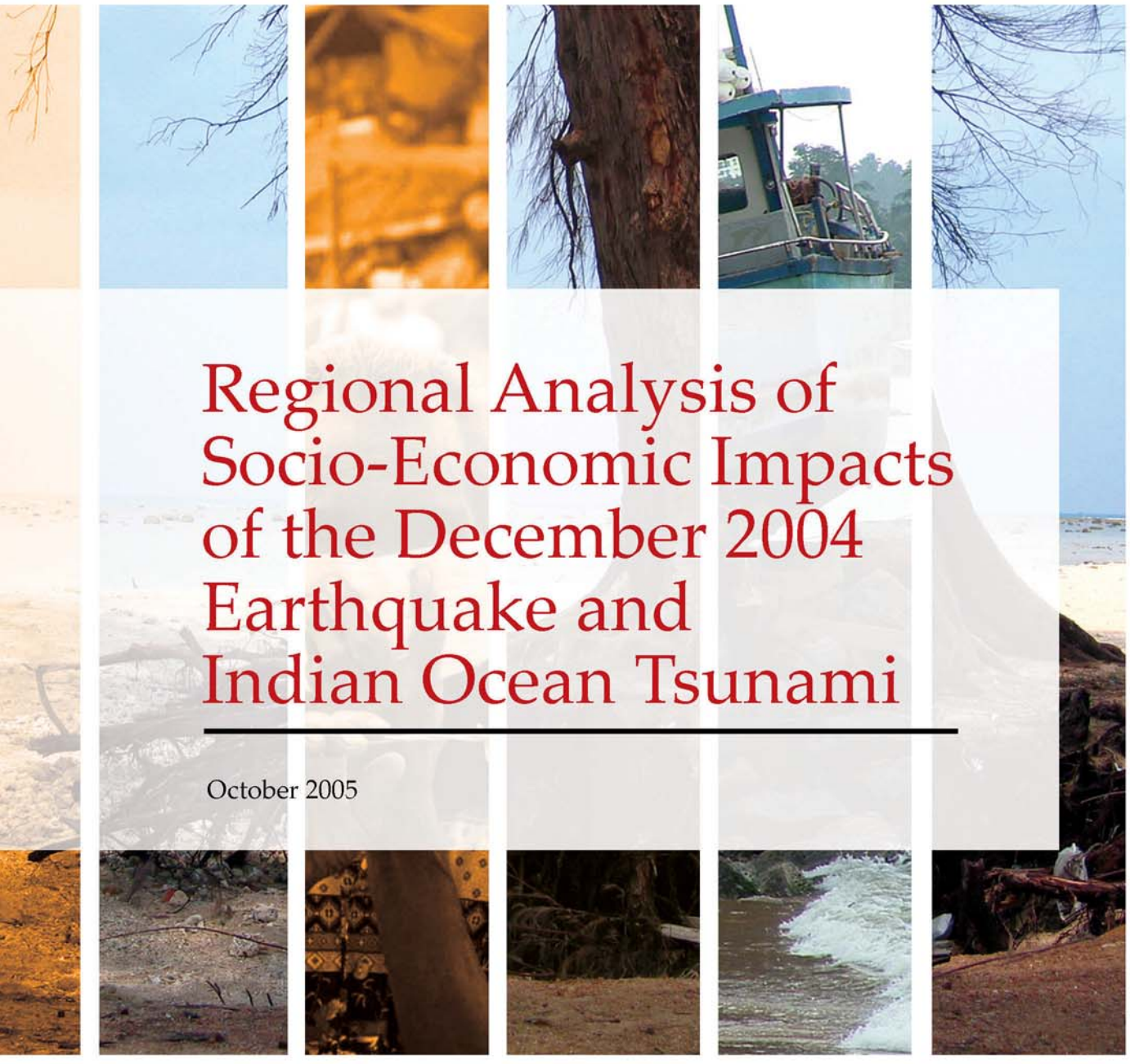


Regional Analysis of Socio-Economic Impacts of the December 2004 Earthquake and Indian Ocean Tsunami

October 2005

ASIAN DISASTER PREPAREDNESS CENTER

ADPC. *Regional Analysis of Socio-Economic Impacts of the December 2004 Earthquake and Indian Ocean Tsunami. Bangkok*: ADPC, 2006, 43 pp.

Authorship

Execution of the study was undertaken under the direction of the Disaster Management Systems Team of ADPC, under the leadership of its Director, Mr. Aloysius Rego.

A senior international consultant, Mr. J. Roberto Jovel, was engaged by ADPC to conduct all substantive activities for the project, including the preparation of this report. Mr. Jovel led the development of the ECLAC methodology, has had a long and extensive experience in its application in the Latin America and the Caribbean region as well as in Asia, and also led the project for the transferring of the damage and loss assessment methodology in the State of Gujarat, India, for ADPC.

In the undertaking of project activities, Mr. Jovel was supported by a number of ADPC Staff including *inter alia* Mrs. Supriya Prabhu Mehta, Project Manager; Mr. Arghya Sinha Roy; and Mrs. Farzana Khan. Senior ADPC officials Messrs. Earl Kessler, Deputy Executive Director, Arjunapermal Subbiah, N.M.S.I. Arambepola and Selvaraju Ramasamy provided substantive comments. Messrs. Ricardo Zapata, Rene Hernandez and Jose Javier Gomez, of the Economic Commission for Latin America and the Caribbean (ECLAC) remotely provided valuable comments and suggestions for the preparation of this report. Comments were also received from Ms. Margaret Arnold and other World Bank officials that were very useful in preparing the final version of this report.

Published by:
Asian Disaster Preparedness Center (ADPC)
P O Box 4, Klong Luang, Pathumthani, Thailand 12120
Tel: (66 2) 516 5900-10
Fax: (66 2) 524 5360
URL: http://www.adpc.net

Lay-out and design by: Philipp Danao, Information and Knowledge Management Unit, ADPC
Printed by: Do My Best Printer, Thailand

Regional Analysis of Socio-Economic Impacts of the December 2004 Earthquake and Indian Ocean Tsunami

October 2005

E. DE VERA/CDP/ADPC

Contents

List of Tables and Figures

TABLES

FIGURES

I. Introduction

A. BACKGROUND

The magnitude and extent of the human toll of the 26 December 2004 Earthquake and Indian Ocean Tsunami caused widespread destruction and mobilized an enormous effort for humanitarian assistance never seen in the past. The special coverage given by the international media, coupled with the unusual and infrequent type and intensity of the natural event and the presence of foreign nationals among the victims gave rise to an unprecedented sense of international solidarity.

The severity of the human suffering was accompanied by widespread destruction of physical, social and productive infrastructure caused by the action of the earthquake and the ensuing tsunami waves that spread havoc in the shores of the Indian Ocean and reached as far as the African coast. As a result, the economies of the affected countries were negatively impacted in both the immediate and medium term. Furthermore, environmental assets were damaged or destroyed, and the associated environmental services they render were disturbed or eliminated in its entirety.

The immediate impact was represented by the loss of human lives, temporary and permanent physical and psychological injuries, total or partial destruction of physical assets. In the medium term, the impact will require the reconstruction of physical assets at unit prices over and above their original value, caused the decline in production of affected sectors, a negative impact on economic growth for the affected provinces and countries, and the loss of livelihood and well being for the affected population.

This event had as special feature that it covered a wide surface area and that it affected several countries. Other slowly developing disasters, usually associated with climate anomalies such as the El Nino phenomenon and the recent drought in Africa have also affected geographical areas. In regard to sudden disasters, only hurricane Mitch – which in 1998 caused havoc in the Central American countries – had caused similar destruction in a widespread area. The sharing of common vulnerabilities, risks and impacts brings about the possibility of identifying and undertaking joint, collaborative efforts for disaster impact mitigation and management in the Indian Ocean basin, from which the affected countries may derive significant benefits and economies of scale.

B. THE PROJECT

With this in mind, the Asian Disaster Preparedness Center (ADPC) – a regional non-profit organization aimed at fostering disaster preparedness and management in the Asian region – formulated a technical cooperation project aimed precisely at the formulation of proposals for collective disaster risk reduction (with special reference to financial risk management) that the countries may adopt.

The project was designed with the following objectives:

- Development objective: to mitigate the socio-economic and environmental impact of disasters in South-East Asia through financial risk management; and
- Immediate objective: to determine the immediate and medium-term economic impacts of the 26 December 2004 disaster in order to contribute to the nascent body of knowledge of socio-economic impact of disasters

The initial project proposal was divided into two phases. The first phase would be comprised of a comparative study to determine the impact of the disaster on the five most affected countries in order to identify possible collective actions for disaster risk management and reduction. The second phase would include an analysis of the existing framework of disaster financial risk in the countries and the formulation of schemes for regional financial risk transfer and reduction schemes. This report describes the results of the first phase.

The study had the following three main outputs and activities:

Output 1. Assessment of immediate and medium-term impact of the disaster in the region.

