often employ somewhat similar installations.

c) Distribution facilities

The distribution and sale of oil derivatives can be broken down according to the main user sectors as follows: gas for domestic and industrial use; liquid fuels for road, sea and air transport; and bituminous residues that are normally used in road construction. Basic distribution facilities include pipelines, storage tanks, pumping stations (which really belong to the transportation or industrial sectors) and standard service stations that supply fuel to automobiles and small vessels. Damage assessment for service stations involves procedures mentioned earlier in this section.

d) Other facilities

This item includes buildings used for administrative purposes and recreational centers for company personnel. Such facilities are common to all sectors, and their damage assessment requires the techniques described for the housing and human settlements sector.

2. Indirect losses

Indirect losses include the additional cost of providing oil and oil derivatives to meet energy requirements during the rehabilitation of affected facilities. It also includes net income not received during the same period, including the additional costs mentioned above.

a) Temporary supply of oil and oil derivatives

The estimate of costs to temporarily provide oil products must be based on the magnitude and nature of the damage sustained and on the duration of rehabilitation work. These two factors would have already been determined by the time the assessment of direct damage is made. Then the demand for oil and oil derivatives needed to replace lost production capacity and for the reconstruction process should be estimated. This calculation should take into account the extent to which the disaster may affect demand among leading residential, commercial and industrial consumers, all types of functioning automobiles and other vehicles, and roads that have to be constructed or repaired with bituminous material. New demand, in terms of volume and type of oil derivates, should be estimated based on the above factors and with due consideration for the diminished purchasing power of affected consumers.

Once new demand levels are projected, the analyst should consider alternative means for fulfilling that need. Several possibilities may arise, depending on the availability and location of existing resources and the facilities available for transportation and transfer. Tanker trucks should be used to meet small demands near deposits. Active and abandoned pipelines can be used for pumping fuel across greater distances, or new pipelines can be built if their investment can be justified. Finally, tanker ships, such as those commonly used commercially to ship oil and oil derivatives around the world, can be pressed into service using either existing facilities if available or, in their absence, provisional installations adapted to emergency situations.

The corresponding costs should be estimated based on the above considerations and after the most economical and feasible alternative has been selected. In any event, this type of activity falls within the transport and communications sector, and it should be recorded as such. Data on capital and operational costs must be calculated, including the purchase cost of oil and oil-derivatives, which is easily obtained since they are sold at international prices.

b) Other indirect losses

As explained in greater detail in the section on the electrical sector, indirect effects due to lost income can be quantified in the following manner. The net income is determined for the post-disaster scenario. Note that gross income is expected to fall, whereas costs should rise as the greater cost of temporary supply is included. Results will very probably be negative. Then the net income that the company under study would have obtained if the disaster had not occurred is determined. This information can be obtained from the files or forecasts of the oil company itself. In those rare cases when records are not available, estimates can be made based on the files of similar companies. The algebraic difference between net income under normal conditions minus income in the post-disaster situation should yield the total indirect loss, which would be equal to the profit not received by the oil company as a result of the disaster.

3. Breakdown of damages and losses

As in the case of the electrical sector, direct damages and indirect losses are broken down, on the one hand, into domestic and foreign currency for purposes of the balance of payments and on the other, into public and private - sector costs for purposes of national accounts. In the case of the oil sector, the macroeconomic effects might be significant, especially in those cases where the country affected is a net oil and oil derivatives exporter, requiring a much more detailed analysis of the indirect and macroeconomic effects by the energy sector specialist, in close cooperation with the macroeconomics specialist.

4. Effects on employment and on women

The electrical and oil sectors employ a limited number of personnel in view of their relatively high dependency on technology, so these industries tend to have limited repercussions on personal income levels following a disaster. For the very same reasons, no significant differential impact on women is expected to arise from these sectors.

5. Impact on the environment

This setcion describes the main links between assessing damage to the energy - sector and assessing that to the environment. The energy specialist is also referred to the chapter on environmental assessment included in Volume Four of this Handbook.

Some environmental changes related to water resources have a negative impact on hydroelectric power generation. Leaving aside droughts, whose effects are obvious, other disasters –such as floods and landslides– may also affect the availability and quality of water. Landslides can result in the obstruction and diversion of water flows that feed dams, thus affecting resource availability for electrical generation. Floods can increase the silting rates of reservoirs, giving rise to a reduction in their storage capacity and, therefore, in their useful life.

When a watercourse is diverted, river training works are required, and their expenditure should be recorded as indirect damages in the energy sector. A decision to omit such works for technical or financial reasons will compromise the future energy production capacity of the hydropower plant and should be registered as direct damage; this can be estimated as the present value of the difference in net income flows resulting from the disaster. When silting reduces the useful life of a reservoir, the approach is very similar, and damage should be estimated as the present value of the lost net income flow associated with the years of lost production. It must be pointed out, however, that estimation of silt deposition volumes requires lengthy field surveys whose results will not be available at the time of the assessment.

Oil is a non-renewable natural resource that is a part of a country's natural capital. Oil spills of significant proportions are registered as direct damage in the energy sector based on market prices. The environmental assessment seeks to identify the share of these damages that correspond to the contribution of natural capital, isolated from contributions of human capital and other assets such as infrastructure, machinery and equipment. This contribution may be estimated using an economic rent concept that, in the case of underground assets, has methodological difficulties. It will therefore be necessary to use estimates from other sources.[1] To avoid double accounting, these estimates will not be included in the damage overview.

Oil spills and the release of other toxic substances into the environment are another usual effect of disasters. Breakage in oil pipelines is one of the major risks associated with earthquakes. Toxic substances (such as sulphur and other compounds associated with geothermal production) may also be released when their collection and disposal systems are damaged or destroyed.