- Activity 1a. Comprehensive estimation of damage and losses in Thailand
- Activity 1b. Updating and refining of existing preliminary assessments of disaster impact available in India, Indonesia, Maldives and Sri Lanka
- Activity 1c. Estimation of overall impact of disaster in the region
- Activity 1d. Comparative analysis of disaster impact and identification of commonalities and singularities arising from the different conditions of the national economies and their exposure to natural phenomena

Output 2. Regional meeting of advisory panel of experts for presentation and discussion of results obtained in the comparative analysis.

Output 3. A final project report describing the results of the comparative study and the outcome of the panel meeting.
It is to be noted that the comparative study whose results are described in this report, have followed the general scope of a similar analysis that was carried out in Central America following the major disaster caused by hurricane Mitch in 1998, which negatively affected the well being and economic development of the Central American countries. The results of the comparative analysis carried out in that occasion led to the adoption, by the Central American Presidents, of a regional strategy and a five-year plan for disaster reduction[1].

[1] See Roberto Jovel et al, *Reconstruction and Transformation of Central America after Hurricane Mitch; A Regional Approach*; Central American Integration Secretariat, San Salvador, May 1999; and *Declaration of Guatemala* , Presidential Summit, October 1999. See also, Ricardo Zapata, *The 2004 Hurricane Season in the Caribbean and the Tsunami in the Indian Ocean; Lessons Learned and Policy Challenges for Development and Disaster Reduction*, ECLAC, Mexico, 2005.


F. J. ABO/ADPC

C. METHODOLOGY

The project was envisaged to rely on the available national assessments of damage and losses for India, Indonesia, the Maldives and Sri Lanka that had been undertaken in early 2005, under the leadership of the World Bank, and in cooperation with the Asian Development Bank, the United Nations, and other international and national organizations. These national assessment reports were the following:

- Indonesia: Preliminary Damage and Loss Assessment; The December 26, 2004 Natural Disaster, Bangkok, January 2005;
- Sri Lanka: 2005 Post-Tsunami Recovery Program, Preliminary Damage and Needs Assessment, Colombo, January 2005;
- Republic of the Maldives: Tsunami, Impact and Recovery, February 2005; and
- India Post-Tsunami Recovery Program; Preliminary Damage and Needs Assessment, New Delhi, March 2005.

Furthermore, to update the existing assessments, the project collected and analyzed additional information on damage and losses that has been collected in recent months by national governments and other organizations. To that end, visits were made to countries and interviews were held with relevant official authorities and other reliable informants.

In the case of Thailand, the government, in cooperation with international organizations, had carried out only sectoral scope assessments. Under the project a full, comprehensive estimation of damage and losses was undertaken[2], and its results were submitted and discussed with government counterpart authorities. In order to ensure that the primary and secondary information of damage and losses was processed using common procedures and that the results would be fully consistent and comparable, use was made of the methodology developed by the United Nations Economic Commission for Latin America and the Caribbean (ECLAC)[3], which has been used extensively since the early 1970s in that region and more recently is being transferred and adapted for use in Asia[4]. Examples of the latter initiatives are the evaluation of damage and losses conducted after the Turkey and Gujarat earthquakes in 2001, and some cases of the earthquake and tsunami.

The concepts and approach used in the methodology are unique. In the first place, the impact of disasters is measured in terms of damage and losses, which are defined below.

- Damage represents the total or partial destruction of physical assets, such as infrastructure, buildings, furniture and equipment. Damage occurs at the time of the disaster, and is measured at replacement value.
- Losses are changes in economic flows that arise as a result of damage. They include decline in production and sales or increased production costs; lower revenues and higher production costs in the provision of services; and increased expenditures arising from the disaster. They occur after the disaster and over a relatively long period of time until full reconstruction and recovery has been attained.

The procedure in which damage and losses are estimated follows a sector-by-sector approach to estimate the impact on individual sectors. This bottom-up approach requires the aggregation of sectoral estimates – duly verified to avoid double accounting – and their insertion into the main macro-economic variables, such as *inter alia* gross domestic product (GDP), foreign sector, fiscal sector and inflation, to determine the manner in which the economy is affected. It is to be stressed here that the terms damage and losses are not interchangeable; they have their special definition as described above. The reader is advised to get thoroughly acquainted with the definitions in order to avoid misunderstandings in the reading of this report. It is also important to point out the distinction between disaster impact (measured in terms of damage and losses) and needs. The latter refer to both the immediate demands of relief and humanitarian assistance in the emergency phase, and the medium term demands for reconstruction and recovery. It is essential to have a good assessment of damage and losses as a basis to define reconstruction and recovery needs.

Results of the analysis presented herein represent an independent assessment of the total impact of the disaster in the Indian Ocean region, as carried out by ADPC and its consultants. These results– contained in a draft version of this report–were presented and discussed during a special meeting of an advisory panel of governmental experts that was held in Bangkok on 19-20 September 2005. Participants in the panel were representatives of national ministries of finance, development planning and other line ministries as well as representatives from central banks of the five affected countries. Representatives of selected regional and international organizations were also in attendance.

---

[2] See Roberto Jovel et al, *Comprehensive Estimation of Damage and Losses in Thailand*, Asian Disaster Preparedness Center (ADPC), Bangkok, 18 August 2005.

[3] See ECLAC, *Handbook for Estimating the Socio-Economic and Environmental Effects of Disasters*, Four Volumes, 2 Edition, 2003.

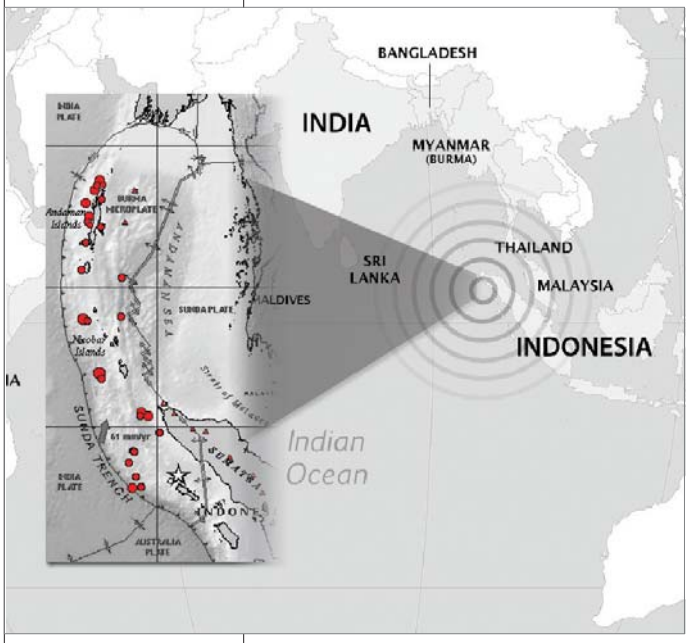
[4] One such instance of adaptation is the recent case of the State of Gujarat, India, where ADPC has recently completed a special technical cooperation project for the Disaster Management Authority, and manuals for the estimation of damage and losses following disasters have been developed following the ECLAC methodology.

DR. PENANG/AIT ADPC

natural event and disaster

...a magnitude of 9.0 on the Richter scale...epicenter was 250km to the Southeast of Banda Aceh...approximately 1,200km of the India tectonic plate slipped...estimates indicate that the width of the fault rupture is around 15m...the megathrust earthquake generated a tsuami that carried many million tons of water in a series of very large waves...reaching as far as the northern extreme of Sumatra, the coast of Thailand, Sri Lanka, India, Malaysia, and the Maldives...

II. Natural Event and Disaster



A. ORIGIN AND CHARACTERISTICS OF THE NATURAL EVENT

The December 2004 Indian Ocean disaster was caused by an earthquake that the United States Geological Survey classified as having a magnitude of 9.0 in the Richter scale[5], making it one of the strongest events of its kind in the past forty years[6].

The epicenter was located 250 kilometers to the South-East of Banda Aceh in the island of Sumatra, Indonesia (See map above). The actual hypocenter was located at the shallow depth of 30 kilometers below sea level in the Indian Ocean. According to the Indonesian meteorology and geophysical observatory (BMG), the amount of energy released was so high that it was surpassed only by the world-famous eruption of Krakatoa in 1883.

The megathrust event occurred in the interface of the India and Burma tectonic plates. It was caused by the release of energy accumulated from the subduction of the Indian plate under the Burma plate. In the area where the quake was originated the India plate is moving towards the northeast, at a rate of six centimeters per year in relation to the Burma plate.

The analysis of information conducted by the USGS on multiple large aftershocks that occurred after the mega-quake states that approximately 1,200 kilometers of the plate boundary slipped as a result of the event. Preliminary estimates indicate that the width of the fault rupture must have been more than 100 kilometers and that that the average displacement of the fault plane is likely to have been around 15 meters. The sea floor overlying the thrust fault would have been uplifted by several meters.

The megathrust earthquake generated a tsunami that carried many million tons of water in a series of very large waves that traversed the Indian Ocean in a matter of hours. These waves impacted on beaches, flooding low-lying lands coastal areas.

The combined action of the two events caused, on one hand, extensive destruction of housing and other infrastructure in Indonesia and, on the other, widespread loss of life, destruction of infrastructure and disruption of production in the entire Indian Ocean basin, reaching as far as Africa. The waves traveled very fast. They reached the northern extreme of Sumatra in a matter of a few minutes; the coast of Thailand within the next hour, and Sri Lanka and India in two hours. The Maldives Islands were swept over three hours after the quake occurred, and Somalia was reached in eight hours. Malaysia was spared from major impact from the waves, as it was protected in this case by Indonesia.