1 For example, Kunte et al. "Estimating National Wealth: Methodology and Results", Discussion Paper, the Environment Department of the World Bank, Washington, 1998.

In general, these direct damages and indirect effects are accounted for either in the energy or in the transport sector. The environmental specialist should work closely with other members of the assessment team to ensure appropriate damage accounting, especially of the expenses required to restore the environment to pre-disaster conditions.[2] In cases where natural areas are affected by these events, the environmental specialist will most likely be put in charge of calculating those damages. The preferred method for assessing these damages is the restoration cost method described in the chapter on environmental assessment in Volume Four.

An example of how the assessment of the energy sector should be carried out is presented in the following appendix.

APPENDIX VII

DAMAGE TO THE ENERGY SECTOR CAUSED BY THE MARCH 1987 EARTHQUAKE IN ECUADOR

A major disaster occurred in Ecuador in March 1987, caused by a series of earthquakes whose epicenter was located in the northeastern region of the country. The disaster badly affected the living conditions of low-income population groups, destroying their homes and basic services. More serious damage was inflicted on the transport infrastructure used by key sectors of the economy, undermining the country's ability to export and generate foreign currency.

1. Electrical sector

The earthquakes, mudslides and floods caused direct damage to some power plants, national-grid transmission lines and two hydroelectric power plants that were still under construction. They also caused indirect losses because the supply of had to be temporarily suspended in some cities, hydroelectric production had to be replaced with higher-cost energy produced in thermal plants, and the unit operational costs of thermoelectric power plants rose due to an increase in the cost of the transportation of diesel fuel.

The repair of power plants and electricity transmission systems was estimated on the basis of costs provided by the companies that operate them, as were the costs to repair and rebuild the camps at the power plants under construction. Direct total damages were estimated at 3.5 million dollars.

Indirect losses included increased costs in the dams that were under construction, higher electricity production costs because thermoelectric plants were used, and lost revenue at utility companies. Total indirect losses were estimated at 0.3 million dollars.

2 Although the energy specialist may have assessed direct and indirect damages caused by these events, environmental restoration measures may be under the responsibility of institutions not directly related to this sector. In such a case, , it is likely that these expenses would not have been accounted for in the energy sector especially if the solution to the problem depends on the environmental authorities.

Therefore, total damages and losses sustained by the energy sector as a result of the disaster were estimated at 3.8 million dollars. Since most of the equipment and materials to be replaced are not produced domestically, a negative effect on the balance of payments was projected of 2.2 million dollars .

Table 1
SUMMARY OF DAMAGE AND LOSSES CAUSED BY THE EARTHQUAKE IN ECUADOR 1987

Item	Damage, millions of dollars			Effect on the balance of payments[3]
	Total	Direct	Indirec	
Total	3.80	3.51	0.29	2.18
Production infrastructure	0.13	0.13		...
Lines and substations	0.12	0.12		...
Construction work camps	3.26	3.26	--	2.18
Greater generating costs and reduced income from billing	0.29		0.29	--

Source: ECLAC, based on official figures.

2. Oil sector

Although no physical damage was detected in the oil-producing wells, mudflows and floods cut the Trans-Equatorial oil pipeline that links the production area located in Lago Agrio to the refinery and oil and oil derivatives export terminal located in Esmeraldas. The flow of crude from the eastern area, which accounts for 99.6% of national oil production, was interrupted, and approximately 100,000 barrels of oil were spilled. The breaks in the pipeline, of different diameters, covered a total length of approximately 78 kilometers, and civil works at some pumping stations were damaged.

Direct damage to pipelines and related works and the value of the oil spilled was estimated at a cost of 120 million dollars. Reconstruction of the pipeline, following the same route of the previous one to facilitate matters, required a four-month period, and indirect losses were much greater than direct damages (see Table 2).

These indirect losses had domestic and external repercussions on the country's economic performance. They refer to a significant decrease in foreign currency earnings from oil exports throughout the reconstruction period, and to higher costs incurred to meet the domestic demand for oil derivatives.

Domestically, higher costs were incurred to supply liquid gas to the capital city of Quito, owing to the broken pipeline, as alternative routes and means with higher operational costs were used. In addition, the internal demand for oil derivatives had to be met by combining a temporary loan of such products from Venezuela and the building of an alternative pipeline to Colombia in order to extract limited amounts of oil, which were then transported by ship to the Ecuadorian refinery at Esmeraldas.

Oil exports had to be suspended until the pipeline was rebuilt, even though temporary loans from Venezuela and Nigeria made it possible to comply with some foreign commitments. Losses were thus spread over a longer time period than that required for the reconstruction of the pipeline.

3 The value of the components that will have to be imported because they are not produced domestically.

In addition to the above, the Ecuadorian State Oil Corporation (Corporación Estatal Petrolera Ecuatoriana – CEPE) sustained losses due to the reduction in domestic consumption of gasoline, and refineries (private and state) processed a lower volume of oil in their facilities. This loss of profits increased indirect losses caused by the disaster.

In sum, the earthquake caused direct damage to the sector's infrastructure totaling 121.7 million dollars and indirect losses worth 766.7 million, resulting in total damage and losses of 888.4 million dollars. Moreover, the country's balance of payments was affected with a negative impact of around 815 million dollars, caused by the fall in oil exports and the increase in imports required for domestic consumption.

Table 2

DIRECT DAMAGE AND INDIRECT LOSSES CAUSED BY THE I987 EARTHQUAKE IN ECUADOR

Item	Damage, millions of dollars			Effect on the balance of payments
	Total	Direct	Indirect	
Total	888.42	121.67	766.89	815.6
Reconstruction of pipelines, pumping stations, and cost of oil spilled	121.67	121.67	--	66.0
Greated costs for internal supply	90.17	--	90.17	87.3
- Investment in pipeline to Colombia	17.05		17.05	
- Greater transportation costs	15.69		15.69	
- Cost of replacement oil	54.56		54.56	
- Greater liquid gas transportation costs	0.87		0.87	
- Greater transportation costs of derivatives to Oriente	2.00		2.00	
Export losses	662.30		662.30	662.3
- lost exports	64.27	--	64.27	
- chaters of loaned oil	19,60		19,60	
Lost profits	14.28		14.28	
- Reduced consumption	5.27	--	5.27	--
- Reduced processsing in refineries	9.01		9.01	

Source: ECLAC, based on official figures.

The March 1987 earthquake caused 892 million dollars in total damages and losses to Ecuador's energy sector. Of this amount, only 14% are direct damages to the sector's infrastructure, and the remaining 86% are indirect losses. In addition, the disaster had an 818 million dollar negative impact on the balance of payments, mainly due to the inability to meet oil sale commitments abroad. This aggravated the economic situation in the country at the time, which had already been weakened largely as a result of a previous fall in world oil prices.

II. DRINKING WATER AND SANITATION

A. INTRODUCTION

In light of the region's epidemiological indicators, mortality rates are closely related to infectious diseases that, to a large degree, depend on the quality of water consumed and on access to adequate sanitation services. When this situation turns critical during disasters, post-disaster activities must concentrate on rehabilitating services that might otherwise constitute sources of epidemics; special attention must be paid to water quality, sanitary removal of excreta and solid waste management.

The search for solutions to restoring water supply must take into account each potential resource, its capacity, its proximity to a drainage system and all potential causes of chemical contamination.

Under normal circumstances, inadequate human waste treatment methods negatively affect the health of the population. In a disaster, removal and treatment of human waste acquires increased relevance in avoiding the transmission of infectious diseases, and it constitutes a public health priority.

Damage in this sector depends not only on the intensity of the disaster, but also on vulnerability, a special characteristic of each component of the entire system. To put it differently, a disaster of a given magnitude and type may cause very different damage to different systems, or to different components of one system. The vulnerability of a system basically depends on four factors: its geographical location, the quality of engineering design, the quality of construction (including technology, equipment and materials used) and the quality of facility operation and maintenance.

Most components of water and sanitation systems require proper operation and systematic maintenance over time; their absence would make the systems less resistant to damage and would hinder repairs when a disaster occurs. In turn, good operating and maintenance require effective organization, with workshops, spare parts and drainage layout plans, which significantly help to size, assess and repair more quickly and at a lower cost any damage produced by a disaster. Hence, operating and maintenance departments of affected systems will be a key source of information for the assessment team.

B. ASSESSMENT PROCEDURE

The assessment process requires, as a prerequisite, the definition of the area affected by the disaster. The water and sanitation specialist must also determine what institutions are involved in the sector and the role each of them plays. The water and sanitation sector requires a multi-disciplinary and holistic approach to the dialectic relationships among its component elements. At the same time, each service or subsector (water supply, sanitary sewage disposal and solid waste collection and disposal) requires special assessment procedures. The assessment team must obtain information on the individual policies to be applied in each of the subsectors, as well as each one's degree of development.

On the technical level, the assessment team should collect basic information and detailed maps of the affected systems, which will be essential for the necessary field evaluations and verifications. After the assessment is concluded, it should be possible for the water and sanitation specialist to prepare a table showing the most accurate and summarized information on damage and losses to the subsystems, as indicated in the following table.

Table 1
DAMAGE AN LOSSES IN THE WATER AND SANITATION SECTOR
(In thousands of dollars)

Component	Damage			Sector		Effect on the balance of payments
	Total	Direct	Indirect	Public	Private	
Total						
Water supply systems						
Urban systems						
Infrastructure						
Rehabilitation expenses						
Diminished utility revenue						
Higher production costs						
Rural systems						
Infrastructure						
Rehabilitation expenses						
Waste water disposal systems						
Infrastructure						
Rehabilitation expenses						
Diminished utility income						
Higher production costs						
Rural systems						
Infrastructure						
Rehabilitation expenses						
Wells and latrines						
Solid waste systems						
Rehabilitation expenses						
Diminished utility revenue						

C. INFORMATION REQUIREMENTS

The water and sanitation specialist should strive to obtain all available information on the subjects listed below as a basis for the assessment.

1. Drinking water supply systems

- Organization of the entire water supply subsector: service provider utilities, municipalities and regulatory and governing bodies;
- Pre-disaster water service coverage levels (urban and rural);
- Breakdown of the population served by collective and individual systems (such as collective water systems, individual wells, multi-family systems);
- Identification of the urban and rural systems affected by the disaster;
- Determination of whether the disaster affected the water supply treatment process and identification of any resulting need for additional chemicals/reagents or equipment;

- Characteristics of the systems affected by the disaster:
  - Population served before the disaster (number of domestic connections, average levels of water consumption, etc.);
  - Water supply rates, existing subsidies, billing collection effectiveness, etc.;
  - Pre-disaster production levels;
  - Water production capacity after the disaster; and
  - Estimated time required for rehabilitating all affected systems;
- Blueprints of all affected systems;
- Characteristics of damage sustained by all affected systems:
  - Description of damage sustained by different equipment/components of the affected systems;
  - Construction techniques and materials used in the systems' components; and
  - Accessibility to different components in the affected systems;
- Temporary organization of the water and sanitation service provider utilities, to meet population's needs until full services are re-established;
- Identification of measures undertaken to rehabilitate systems; and
- Costs of materials, construction, equipment, chemicals/reagents and other inputs required for the rehabilitation and reconstruction of systems.