The height of the waves was between 10 to 30 meters in Sumatra, 5-10 meters in Sri Lanka, 5-6 meters in the India coastline, 3-5 meters in Thailand, and over 1.5 meters in the Maldives. Depending on the terrain relief, the sea penetrated inland up to 5 kilometers in Indonesia, and less so in India, Sri Lanka and Thailand.

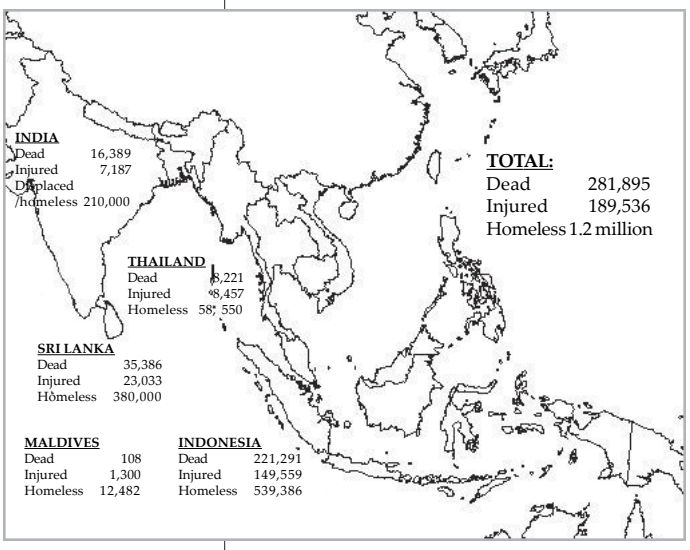
The destruction was widespread. The most obvious cases were in the urban area of Banda Aceh, which was decimated, as well as in tourism resorts and hotel areas of Thailand, Sri Lanka and the Maldives. Many small and medium sized rural villages located along the beachside in the five countries were also wiped out.

---

[5] See *Preliminary Earthquake Report, Magnitude 9.0 Off the West Coast of Northern Sumatra; Sunday, December 26, 2004 at 00:58:53 UTC*, in USGS web site at http://neic.usgs.gov/neis/

[6] According to the USGS, the largest recorded earthquakes have been of the megathrust type, and include the magnitude 9.5 Valdivia earthquake in Chile (1960), the magnitude 9.2 Prince William Sound in Alaska (1964), the magnitude 9.1 Andreanof Islands earthquake in Alaska (1957) and the magnitude 9.0 Kamchatka earthquake in 1952.

Figure 2.1: Detailed number of affected people by country



B. THE FREQUENCY OF THE EVENT

No early warning system was in place and the people received no information about the impending disaster or on the need to evacuate. Many of the beachside inhabitants did not have a recollection of a similar event in the past and did not seek shelter when the sea receded in the coast, to be struck by the waves shortly after. In some areas of very low terrain relief, there would not have been any high ground to run to. As a result, the death toll was extraordinary.

Existing historical data on the occurrence of earthquakes and tsunamis in the Indian Ocean and Pacific Ocean basins shows that these events have a relative low frequency of occurrence (See table 2.1). Nevertheless, for the Indian Ocean basin other earthquake/tsunami events, albeit of lower magnitude, have occurred in relatively recent times. The frequency with which these events occur is relatively low, but the human toll and the over-all impact is so high that they warrant the establishment of a culture of prevention among the population as well as early warning systems.

Table 2.1: Geophysical Events involving Tsunamis in Indian Ocean and Pacific Ocean Basins

DATE	EVENT	LOCATION
	Indian Ocean Basin	
1881	Earthquake and tsunami	Andaman Sea
1883	Volcanic Eruption and tsunami	Krakatoa, Indonesia
January 1941	Earthquake and tsunami	Andaman Sea
November 1945	Earthquake and tsunami	North Arabia Sea
August 1976	Earthquake and tsunami	Philippines
August 1977	Earthquake and tsunami	Indonesia
July 1998	Earthquake and tsunami	Papua, New Guinea
December 2004	Earthquake and tsunami	Indian Ocean
	Pacific Ocean Basin	
June 1896	Earthquake and tsunami	Honshu, Japan
April 1946	Earthquake and tsunami	Aleutian Islands, Alaska
November 1952	Earthquake and tsunami	Kamchatka
March 1957	Earthquake and tsunami	Aleutian Islands
July 1958	Landslide and tsunami	Lituya Bay, Alaska
May 1960	Earthquake and tsunami	Valdivia, Chile
March 1964	Earthquake and tsunami	Prince Williams Sound, Alaska
November 1975	Earthquake and tsunami	Hawaii
September 1992	Earthquake and tsunami	Nicaragua
June 2001	Earthquake and tsunami	Arequipa, Peru

Compiled by ADPC

III. The Impact of the Disaster

A. GENERAL COMMENTS

As explained in the Introduction, disaster impact for the five most affected countries was estimated using a common conceptual framework and a unified assessment procedure. To that end, primary data on damage and losses caused by the disaster, as found in the national assessment reports for India, Indonesia, the Maldives Islands and Sri Lanka was utilized. More recent primary data on productive sector performance – in some cases covering up to June and July of 2005 – for Sri Lanka and the Maldives was used to update and refine the estimation of losses. In addition, updated data on damage to assets was made available for Sri Lanka (in the case of the housing sector) and for the Maldives (all affected sectors). Most unfortunately no comparable damage and loss information was available for the case of the Andaman and Nicobar Islands of India, which were devastated by the tsunami. Thus, the impact of the disaster on these islands was not included in the regional analysis.

In the case of Thailand, a full, comprehensive estimation of disaster impact was carried out under the project, and its results were submitted and discussed with government officials on 19 August 2005. It provided for a valid, quantitative framework for analyzing the total impact of the disaster in the region. This framework used information that does not necessarily coincide with the initial estimates of disaster impact in individual countries, especially in the cases of the Maldives and Sri Lanka, where more detailed analysis have been made using more recent information on losses and where revisions of damage figures were taken into consideration. It should be pointed out that the present estimates include damage and losses sustained by both the private and public sectors in the countries. In the analysis presented in this report, the impact on the public sector refers to assets and services owned and provided by national, regional or local governments. The impact on the private sector includes damage to assets and losses sustained by enterprises and by private individuals.

B. POPULATION AFFECTED

It is difficult to obtain fully accurate data of the number of people that were directly and indirectly affected by this disaster. The very large area covered by the natural phenomenon, the lack of effective communications and the resulting relative isolation of many human settlements (especially in many small, sparsely inhabited islands) prevents fully comprehensive estimations. Nevertheless, care has been exercised to acquire and utilize information from the most reliable sources, both at the national and the international levels.

Pre-Disaster Conditions

A description of the basic social indicators for the affected countries is included in table 3.1 below. The Maldives and Thailand have the highest per capita GDP; Indonesia and Sri Lanka have intermediate values; and India has the lowest. The five countries share the medium human development index bracket, although India is located in the lower end of the scale[7]. The data below is representative of the average living conditions of the population in the affected countries as a whole. However, with the exception of the urban areas of India and Sumatra, the Maldives and the tourism areas of Thailand and Sri Lanka, the population located in the coastal areas affected by the disaster – which consists mainly of fisher folk and small farmers – normally has much lower social indicators and income. Therefore, as in most disasters, the most affected population belong to the lower income strata, and have less resilience and capacity to overcome by themselves the impact of the disaster[8]. Assistance from the respective national governments and from the international community is therefore essential to bring them back to their feet.

[7] See *Human Development Report 2004*, pages 140 and 141, United Nations Development Programme (UNDP), New York, 2004.
[8] Available information shows that even in industrialized countries and developed societies vulnerability correlates inversely to income strata, as dramatically exemplified in recent days in the case of New Orleans after hurricane Katrina.

Table 3.1: Selected Social Indicators for the Affected Countries in 2003

	India	Indonesia	Maldives	Sri Lanka	Thailand
Population, million	1,064.4	214.7	0.293	19.2	62.0
Population density, per sq.km.	324	113	977	293	121
Population growth, percent[a]	1.52	1.21	1.96	0.94	1.14
Urban population, percent	28.4	40.9	27.4	23.6	21.6
Life expectancy at birth, years[a]	62	68	65	74	73
Infant mortality at birth, per thousand[a]	68.0	41.4	21.0	15.4	21.5
Literacy rate, percent	45.4	81.9	96.8	89.0	93.9
GDP per capita, US$	564	970	2,440	950	2,306
Human Development Index	0.602	0.697	0.745	0.751	0.778
Surface area, sq. km.	3,287,260	1,904,570	300	65,610	513,120

Sources: World Development Indicators 2005, World Bank; Basic Indicators 2002, World Health Organization; and http://hdr.undp.org/reports/global/2005/ for 2004 Human Development Index.
[a] Data for 2002

Impact of Disaster on Population

While constantly changing and sometimes conflicting information emerged during the early post-disaster phase, recent data indicates that a total of 281,900 persons died as a result of the earthquake and tsunami[9]. Furthermore, 189,500 persons were injured, physically and psychologically, and required immediate or medium term treatment. In addition, about 1.2 million persons became homeless and even a year after the tsunami many were still housed in temporary camps, a sizable fraction of which still requires shelter, food and health services. Table 3.2 below shows the information broken down by country.