2. Wastewater disposal systems

- Organization of the sewage disposal subsector: service provider utility, municipalities, etc;
- Coverage levels of the urban and rural sewage disposal and sanitation systems prevailing before the disaster;
- Breakdown of the population served by collective and individual systems (latrines and septic tanks);
- Identification of urban and rural systems affected by the disaster;
- Characteristics of the systems affected by the disaster;
  - Population served before the disaster (number of household connections,etc.);
  - Sewage disposal rates, subsidies and billing effectiveness (include any link to billing for drinking water);
  - Pre-disaster wastewater treatment levels;
  - Post-disaster treatment capacity; and
  - Estimated time required to rehabilitate affected systems.
- Characteristics of damage to the affected systems:
  - Description of damage to equipment/components of the affected systems;
  - Construction techniques and materials used in sanitation systems; and
  - Accessibility of affected systems;
- Temporary organization of water and sanitation utilities for meeting the population's needs until services are re-established;
- Identification of measures required for the rehabilitation of systems; and
- Costs of materials, construction, equipment, chemicals/reagents and other inputs needed for system rehabilitation and reconstruction.

3. Solid waste collection and disposal

- Description of existing local utility for the collection, processing and final disposal of solid domestic waste;
- Characteristics of damage to the service's assets (trucks, access roads to towns and dumps, etc);
- Geographical coverage and beneficiaries of these services before the disaster;
- Identification of measures required for the rehabilitation of affected systems; and
- Costs of materials, construction, equipment, chemicals/reagents and other inputs needed for system rehabilitation and reconstruction.

D. SOURCES OF INFORMATION

The water and sanitation specialist should enlist the assistance of all institutions and sources that may have basic information required for the damage and loss assessment, such as the following:

- Governing bodies and regulatory institutions, and water and sanitation services provider utilities:
  - Municipalities responsible for operating and maintaining water and sanitation systems and services; and
  - Ministry of health, housing or public works, when they have jurisdiction over the water and sanitation sector;

- National or departmental associations of municipalities.
- Water and sanitation utilities whether national, state, municipal, private, mixed or community managed:
  - Their annual reports in particularly;
  - Local water and sanitation management boards,
- Non-governmental organizations (NGOs) that usually construct rural water systems (CARE, Save the Children, OXFAM, Catholic Relief Services, etc.) and then transfer the systems to be self-managed by the community itself;
- National Chapters of the Inter-American Association of Sanitary and Environmental Engineering (AIDIS);
- UNDP, UNICEF and PAHO/WHO reports on the state and coverage of water and sanitation services, normally issued once every ten years.

E. DESCRIPTION OF DAMAGE

1. Direct damages

The water supply and sanitation specialist should be able to describe all direct damages sustained by the systems that make up the sector, as described below.

Drinking water supply systems. Ascertain the following:

- Damage to infrastructure and equipment of urban systems, preferably broken down by component;

- Damage to infrastructure and equipment of rural systems, preferably broken down by component; and
- Loss of stocks (chemicals, stored water, spare parts, other assets).

Wastewater disposal systems. Obtain the following information:

- Damage to infrastructure and equipment of urban systems, preferably broken down by component;
- Damage to infrastructure and equipment of rural systems, preferably broken down by component; and
- Loss of stocks (chemicals, spare parts, equipment, etc.).

Solid waste disposal systems. Ascertain the following information:

- Damage to infrastructure and equipment;
- Damage to access routes to facilities or dumps for final waste disposal; and
- Impact on waste disposal dumps.

2. Indirect losses

Here again, the water and sanitation specialist should obtain all information relevant for estimating indirect losses in the three subsectors.

Drinking water supply systems. The following data would be required:

- Activities related to rehabilitation (distribution of water by tanker truck or other means, purchase of equipment and machinery, repairs, changes in water treatment processes, use of materials and inputs kept in stock ready for rehabilitation efforts, personnel overtime);
- Reductions in potable water output (as it relates to intake, treatment, storage or distribution facilities);
- Reduction of operational costs due to the partial functioning of systems;
- Increase in potable water production costs;
- Losses due to income not received (water not billed, suspension of service, etc.); and
- Insurance coverage.

Wastewater disposal systems. The following information is essential for estimating indirect losses:

- Activities related to rehabilitation (network inspection work, acquisition of equipment and machinery, repairs, etc.);
- Reduction in wastewater treatment capacity;
- Increases in wastewater treatment costs;
- Losses due to income not received; and
- Insurance coverage.

Solid waste disposal systems

- Losses due to income not received
- Decrease in solid waste collection and disposal costs; and
- Insurance coverage.

F. QUANTIFICATION OF DAMAGE AND LOSSES

1. Direct damages

To facilitate their quantification, we suggest that damages be grouped in accordance with the following components.

- First damage should be identifird by type of system:
  - Potable water supply systems;
  - Wastewater disposal systems; and
  - Solid waste disposal systems.
- Second within each city and individual system, damage should be grouped by component or subsystem; for example, for the potable water supply system of a city:

  - Water intake facilities (intake A, intake B, etc.);
  - Pumping stations (station 1, station 2, etc.);
  - Water treatment plants (plant 1, plant 2, etc.);
  - Main lines to storage tanks;
  - Storage tanks (tank A, tank B, etc.);
  - Distribution networks; and
  - Other components, to be defined in each case.

The total damage to the potable water system of each city may then be obtained by summing the individual component damages.

A list of damage sustained by each subsector (water supply, wastewater disposal, and solid waste disposal) should be prepared, with a breakdown by materials, equipment or facilities. A procedure similar to the one described below could be adopted:

- A summary description for each damaged component should be made including its main elements, the type of damage and the approximate amount of work or material affected, in appropriate measurement units. For each damaged component, the following should be indicated:
  - Type of work and/or materials required;
  - Unit construction prices at replacement value (UP); and
  - Cost of repairs, estimated as a percentage (R%) of the unit reconstruction price described above.

- The estimate of the percentage (R%) to which facilities, materials or equipment may be damaged should be obtained directly from the service provider utility, or on the basis of a weighted estimate that would take into consideration whether the facility, material or equipment can be repaired or partially reconstructed or must be totally reconstructed or replaced. If there is a chance that the damage can be repaired, the cost of the damage should be estimated as a percentage (R%) of the total cost of said facility, material or equipment. If the facility has to be totally rebuilt or replaced, R should be taken to be 100%.

- The initial R% can be based on estimates provided by personnel from the utility that is responsible for each system, or from other sources, but the final figures adopted should be those calculated by the water and sanitation specialist on the assessment team on the basis of information he/she collected during the field mission.

In addition, one must take into account the cost of demolition, dismantling and debris removal in the manner described below.

- For each system component (identified in accordance with the above recommendations), a determination must be made as to whether reconstruction or repair will be required prior to demolition, dismantling or debris extraction. If such prior work is needed, an indication should be made of the approximate amount of work or material to be demolished and removed, in the appropriate unit of measurement, which as far as possible should be the same unit as the one used to quantify the damage to this item.

- A description should be made of the work or main activities considered part of demolition, dismantling and debris removal (adopting a single unit price for each item).

- The degree of difficulty and costs involved in work and materials should be taken into consideration. For example, distinctions should be made between the "demolition" of a reinforced concrete storage facility and the "dismantling" of asbestos cement pipes, whose joints can be much easier to take apart and which could be partially recovered and re-used.

- If an accurate estimate of prices under this heading is not possible, a criterion similar to that indicated in the previous point should be adopted, where the cost of "demolition and removal of debris" should be expressed as D% of the unit price. However, D% is not necessarily equal for each item, owing to the varying degrees of difficulty of demolition or removal.

- If part of the material can be recovered as a result of demolition or dismantling, whether for re-use by the same utility or for sale, its remaining value should be estimated as a percentage (V%) of the unit price of said material when new. These results should be deducted from demolition, dismantling and debris-removal costs.

If the disaster directly affects the warehouses or other storage facilities where spare parts, chemicals, reagents and water tanks are kept, this must be taken into consideration. The water and sanitation specialist should consider all available sources to ascertain the amount and unit prices of the materials in question.

Unit prices to be used in damage assessment can usually be obtained from recent feasibility studies or from the unit price lists normally used by the utility that provides the affected services. In this case, the date the lists were made should be ascertained so that, when necessary, adjustments for inflation can be made. The unit prices to be used can also be based on estimated unit prices derived from direct surveys or suitable local sources. “Comparative unit prices” available for the region that can also be used for comparisons with the two previous points, and used instead of them, when necessary.

No matter where the list or estimate of unit prices is obtained, it should include the labor content and the percentage of domestic and imported materials as a percentage of total unit prices. This will make it possible to distinguish the total amount of direct damage, the value of imports and their corresponding effect on the balance of payments.

Water supply, wastewater disposal and storm drainage systems include a wide array of facilities, materials and equipment. The cost of some of these facilities may easily be estimated on the basis of unit price lists. Such is the case of water pipes, whose unit price can be expressed in linear meters either for the simple purchase of the pipe or for their complete installation. The costs of other types of facilities (e.g., potable water treatment plants) that include components employing varied technologies and prices should be estimated based on a total price for the facility.

2. Indirect losses

Indirect disaster effects usually last throughout the rehabilitation and reconstruction period or until facilities return to normal operation. These effects include the water supply utilities’ income shortfall (owing to reduced billings as they supply less water) and to increased water leakage from yet-to-be- repaired pipelines. They also extend to the higher operational costs the utility must assume to ensure the temporary provision of water until normal service is re-established. The negative impact on health should also be included. An agreement should be reached with the health sector specialist in order to avoid duplications or omissions in this regard.

a) Drinking water supply systems

i) Rehabilitation of normal operations. Depending on its magnitude, a natural disaster may affect very large geographical areas that might include cities of various sizes, towns and rural areas. The random nature of the disaster and its ramifications might require a broad range of activities for rehabilitating services; these involve costs that should be included as indirect damage (in addition to the repairs of direct damage). These rehabilitation activities include the following:

- Pipeline repairs, using plastic patches or jackets, provisional by-pass pipelines and also works to divert flows away from holes in order to avoid losses of water in damaged pipe networks;

- Use of existing stocks or reserves of equipment, materials, chemicals and reagents;
- Increased chlorine concentration in already chlorinated water, with temporary functioning of chlorination facilities for untreated water and for storage tanks and preventive chlorination in deep and shallow wells in both urban and rural areas;
- Use of other existing potable water sources such as the deep wells of private factories, businesses or sports facilities (this calculation includes water connections to the network, the supply of power to pumping equipment, etc.);
- Temporary conversion of existing water storage facilities –such as swimming pools, factory and business storage tanks– as well as fiberglass and plastic tanks to store and distribute drinking water;
- Temporary use of tanker trucks or other vehicles pressed into service for delivering drinking water to the population;
- Activities required to implement, when necessary and possible, temporary rationing of drinking water in the network;
- Increasing water pressure in the network to avoid contamination of the potable water, which might be essential even in the event of increased water leakage;
- Preparation and delivery of instructions to the population on preventive measures for the use of water (boiling, for example), rationing timetables, tanker truck routes, water distribution points, etc; and
- The cost of alternative means for the public to acquire/purchase water (e.g.; the premium paid for such water, health problems).

ii) Estimating the cost of rehabilitating services. Rehabilitation activities vary greatly owing to the wide range of potential disasters and the peculiarities of each region. In order to simplify matters, one should begin by grouping these costs into a limited number of categories:

Increased labor costs. This item includes any increases in costs of professional, technical, administrative and manual labor employed in rehabilitation operations, over and above the normal payroll levels. They may be estimated as follows, bearing in mind that the affected utility company would already have some estimates on the matter:

- Prepare a simplified list of personnel categories employed in this type work, indicating their unit cost in each category (person-months, person-days, as applicable);
- Estimate the “number of person-units” in each category that will be required for the rehabilitation operations during the entire period they are expected to last; and
- Multiply these values and add the subtotals to obtain total losses.