The death toll makes the 26 December 2004 Indian Ocean disaster the most lethal event of geophysical origin, surpassing the Tangshan, China, earthquake that caused 228,000 deaths in 1976[10]. Even in terms of national population the death toll is very significant; the most affected countries being Sri Lanka (0.2% of total country population) and Indonesia (0.1%). Furthermore, the human loss is even higher when the population of affected individual provinces is considered. Indeed, the provinces of Aceh in Indonesia and Mullaitivu in Sri Lanka sustained very significant death ratios of 3.0% and 2.7% respectively. Other provinces in Sri Lanka, Thailand and India sustained relatively high death ratios as shown in table 3.3. The case of individual cities would be even worse, such as in Banda Aceh where a sizable fraction of the population perished. The number of deaths was so high in the Aceh Province of Indonesia that the reconstruction program will require a number of housing units that is lower than the pre-disaster housing stock.

The size of the temporary shelter operation is unprecedented. In the weeks immediately following the disaster, reports show that up to 1.7 million persons had to be attended to. Furthermore, the present scheme of temporary housing – which attends to 1.2 million people – will require to be extended for a long time, as the reconstruction program for housing is expected to require more than two years to complete. Causes for that are twofold: the limited capacity for housing construction, and the corresponding rate of flow of financing. The United Nations in coordination with the affected countries and donors has faced the largest post-disaster shelter operation of its history in events of this kind. Thus, not withstanding the very generous response obtained from the international community in the UN mid-January Flash Appeal, this is expected to be a long haul operation with varying speeds of recovery in each country. In some cases – where human life was decimated and where a very large fraction of the population's livelihood was destroyed – it is essential to first solve important issues such as relocation and the manner of livelihood restoration.

[9] In Thailand, a total of 3,146 foreign tourists, of different nationalities, perished in the disaster.

[10] Other similar disasters with high death tolls were the Xining and Gansu earthquakes in China that caused 200,000 deaths each in 1927 and 1930, respectively; the 1923 Tokyo earthquake (143,000 deaths); and the 1755 Lisbon and 1908 Messina tsunamis that caused 100,000 and 70,000 deaths, respectively. The 1883 Krakatoa tsunami caused 36,000 deaths. Major disasters caused by hydro-meteorological events have caused significantly many more deaths.

Table 3.2: Direct Impact of the Disaster on Population

	India*	Indonesia	Maldives	Sri Lanka	Thailand	Region
Dead (incl. mising)	16,389	221,291	108	35,386	8,221	**281,895**
Injured	7,187	149,559	1,300	23,033	8,457	**189,536**
Homeless	210,000	539,385	12,482	380,000	58,550	**1,200,417**

Source: Ministries of Health

**These figures do not include information on the population of the Andoman and Nicobar Islands.*

Table 3.3: Death Ratios in Most Affected Provinces or Districts

Province/ District	Country	Total Population (2004)	Number of Deaths	Death to Population Ratio (%)
Aceh	Indonesia	4,037,276	163,978	4.1
Mullaitivu	Sri Lanka	129,875	3,552	2.7
Ampara	Sri Lanka	625,417	11,312	1.8
Phang Nga	Thailand	235,972	3,651	1.5
Hambantota	Sri Lanka	542,899	5,463	1.0
Jaffna	Sri Lanka	461,769	3,180	0.7
Batticaloa	Sri Lanka	514,705	3,530	0.7
Galle	Sri Lanka	1,020,553	4,695	0.5
Killinochchi	Sri Lanka	133,470	561	0.4
Trincomalee	Sri Lanka	354,646	1,294	0.4
Andaman and Nicobar	India	385,058	1,316	0.3

Source: Ministries of Health

C. ECONOMIC IMPACT

In order to best appreciate the economic impact of the 26 December 2004 Indian Ocean disaster, a brief description of the recent economic performance of the countries is presented below.

Economic Position and Prospects

According to the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the economies of the region grew at an average rate of 4.0% in 2004, one of the highest in the past three decades, and inflation rates remained stable[11]. The economies of the countries affected by the disaster, however, grew at even higher rates as shown below, placing them among the most dynamic world economies.

Such vigorous economic performance was achieved by the countries despite the combined negative impact of rising international prices of oil and of rising domestic interest rates. The average price of oil in the second half of 2004 was almost 50% higher than the one that prevailed in the past two years. To counter the risk of potentially higher inflation, Central Banks began to slowly raise in stages the interest rates during the second half of the year. Prospects for the immediate future are unclear at present. The combined action of high oil prices and interest rates, if sustained over time, may have a negative impact on the governmental efforts that enabled them to increase employment after the 1997-1998 economic crisis and the 2001 slowdown that occurred as a result of the ending of the *dot com* boom, and affect the prevailing macro-economic stability[12]. Economic forecasts made at the beginning of 2005, assuming that the average price of oil would remain at around US$ 38 per barrel, indicated that the growth rate of the developing economies in the region would drop below that of 2004. However, the prognosis made at that time will surely be proven to be optimistic as oil prices have continued to rise, exceeding US$ 60 per barrel in certain markets, and prospects of the world economy are affected by the impact on the US economy caused very recently by hurricane Katrina, since it involves the oil production in the Gulf of Mexico region.

Forecasts on economic growth for the five affected countries covered in this report, made just before the disaster occurred, gave annual rates similar to the ones in the preceding year (See table 3.4). However, the tsunami will impose reductions in the forecasted growth in 2005 and beyond, as the negative impact on productive sectors may not be fully compensated by the reconstruction and recovery investments.

[11] See *Dealing with Shocks; Economic and Social Survey of Asia and the Pacific, 2005*, Economic and Social Commission for Asia and the Pacific (ESCAP), Bangkok.

[12] Other local factors, such as civil unrest and droughts, impacted negatively on economic growth for some countries in 2001.

Table 3.4:
Annual Rates of Growth of Gross Domestic Product in the Affected Countries (2000 to 2004)

	India	Indonesia	Maldives	Sri Lanka	Thailand
2000	3.9	4.9	4.4	6.0	4.8
2001	5.1	3.5	3.3	-1.6	2.2
2002	4.1	3.7	6.1	4.0	5.3
2003	8.6	4.1	9.2	5.9	6.9
2004[a]	6.9	5.1	8.8	5.4	6.1
2005[b]	7.2	5.4	7.5	6.0	6.0

Source: World Development Indicators 2005, World Bank; ESCAP and Governments for 2004 and 2005

[a] *Preliminary estimate*

[b] *Forecasts made before the tsunami occurred*

Magnitude of the Disaster

The magnitude of a disaster is measured in terms of the comparison of the total effects – that include damage and losses as indicated in the Introduction – and the main economic aggregates for each country. The following sections describe the estimated values for these impacts, as well as their spatial distribution.

■ **Total Impact**

The total effect of the 26 December 2004 Earthquake and Indian Ocean Tsunami has been estimated at 9,930 million United States Dollars. It is to be noted here that this figure has been produced after updating and expanding the existing national assessments to ensure that all sectors are included, and especially that private sector impact is given due consideration. Furthermore, the by-country breakdowns to be shown later on will also differ from the national assessments produced in the first quarter of the year.

Due to its high human toll and social impact and to the number of countries affected, the Indian Ocean disaster ranks among the most important major disasters in recent times, even though in economic terms it may fall below other recent and major events (See table 3.5). In this regard, it must be pointed out that disasters cause higher amounts of damage in industrialized countries due to the higher concentration of invested capital, and lower numbers of deaths in view of the implementation of a number of structural and non-structural risk reduction measures. The opposite is true in developing countries; that is to say, there occur relatively lower damages and a much higher number of deaths[13].

The frequency with which these events occur is relatively low, but the human toll and the overall impact is so high that they warrant the establishment of a culture of prevention among the population as well as early warning systems.

But, while Andrew caused damage and losses exceeding 32 billion US Dollars and the Indian Ocean disaster "only" 10 billion, the impact on the economy of the respective affected areas were different. The effects of Andrew represented 0.4% of GDP in the USA, and the Indian Ocean disaster is equivalent to 1.0% of the region's combined GDP. This fact indicates that reconstruction and recovery in the Indian Ocean area after the disaster will be more difficult, as the economies of the countries are less able to absorb the negative impact and there is no significant insurance coverage involved.

■ **Ownership of Effects**

It is important to point out that the disaster impact was concentrated on the private sector assets and activities (77% of the total amount of damage and losses)[14], while the public sector sustained only a fourth of the total (See table 3.6). Nevertheless, since a fraction of the damage and losses belonging to the private sector refers to housing of lower income population, and in order for livelihoods to be reinstated promptly, the governments of the affected countries will end up assuming more a larger share of the impact.

[13] The fact that the Indian Ocean disaster has caused so many deaths - as shown in the comparison given in Table 3.5 - highlights the inverse relationship that exists between number of deaths and the degree of development. This no doubt reflects the need for early warning schemes, strict building codes and public education and awareness. .