Estimated cost of works and repairs. This point includes any costs not included under the previous item. It should include all materials, transport, fuel and so forth, that may be used in works and repairs. Only a fraction of the total value of equipment, machinery, pipe and valves installed on a temporary basis is to be included in these estimates, which would include an amortization estimate (r%), whose value will depend on the use made of such elements during the rehabilitation.

A list of the main material works performed should be made, including a summarized description of each work or other material costs; the approximate volume of each work, materials or item; the unit price of each; and any overhead expenses and profits (where appropriate).

Estimated cost of using water sources or intake works not belonging to the public water utility. This involves expenses that have to be paid in accordance with special agreements with third parties.

Use of tanker trucks for drinking water distribution. Tanker trucks may deliver water in order to alleviate problems in those areas where the disaster disrupted normal service. Estimates should take into account such factors as the capacity of trucks engaged to deliver water and the rates charged per delivery.

iii) Reductions in drinking water production. The disaster may reduce the volume of water tapped from any source for treatment and delivery to the public. This shortfall may be the result of direct damages such as:

- A drought-induced decrease in water availability;
- Contamination of water sources; and/or
- Damage to intake facilities, pumping stations or other equipment.

iv) Reductions in the distribution capacity of drinking water systems. Damage to major pipelines that convey drinking water to cities or intermediate facilities (such as treatment plants, pumping stations, storage reservoirs, etc.) may impair the system's overall delivery capacity. Damage to secondary pipelines or to distribution networks may partially affect drinking water distribution capacity. Damage to domestic connections and or interior networks of buildings, houses, factories, markets and the like may curtail local delivery capacity. Damage to pumping stations may also affect the system's total or partial water conveyance capacity.

v) Reductions in the regulation and storage capacity of drinking water systems. Any reduction in water regulation capacity diminishes the ability of a system to meet demand over time and avoid losses to water sources. This item includes any damage to a system's regulation and/or storage capacity, as well as damage to minor, industrial, commercial or domestic reservoirs.

vi) Reduced consumption of drinking water. Consumption in affected cities and towns may be partially or totally curtailed by the supply constraints noted above (e.g., direct damage to the potable water supply system) and/or the displacement of the consuming public. Should the sanitary quality of the water be undermined, residents would be forced to boil water. Obviously, a fall in supply and/or demand would reduce utility billings and revenues.

vii) Increased water production costs. These usually result from an elevation of existing water intake points or the need to draw on alternative sources; an increase in the daily volume of water production to compensate for leakage in either the main pipelines or in the distribution networks; and/or higher power and other input costs.

viii) Lost income (water not billed, temporary suspension of supply, etc.). To estimate the extent to which billings have declined (or the probable reduction in water sold to consumers in cities and towns located in the disaster area), one must determine the main factors responsible for the shortfall.

ix) Impact on public health because water flows have become inadequate, inconsistent or of inferior quality. The impact on health, particularly on that of children and the elderly, can vary and should be analyzed under the health sector.

b) Wastewater disposal systems

Three main types of indirect losses may be sustained, by wastewater disposal and storm drainage systems.[1]

i) Increased health-risk levels and reduced quality of life. Apart from the fall in the level of hygiene that may result from the lack of sufficient drinking water, the lack of sanitary or storm drainage may pose significant public-health risks for the following reasons:

- Wastewater disposal systems cannot be used in those areas that do not have a potable water supply because water is essential to flush away excreta and other waste;
- Breaks and blockages in the sewage disposal network will likely result in wastewater flowing to the surface of streets, increasing the risk of disease and epidemics either by direct contamination or by the action of vectors.
- Any problems at wastewater treatment plants might further pollute the water resources into which effluents are discharged; and
- The risk of flooding increases when rainwater drains are damaged.

ii) Rehabilitation involves a wide array of activities including pipe repairs, the laying of provisional pipelines or drains and the digging of drainage ditches. These also may include maneuvers involving valves, gates and other facilities to divert flows from wastewater or rainwater pumping stations and to expel wastewater that has flooded plants, chambers or ditches. The cost of maneuvers and rehabilitation works for sewers should be estimated in the same fashion as drinking water.

1 In some instances, the same system is used to evacuate both wastewater and storm runoff. In other localities, separate systems exist.

iii) Decreased income from wastewater billings. How the disaster affects billings for wastewater disposal services depends on how billing is normally done in the affected cities. Where the charge is computed as a percentage of water supply billings, losses should be estimated using the following formula:

I_t = total decrease in water supply billings in the city;
a% = percentage (%) overcharge in water supply bills included to pay for the wastewater disposal service;
s% = percentage of population having both water supply and wastewater system in relation to the total population having water supply connection.

Hence, the decrease in billing for wastewater disposal services will be obtained as

$$\triangle f_a = I_t \text{ x } (a\%) \text{ x } (S\%).$$

However, there could also be an additional segment of the population that cannot make use of the wastewater disposal service because it is broken. This loss might be estimated as an additional percentage (Z%) to the one indicated above, in the following manner:

$$\triangle f'_a = (Z\%) \text{ x (Normal billing for waste water disposal service)}$$

When the cost for use of the wastewater disposal service is a flat rate for connecting to the system, the loss in billings can be estimated by applying a percentage to the overall billing for the city.

Given:

F_a = total monthly billing for wastewater disposal service for the entire city;
$F_a/30$ = average daily billing;
g% = estimated billing percentage not charged due to the disaster;
p = length of the period during which irregular or no service is provided, in days

Then:

$$\triangle f_a = (g\%) \text{ x } p \text{ x } (F_a/30), \text{ in US\$/period}$$

Where no charge is made for wastewater disposal service, the utility's revenues would not be affected.

G. MACROECONOMIC EFFECTS

All items, information, background and procedures necessary to asses the water supply and sanitation sector's impact on the country's macroeconomic performance are described below.

1. Effects on gross domestic product

a) Reduced output

This refers to the reduction in production of water that occurs from the time the disaster occurs until normal production capacity is restored. The lost production should be estimated as the shortfall in utility revenues resulting from the reduced volume of water billed to the users, plus any increase in the cost of providing the service because of water produced that fails to reach consumers due to leaks in networks or other reasons.

It is possible to estimate how long it will take to resume normal supply and billings in light of the scale and characteristics of direct damages and the financial, repair and reconstruction capacity of the corresponding water-supply utilities.

A table should be prepared for each affected city and/or utility, the following data:

- The reduction in drinking water volumes billed each month to users from the time of the disaster until service is likely to be normalized;
- Any variations in average rates charged to the public for the volume of drinking water delivered;
- The shortfall in the utility's monthly revenue (the difference between pre- and postdisaster billings); and
- Any added costs associated with the population having to acquire water by other means.

b) Projected sector performance prior to the disaster

The macroeconomic specialist may have access to such data for the entire country and the affected area. However, in Latin America and the Caribbean, the only such projections normally to be found involve the volume of water tapped, treated or lost through network leaks in urban areas, so it might be more practical to estimate the sector's GDP based on the volume of water billed to consumers. We recommend that the water and sanitation specialist, in close cooperation with the macroeconomics specialist, carry out the following tasks;

- Analyze national accounts and consult all institutions overseeing the sector in order to obtain, where possible, data on changes in GDP for the previous five years, together with a forecast by the corresponding officials on the sector's expected performance for the current year had the disaster not occurred; and
- Analyze any changes in the sector's strategies that would allow the service to be restored and further developed.

2. Effects on gross investment

These include the following three items:

a) Projects under execution and other projected investments that must be suspended or postponed, or whose funds must be reassigned to meet disaster-related needs

This information should be summarized in a table identifying the main projects affected and the investment envisaged for each one. Finally, an estimate is to be made of the expected reductions in investment for each project as a result of the disaster, in the current and succeeding years.

b) Losses of stock

A table must be prepared showing losses of stock (such as water stored in reservoirs and/or in storage tanks, chemicals and reagents for the treatment of water), as well as losses of materials and spare parts stored and/or available in facilities that were under construction.

c) Financial requirements for repair or reconstruction

The background for developing this item will mainly come from the direct damage lists and assessment, providing total and itemized costs for the damage. Based on that information, a table comprising the following information can be prepared:

- A list of affected works, broken down by systems, subsystems and main facilities and indicating the overall cost of the damage to each one. This list should separately identify works in the different cities and companies (if there is more than one responsible for the service in the same city), as well as for rural areas.
- A forecast of investment needed in the succeeding years for repairing said damages. The forecast should reflect the relative urgency of the respective works, the engineering capacity of the country and/or utility, and possible sources of financing. Special regard should be given to weighing the relation between national project execution capacity and new construction demands, and domestic capacity for covering the post-disaster surge in demand for reconstruction-related inputs vis-à-vis imports.

The water and sanitation specialist should make special reference to any expected requirement and capacity limitations for reconstruction and repair and make appropriate recommendations (as time and information limitations permit).

3. Effect on the balance of payments

The water and sanitation specialist should provide basic information on indirect losses so that the macroeconomic specialist may calculate the effects of the disaster on the current account. The information listed below should be included.

a) Decreased exports of goods and services

Since drinking water is very rarely exported, this item would not normally be taken into consideration. However, if an affected country normally exports engineering services related to the sector, the increased internal demand determined by the disaster might reduce or eliminate the export capacity for such services over a period of time. The reduced value of this export should be expressed as follows:

M$s = decreased value of exports of services, in a given period;
MsO = decreased value of exports of services, in the year of the disaster;
Ms1 = idem for the year following the disaster; and
Ms2 = idem for the second year following the disaster

Therefore: M$s = (MsO + Ms1 + Ms2)

b) Increased imports

To estimate the value of this item, imports required for rehabilitation and reconstruction of direct damages should be taken into consideration. Such imports may be obtained from the summation of the imported components of direct damage estimates made previously.

To estimate increased imports, the following procedure might be used:

Given:

Idd = increased imports as a result of direct damage;
Idd0 = idem, during the year of the disaster;
Idd1 = idem, during the year following the disaster; and
Idd2 = idem, during the second year (etc.) following the disaster (as applicable)

Thus: Idd = Idd0 + Idd1 + Idd2

c) Donations

This item includes international assistance for the sector consisting of donations in kind, equipment, materials and machinery. Although these donations will probably occur in the period immediately after the disaster (year 0), there should be an indication of whether donations are expected in the following years.

d) Reductions in international debt servicing

If a reduction in interest payments has been granted by creditors, due note should be made of it under the year in which it occurs.

e) Insurance and re-insurance

Increasingly, both the assets and revenues of the water and sanitation sector are domestically insured against disaster risks. Should that be the case, estimates must be made of insurance payments due after the disaster, as well as the expected amounts of reinsurance to be received from abroad, since these will have an effect on the country's balance of payment.