[14] The term private sector as used in this analysis and report refers to privately owned assets and activities, whether they belong to large, medium, or small enterprises or to individuals.

Table 3.5: Impact of Selected, Recent Major Disasters in the World

Disaster		Number of Deaths	Total Effects, Million US$*	Magnitude,% of GDP
Hurricane Andrew (1992)	Florida, USA	29	32,370	0.4
El Ni◎o 1997-1998	Andean countries	600	8,220	3.6
Hurricane Mitch (1998)	Central America	18,385	6,560	13.2
Earthquake & Tsunami	Indian Ocean	281,900	9,930	1.0

Data Source: CRED and ECLAC
** Figures for past disasters have been adjusted for inflation in order to allow comparability*

Table 3.6: Breakdown of Total Impact between Private and Public Sectors
(Million US Dollars)

	India	Indonesia	Maldives	Sri Lanka	Thailand	Total
Private	891	3,168	374	1,060	2,137	7,632
Public	332	1,283	228	394	61	2,298
Total	1,224	4,452	602	1,454	2,198	9,930

Source: ADPC

Types of Effects

The breakdown of total impact into its main components is given in table 3.7. It is to be noted that the larger portion (nearly 56% of the total refers to destruction of assets, and 44% are production losses. The value of damage is roughly indicative of the amounts of investment that will be required for reconstruction, which will have to be approached in a staged fashion that may last up to 2-to-3 years. The value of losses will impact negatively on production and economic growth of the present and two following years, although they would be partially compensated by the growth in the construction sector depending on reconstruction implementation rate.

Table 3.7: Breakdown of Damage and Losses caused by the Indian Ocean Disaster

	Million US$	%
Damage	5,596	56.4
Losses	4,333	43.6
Total Impact	9,930	100.0

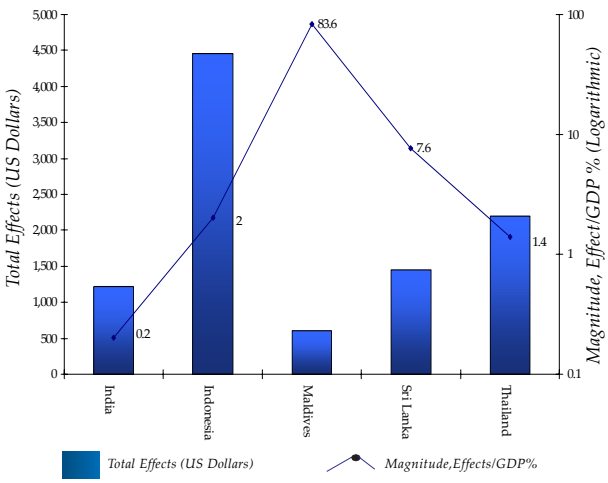
Source: ADPC

Sectoral Distribution of Impacts

Country level distribution of disaster impact

The affected Countries, States and Provinces were impacted in different ways by the disaster. Destruction of assets and losses in production varied among them, depending on the specific geographical exposure to the impact of the earthquake and tsunami. In terms of total impact, Indonesia was the most affected of the countries (US$ 4,451 million), followed by Thailand (2,198 million), Sri Lanka (1,454 million), India (1,224 million) and the Maldives Islands (603 million). (See table 3.8). A comparison of total impact *vis a vis* the size of the national economies – expressed in terms of Gross Domestic Product (GDP) – provides a measure of the magnitude of the disaster in each country. It is no surprise that the Maldives Islands sustained the highest value of this index, since the total impact represents 84% of the national GDP. The magnitude of the disaster in Sri Lanka was also of relevance (7.6%), while the other countries had much lower values (See figure 3.1).

Figure 3.1: Comparison of Total Impact *vis a vis* Size of the National Economies *(expressed as % of GDP)*



Experience in the international arena indicates that when the ratio of total impact to GDP is below 4%, the magnitude of the disaster is considered as low; between 4.1 to 10%, the magnitude is moderate and the affected country can usually absorb the disaster resorting to foreign financing; and above 40%, magnitude is very high, and significant assistance from abroad under relatively soft conditions is indispensable in order for the country to overcome the situation[15].

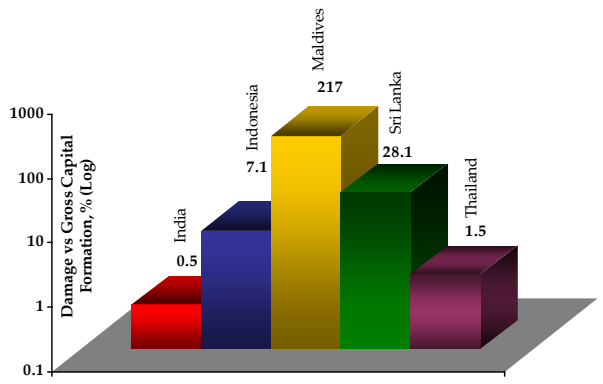
[15]These ranges would have to be revised when more data from Asian disasters become available in the future.

Table 3.8: Distribution of Disaster Effects by Countries
(Million US Dollars)

Country	Damage	Losses	Total Impact	Magnitude, Effect/ GDP, %
India	575	649	1,224	0.2
Indonesia	2,920	1,531	4,451	2.0
Maldives	450	153	603	83.6
Sri Lanka	1,144	310	1,454	7.6
Thailand	508	1,690	2,198	1.4
Total Region	**5,597**	**4,333**	**9,930**	**1.0**

Source: ADPC

Figure 3.2: Disaster Damage *vis a vis* Annual Rate of Gross Capital Formation



On that basis, the Maldives Islands – and Sri Lanka to a lesser extent – should depend on significant amounts of external financial assistance for their reconstruction and economic recovery process. In the case of Indonesia, in view of its present economic and fiscal position, it is expected that important amounts of foreign financing will be required to meet reconstruction requirements. In the case of Thailand, and taking into consideration that most of the damage and losses sustained are in the private domain, with partial insurance coverage, the national economy is expected to recover with relative ease. India initially expressed its intention to meet post-disaster needs using its own financial resources to a great extent and recently obtained a loan of US$ 465 million from the World Bank.

In relation to the value of damage, Indonesia (US$ 2,920 million) and Sri Lanka (US$ 1,144 million) were the most affected. The remaining three countries sustained similar amounts of damage. The comparison of damage to gross capital formation ratios provides an insight into the effort that will be involved in reconstruction for each country. These ratios are evidently higher in the case of the Maldives and Sri Lanka, less so in Indonesia, and very minor in Thailand and India (See table 3.9 and figure 3.2).

Table 3.9: Disaster Damage *vis a vis* Annual Rate of Gross Capital Formation

	India	Indonesia	Maldives	Sri Lanka	Thailand
Annual Gross fixed capital formation, million US$ [a]	119,193	41,082	207	4,072	34,417
Amount of damage, million US$	575	2,920	450	1,144	508
Damage/GCF ratio, %	**0.5**	**7.1**	**217.0**	**28.1**	**1.5**

Source: ADPC
[a] Figures in local currency were taken from Key Indicators 2004, Asian Development Bank

In regard to losses, Thailand and Indonesia sustained the most, by far (US$ 1,690 and 1,531 million, respectively); India, Sri Lanka and the Maldives followed behind, in order of decreasing magnitude. A measure of the impact on production that the countries will sustain in the present and next two years is obtained by the losses-to-Gross Domestic Product (GDP) ratios (See table 3.10).

In brief, from the above comparisons it can be stated that the Maldives is the country that will require more efforts in terms of rebuilding the fixed assets that the Indian Ocean disaster destroyed, and that it will sustain a significant set back in terms of production for the present and, possible, the two years following the 2004 tsunami. Second in order of decreasing effect would be Sri Lanka, especially in regard to the intensity of the efforts required for the replacement of fixed assets, although the impact on national production would be relatively low. Indonesia would be the third most affected economy, with special reference to fixed asset replacement efforts.

Table 3.10: Disaster Losses *vis a vis* Gross Domestic Production

	India	Indonesia	Maldives	Sri Lanka	Thailand
Amount of losses, million US$	649	1,531	153	310	1,690
Losses to GDP ratio, %	**0.1**	**0.7**	**21.3**	**1.5**	**1.0**

Source: ADPC

■ **Provincial Level Distribution of Disaster Impact**

The above statements are valid when the situation is considered at the national level only. An analysis made at the State or Provincial level, however, can provide a valuable insight on the more localized disaster impact. The results for such analysis are indicated in table 3.11.

Table 3.11: Total Impact and Magnitude of Disaster by Province (Million US$)

Country and Province	Gross Provincial Domestic Product (GPP)	Damage	Losses	Total Impact	Impact to GPP ratio, %
India					
Andhra Pradesh		30	15	45	0
Kerala	29,800	62	39	101	1
Tamil Nadu	12,145	438	377	815	2
Pondicherry	33,265	45	7	52	4
Indonesia	1,290				
Aceh		2,920	1,531	4,451	97
Maldives	4,589				
Data available for total country only	720	450	153	603	84
Thailand					
Krabi		113	391	504	69
Trang	733	8	54	62	6
Phuket	1,030	219	135	354	68
Phang Nga	520	139	1,062	1,201	90
Ranong	1,333	12	36	48	16
Satun	297	17	14	31	7
Sri Lanka	508				
Data available for total country only	20,200	1,144	310	1,454	8

Source: ADPC

Despite the fact that no breakdown by province is available for Sri Lanka and the Maldives, the information for the other countries is very revealing. A first group of provincial-level territories having very high Impact-to-GPP relations includes Aceh in Indonesia (97%), Phang Nga province in Thailand (90%), the entire Maldives (84%), and Krabi and Phuket in Thailand (68% each). Such high relative magnitude may only be overcome through considerable assistance from the central governments and the international financial community, since the reconstruction and economic recovery requirements are equivalent to nearly the size of their economies. A distinction is to be made about the case of the Phang Nga and Krabi provinces of Thailand that have sustained more economic losses than damage to assets, so that the impact of the disaster will be concentrated on the very significant decline of their production activities. The other three cases (Aceh, Maldives and Phuket) have a different composition of total impact in that they have sustained more damage to assets than production losses.

The Province of Ranong in Thailand stands by itself in a second bracket, with a total impact to GPP ratio of 16%, where economic losses again exceed damage to assets. A third group of provinces follow, that have magnitude ratios between four to eight and include the average for Sri Lanka[16] (where no sufficient information was available to conduct more detailed analyses), the Thailand provinces of Satun, Ranong and Trang, and Pondicherry, a Union Territory of India. Finally, another group composed of the Indian States of Tamil Nadu, Kerala and Andhra Pradesh has Impact-to-GPP ratios below four percent. It is considered that their reconstruction and economic recovery should require efforts that might be within their own internal capacities.

[16] It was unfortunate that the basic information to analyze the provincial or district level impact at Sri Lanka was not available for this analysis. It is estimated that impact-to-GPP ratios there would range between 25 to 80%.

The impact of the disaster on individuals and on families was not analyzed[17], but it was very significant. People lost many of their loved ones, and they sustained destruction or damage to their limited assets, lost income due to the interruption or slowdown of production activities, so that their livelihood is jeopardized since they have very limited recovery capacity by themselves. In any case, estimates have been made of the per capita impact of the disaster in the affected provinces, as shown in table 3.12 below.

Table 3.12
Per Capita Impact of Indian Ocean Disaster in Most Affected Provinces

Country andProvince	Per Capita GDP,US$	Total Impact,US$ million	Per Capita Impact, US$
India			
Andhra Pradesh	378	45	1
Kerala	371	101	3
Tamil Nadu	518	815	13
Pondicherry	1,248	52	50
Indonesia			
Aceh	1,137	4,451	1,102
Maldives			
Data available for total country only	2,271	603	2,058
Thailand			
Krabi	1,879	504	1,292
Trang	1,622	62	98
Phuket	1,826	354	1,243
Phang Nga	5,649	1,201	5,090
Ranong	1,656	48	268
Satun	1,848	31	113
Sri Lanka			
Data available for total country only	1,054	1,454	76

Source: ADPC

The available estimates in *per capita* terms indicate that the people in Phang Nga Province of Thailand (US$ 5,090 per person) sustained the highest impact, followed by the average for the Maldives (US$ 2,058). In third position are the provinces of Krabi and Phuket of Thailand and Aceh in Indonesia, with per capita impact values ranging from US$ 1,100 to 1,300. The per capita impact in the rest of the affected provinces – excepting the case of Sri Lanka, where no data was made available on the impact per province or district – is well below US$ 300. It is to be noted that the distribution of per capita impact does not follow that of total impact per province, as the differences in population and population density play an important role in this issue.

[17] Using the available information on losses of production and sales, and developing labor-to-production ratios for the affected sectors, it is possible to estimate the amounts of employment and income losses. However, this information was not available for all affected countries.

Sectoral Distribution of Impacts

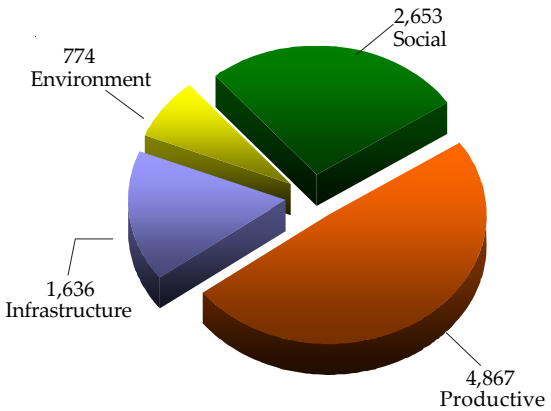
A general overview of the most affected sectors is presented below, followed by a sector-by-sector analysis of impact caused by the disaster.

■ **Distribution of Impact among Main Sectors**

The final impact on the economies of the affected countries depends not only on the amount and spatial distribution of total impact, but on the distribution per sector as well. In addition, this knowledge would provide the means for the proper assignation of priorities and resources in both the reconstruction and the economic recovery programs.

The amount of damage provides an indication of the resources required for the reconstruction program, while the amount of losses yields a target for the design of an economic recovery program for the affected areas. The results of the analysis show that the Indian Ocean disaster concentrated its impact on the productive activities and the social sectors, both of which affect the living conditions of the population (See figure 3.3). This negative impact will prevail until social assets, infrastructure and livelihood are restored. Destruction of physical infrastructure and damage to the environment were of comparably more limited value[18]. (See figure 3.4 and table 3.13).

Figure 3.3
Distribution of Total Impact by Main Sectors
(Million US$ Dollars)



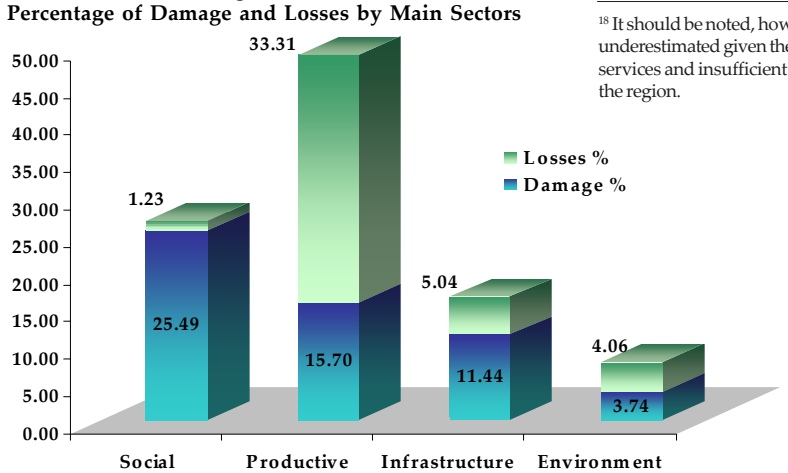
Source: ADPC

Table 3.13:
Breakdown of Damage and Losses by Main Sectors

	Total Impact, million US$		
	Damage	**Losses**	**Total**
Social	2,531	122	2,653
Productive	1,559	3,308	4,867
Infrastructure	1,136	500	1,636
Cross-Sectoral	371	403	774
Total	**5,597**	**4,333**	**9,930**

Source: ADPC

Figure 3.4:
Percentage of Damage and Losses by Main Sectors



[18] It should be noted, however, that damage to the environment was largely underestimated given the present small operating market for environmental services and insufficient valuation of environmental assets that prevails in the region.