4. Effects on public finances

A disaster might disrupt public finances in several ways, as described below.

a) Decline in tax revenues due to lower production of goods and services

If water and sanitation billings are subject to taxation and if, utility revenues decline as a result of the disaster, the corresponding fiscal or municipal revenue will also diminish. To estimate these tax revenue shortfalls, due consideration should be given to the following:

- Declines in revenues due to decreased billing and water losses; and
- Information on the percentage (p%) and value of said taxes as estimated by the utilities.
- The value of lower taxes may then be estimated as follows:

  Mi = Mi0 + Mi1 + Mi2 = lower tax revenue in years 0, 1 and 2.

b) Decline in public utility revenues

Lower billings due to a decreased supply of drinking water, as indicated above, results in decreased revenues for the affected utilities.

Thus:

Mf = Mf0 + Mf1 + Mf2 = Lower billing for years 0, 1 and 2.

c) Increased outlays for reconstruction and damage repair

Information required to estimate this effect on public finances should be obtained from tables included in the previous example on gross investment.

Let: Mgi = higher outlays in reconstruction investment.
Then: Mgi = Mgi0 + Mgi1 + Mgi2 = idem, year 0 + year 1 + year 2

5. Effects on prices and inflation

Damage caused by the disaster may have a bearing on changes in the prices of water and construction materials required to repair damages in the sector. This would depend on several factors, including the magnitude of the disaster and the amount of damage caused.

a) Possible change in the price of water

The cost of water may vary as a result of a disaster for several reasons. Among them:

- Water production costs may vary owins to the need to change the place or type of water resource intake, the type or types of treatment plants or the conveyance or elevation of the water, or because of a drawdown in groundwater levels;
- If the resulting difference in costs compared to those before the disaster is absorbed by the utility through subsidies, there should be no effect on the price to the public.

Information on these matters should be provided by the water utility. However, it is unlikely that they could be reasonably certain of the exact impact on pricing so soon after the disaster, so the analyst must also make possible trend projections. If the cost increases as a result of the factors indicated above, the relationship between the new cost per cubic meter and the previous cost, or the expected variation in the new price to the public, should be indicated.

b) Possible effects on the price of construction materials.

Heightened demand for construction materials in this sector and throughout the economy in the wake of a disaster is likely to exert significant pricing pressures. Therefore, the assessment team as a whole should analyze the situation concerning a possible increase in construction material prices.

From the point of view of the water and sanitation sector, it would be useful to have an estimate of the increased demand for the main materials that will be involved in repair and reconstruction during the years following the disaster. The specialist should also develop an idea of the domestic production capacity, its relation to the increased demand and the capacity to import said materials. In addition, consideration should be given to possible price controls adopted by the government.

H. OTHER EFFECTS

1. Possible effects on employment

As in the case of the energy sector, the growing use of technology and equipment impliest that the water and sanitation sector employs a limited amount of personnel for the operation of its networks. A disaster is thus likely to have a very limited effect on employment and personal income in this sector. In fact, personal income of utility enterprises may actually increase during the rehabilitation period due to the payment of overtime.

The water and sanitation specialist should work in close cooperation with the employment specialist of the assessment team to arrive at the overall effects that the disaster may have on employment and income, ensuring that figures for the water and sanitation sector are duly included and not duplicated in the latter's global estimates.

The following paragraphs describe possible effects on employment for the sector.

a) Effects due to replacement of facilities and infrastructure

Since availability of drinking water is essential to the population, destroyed facilities and other infrastructure must be replaced as quickly as possible. The technology and design of the new facilities might require a different number or type of personnel for purposes of operation and maintenance. Any differences in employment arising from technological changes must be duly noted.

b) Effects occurring during the reconstruction and repair stage

Employment requirements during the emergency phase fall outside the scope of the assessment described in this Handbook. However, any of the following possible impacts on employment during the reconstruction process should be indicated:

- Employment levels could remain unchanged if reconstruction efforts absorb workers who were laid off when projects begun prior to the disaster were cancelled or suspended;
- Employment could increase if normal projects and activities are maintained while additional workers are hired for reconstruction and rehabilitation projects; or
- The employment scenario could be mixed, with only a percentage of pre-disaster development projects being canceled or postponed.

The disaster may have an impact on the investment decisions of government officials and the drinking water utilities, so the water and sanitation specialist should obtain the relevant information from these institutions for estimating any variations in employment for years 0 1, and 2 (if reconstruction works require more time, more years must be added).

These employment projections must be consistent with the time-frames and investment projections made earlier with regard to reconstruction requirements.

2. Differential effects on women

Any damage to drinking water systems in rural and marginal urban areas has a differential effect on women, who generally bear the burden of obtaining water for household consumption where no domestic water connections are available.

When a family or community well or spring is rendered useless as a source of drinking water because of contamination or silting, women are forced to dedicate greater time and effort to obtaining water from more distant locations, thus increasing their reproductive workload.

The section on the differential impact of disasters on women in Volume Four of this Handbook explains in detail how this increase in reproductive work can be estimated through field surveys. The water and sanitation specialist should work in close cooperation with the gender specialist in making such estimates.

3. Impact on the environment

Any change in the availability or quality of the water resource used by the drinking water supply system constitutes an environmental modification that has negative effects on people's health and well-being. The same is true of sanitation problems caused by disruption of wastewater disposal and solid waste management systems. While the chapter on environmental matters in Volume Four deals with these issues, the estimation of related costs falls within the purview of the water and sanitation specialist, who should coordinate with the environment specialist to ensure that all the relevant information is effectively obtained and that there is no double accounting.