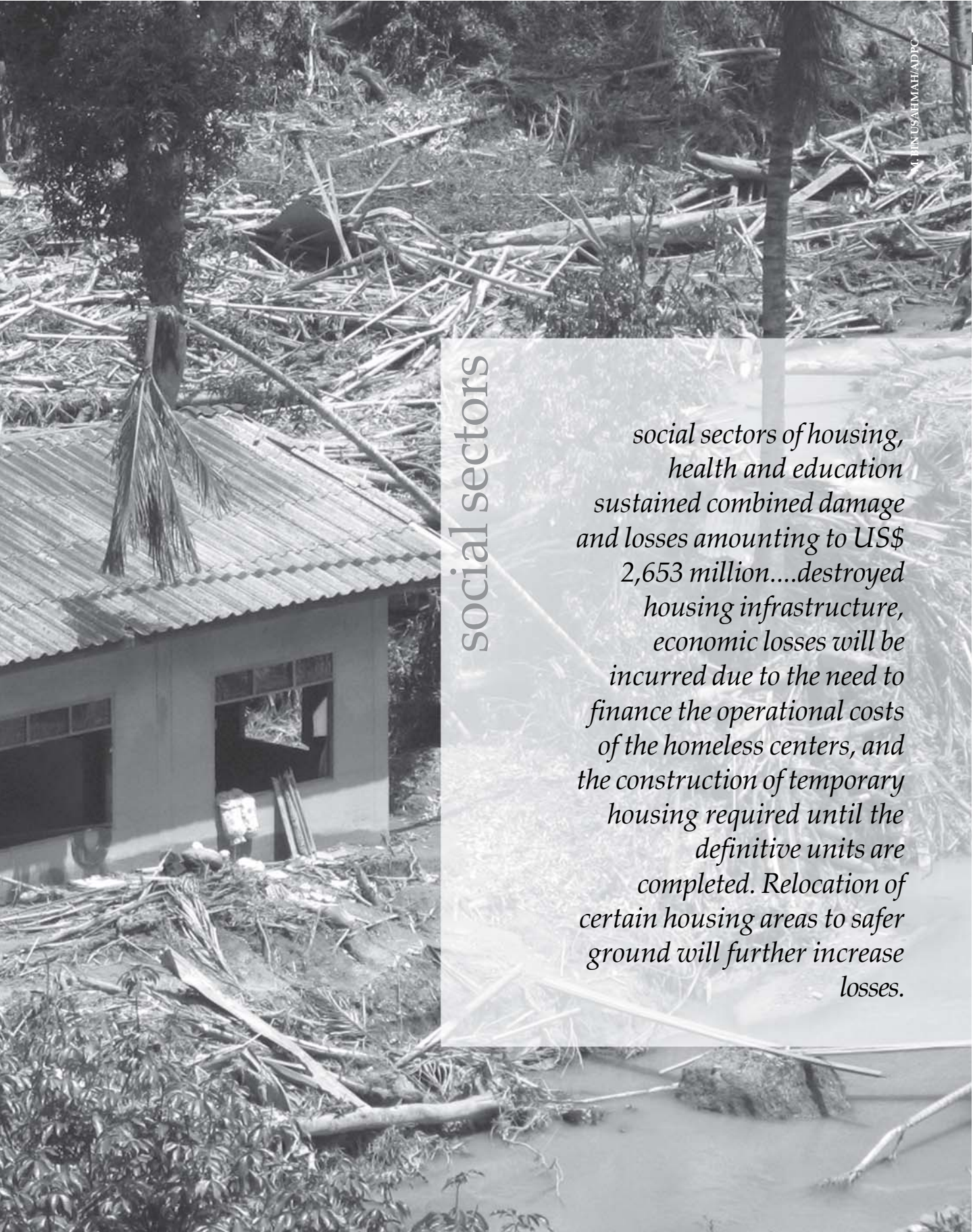
Analysis of Impact on Individual Sectors

Analyses of the impact on each affected sector are described in the following subsections of the report. The summary of damage and losses by sector and country is indicated in table 3.14 below.

Table 3.14: Estimated Damage and Losses Caused by Tsunami in Indian Ocean Region
(million US$)

	Indonesia			India			Sri Lanka			Maldives			Thailand			Region		
	Damage	Losses	Total	Damage	Losses	Total	Damage	Losses	Total	Damage	Losses	Total	Damage	Losses	Total	Damage	Losses	Total
Social Sectors	**1675**	**66**	**1741**	**204**	**48**	**252**	**494**	**5**	**499**	**127**	**0**	**127**	**31**	**3**	**34**	**2531**	**122**	**2653**
Housing	1398	39	1437	193	35	229	412	2	414	94		94	22		22	2120	76	2196
Health	111	9	120	11	13	24	57	3	60	12		12	9	3	12	199	28	227
Education	166	18	184			0	25		25	21		21			0	212	18	230
Productive Sectors	**352**	**830**	**1182**	**265**	**398**	**663**	**367**	**269**	**636**	**125**	**146**	**271**	**450**	**1665**	**2115**	**1559**	**3307**	**4866**
Agriculture	84	141	225	15	22	38	3	4	7	11	1	12	8	2	10	121	170	291
Fisheries	102	409	511	230	338	568	108	114	222	14	6	20	67	100	166	520	967	1487
Industry & Commerce	167	280	447	20	38	58	6	127	133		3	3		93	93	193	541	733
Tourism			0			0	250	24	274	100	136	236	376	1470	1846	726	1630	2355
Infrastructure	**636**	**241**	**876**	**78**	**201**	**279**	**273**	**36**	**309**	**123**		**123**	**27**	**22**	**49**	**1136**	**500**	**1636**
Water Supply	27	3	30			0	31	9	40	45		45	1	3	4	103	16	119
Electricity	68	0	68			0	17		17	5		5	4	10	14	94	10	104
Transport	409	148	558	35	0	36	225	27	252	73		73	7	9	16	749	185	934
Others	132	89	221	43	201	244			0			0	15		15	190	290	480
Cross-Sectoral	**258**	**394**	**652**	**28**	**2**	**30**	**10**	**0**	**10**	**75**	**7**	**82**	**0**	**0**	**0**	**371**	**403**	**774**
Environment	155	394	549			0	10		10	10		10			0	175	394	569
Others	103		103	28	2	30			0	65	7	72			0	196	9	205
Total	**2920**	**1531**	**4452**	**575**	**649**	**1224**	**1144**	**310**	**1454**	**450**	**153**	**602**	**508**	**1690**	**2198**	**5596**	**4332**	**9929**

Source: ADPC



© UN-USAID/MAH/ADPC

social sectors

social sectors of housing, health and education sustained combined damage and losses amounting to US$ 2,653 million....destroyed housing infrastructure, economic losses will be incurred due to the need to finance the operational costs of the homeless centers, and the construction of temporary housing required until the definitive units are completed. Relocation of certain housing areas to safer ground will further increase losses.

Social Sectors

The social sectors of housing, health and education sustained combined damage and losses amounting to US$ 2,653 million. This figure is very significant on its own due to the large amount it entails, and also because it directly impacts negatively on the living conditions of the affected population. This is more so, because the affected persons belong, in general terms, to the lower income strata of the population.

■ **Housing**

The earthquake and the tsunami affected a total of 546,655 housing units located in areas near the seaside, both of the urban and rural type. Of these, 329,722 houses were fully destroyed while 216,933 more sustained damage of varying degrees. Needless to say, household furniture and equipment were also lost or destroyed. In many cases, homes were also used as a base for small-scale income generation activities, and the corresponding equipment and stock of manufactured goods were also lost.

The most important single example of destruction of human settlements was that in the city of Banda Aceh. There, the earthquake directly destroyed many homes and large buildings, the tsunami introduced further destruction, and there was even some land subsidence that now prevents reconstruction of houses and buildings in certain areas.

This caused the large flow of homeless persons that were housed in temporary camps, as described in the section on human impact. Since the number of houses to be reconstructed is so large, a minimum period of 2 to 3 years will be required for completion of the new housing units. Sadly, in the case of Indonesia the housing reconstruction program will involve a lower number of homes than were actually destroyed, in view of the high number of deaths caused by the disaster.

It should be emphasized that, in addition to the destroyed housing infrastructure, economic losses will be incurred due to the need to finance the operational costs of the homeless centers, and the construction of temporary housing required until the definitive units are completed. Furthermore, relocation of certain housing areas to safer ground will further increase losses.

The total impact of the disaster on the housing sector is estimated at US$ 2,196 million, of which 2,120 million represent the replacement value of homes and their contents and the remaining 76 million are losses. This makes housing the second most affected individual sector in this disaster.

■ **Health**

A total of 100 health centers and hospitals were fully destroyed or partially affected; they are located in the coastal areas where the waves of the tsunami entered, as well as in the zones of Aceh and North Sumatra that were affected directly by the earthquake. In addition to the buildings, furniture and medical equipment as well as medicines were damaged or rendered useless by the saltwater.

The demand for medical attention of the injured persons, at times and in some places, exceeded the capacity of the medical services, which was especially true in the case of major cities (such as Banda Aceh) that sustained major impacts. In addition, many survivors required and continue to require psychological attention for a relatively long period of time. Sector authorities devoted special efforts to provide adequate health care for the homeless that were in the temporary shelter camps, and undertook vaccination and other public health prevention campaigns. The control of vectors also received priority attention. No major epidemics occurred in the camps.

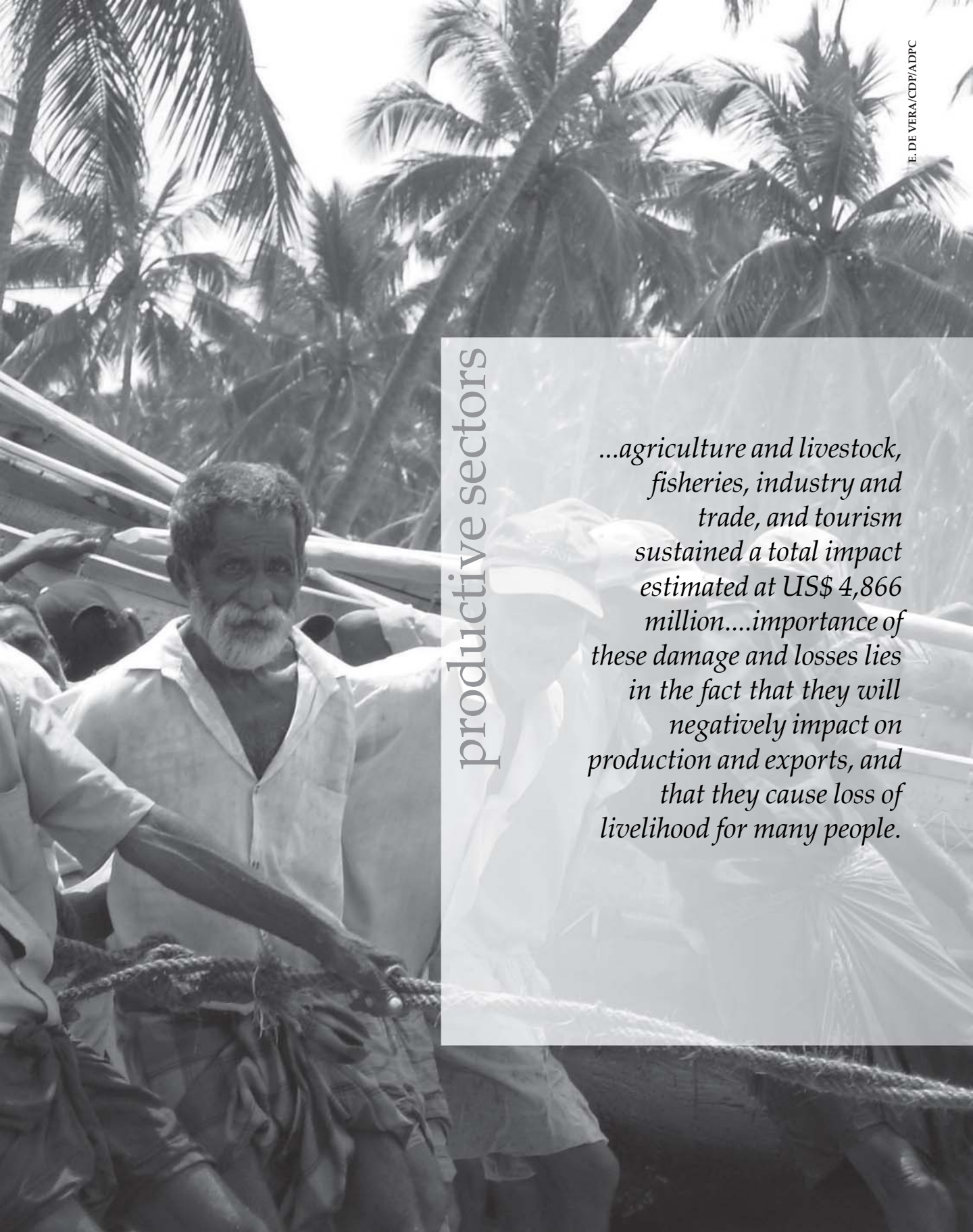
A total impact of US$ 227 million was estimated for the health sector in the affected countries. Of this, damage was estimated as 199 million and losses at 28 million.

■ **Education**

In the education sector, schools, equipment, furniture and education materials were destroyed or damaged. Classes were suspended for different periods of time, depending on the severity of damage and on the temporary use of school buildings for shelter of homeless people. The death of many teachers imposed a heavy loss to the sector. As a result, children spent more time at home and their mother's workload correspondingly increased. The latter issue points to a socially and strategically important non-qualified impact represented by the gender-related differential impact which has not been evaluated due to the lack of ex-specific, quantitative information.

There also occurred damage to some cultural heritage buildings and to sports facilities, whose replacement or restoration is very difficult and costly.

It is estimated that the total impact to this sector amounts to US$ 230 million, a similar figure to that of the health sector above. Damage was estimated at 212 million; losses at 18 million.



E. DE VERA/CDP/ADPC

productive sectors

...agriculture and livestock, fisheries, industry and trade, and tourism sustained a total impact estimated at US$ 4,866 million....importance of these damage and losses lies in the fact that they will negatively impact on production and exports, and that they cause loss of livelihood for many people.

Productive Sectors

Agriculture and livestock, fisheries, industry and trade, and tourism were significantly affected in their assets and especially in their production and sales. The combined total impact for these sectors was estimated at US$ 4,866 million. The importance of these damage and losses lies in the fact that they will negatively impact on production and exports, and that they cause loss of livelihood for many people.

■ **Agriculture and Livestock**

The earthquake caused structural damage to agricultural infrastructure in irrigation and drainage systems in Indonesia, while the waves of the tsunami destroyed the standing food crops grown in coastal areas (44,256 hectares) and in some cases uprooted the trees of some permanent crops in the entire region. It is to be noted that the main crop of rice and other products was precisely standing at near maturity when the disaster occurred; so that most of the seasonal production was lost. Furthermore, the deposit of salt water into the soils of agricultural lands located adjacent to the coastal areas will prevent the future growth of some salt-sensitive crops, or reduce their yield, until natural leaching of the salts occur through rain and drainage.

Rice, maize, vegetables, fruits and oil and coconut palms were the most commonly affected crops. In Sri Lanka, in addition to the extensive agricultural practices affected, a relatively large number of small family plots for self-production were destroyed by the tsunami. Part of the oil palm plantations in Thailand will have to be replanted in order to replace the uprooted trees, and no production can be expected until the new trees reach maturity after a minimum of two years.

In addition, it is estimated that nearly 2.7 million domestic animals – including laying and broiler poultry as well as cattle – died as a result of the tsunami.

The total estimated impact of the disaster on the sector amounts to US$ 291 million. Of this, 170 million (nearly 60%) represent production losses in the present and following years, and the rest is the replacement value of plantations and some infrastructure of the sector.

■ **Fisheries**

This sector, which provides the livelihood for many people living in the coastal areas and which also produces fish on a commercial scale, was severely affected.

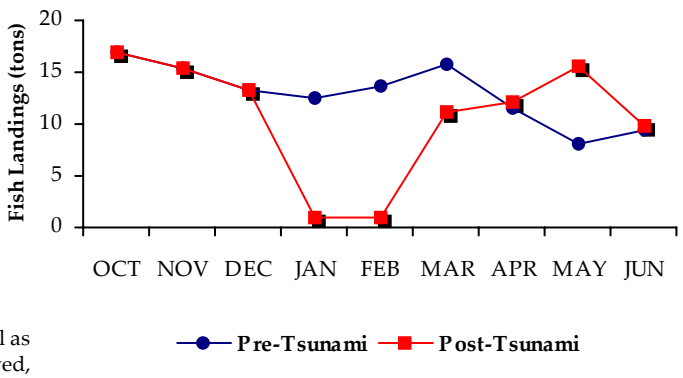
Boats (118,000 artisan and commercial units) and fishing equipment and gear, aquaculture facilities, as well as docking and landing facilities and equipment were destroyed, damaged or sunk.

In some coastal areas, the action of the tsunami destroyed the habitat of fish – the sea grass, mangrove forests and coral reefs – and it is now more difficult for fishermen to find adequate catches of different fish species, since they have migrated to find food. This combines with the fact that many artisan fisher folk do not have the capacity to operate in open seas or to travel large distances in their old boats. The above situation, combined with the significantly reduced boat fleet, has resulted in a decreased volume of fish capture since the disaster occurred and which will extend beyond the present year in some cases, with the corresponding negative impact on the livelihoods of fishermen and on commercial fisheries. Until new boats can be purchased or until damaged or sunk boats can be repaired and put back into operation, this decline in fish capture will continue. The same is true of aquaculture production, since its cages and ponds must be repaired or replaced.

By mid-year, however, fishery operations in the Maldives had not only recovered pre-disaster levels but were already exceeding the usual catch for the season, a situation that was entirely different from the other affected countries (See figure 3.5). It is believed that this speedy recovery was due to the high resilience of the sector in the islands and to the incentive of higher international prices of tuna fish.

The fisheries sector sustained a high total impact of US$ 1,487 million, of which 967 million (65%) represents loss of catch for 2005, and the remaining 520 million is the replacement value of the boat fleet and ancillary equipment and gear. It is to be noted that the total impact on this sector is the third in the region, after tourism and housing; when losses in production are considered, however, fishery is the second most affected, surpassed only by tourism.

Figure 3.5
Post-Tsunami Recovery of Fish Landings in the Maldives



Source: Economic Research and Statistics Division, Maldives Monetary Authority

Industry and Commerce

A limited number of fish and food processing industries, as well as a large number (more than 100,000) of small and medium sized commercial establishments were damaged by the earthquake and tsunami, and lost their stocks and inventories.

Production in these sectors will be reduced due to two factors. First, because of the stoppage of processing and sales, respectively, over the time period required for repairs or reconstruction of their buildings and equipment. And, second, because they have less inputs for processing and selling as a result of the production losses in agriculture and fishery.

In two of the previous assessments conducted in the countries, these private sector losses had not been fully considered. The present analysis does include them, as losses in the forward links of production. They have proved to be significant, especially since – again – they cause to reductions in GDP and in the livelihood of many persons.

It has been estimated that the total impact of the disaster on these good-producing sectors is US$ 734 million, of which 541 million represent production and sales losses, the third highest loss below tourism and fishery.

Tourism

The tsunami imposed heavy destruction and damage to hotels and resorts and to other tourism-related commercial establishments and their related equipment and furnishings in Thailand, Sri Lanka and the Maldives.

The bed capacity of the sector was significantly reduced. However, the most important impact on the sector was the immediate and drastic reduction of tourist arrivals, especially from abroad. This was caused by the information in regard to the disaster that was carried live by the international media, especially through television, that almost instantaneously reached the main markets for tourists that normally come to this region. It must be stressed that the disaster occurred during the peak season in most of the countries, as shown below.

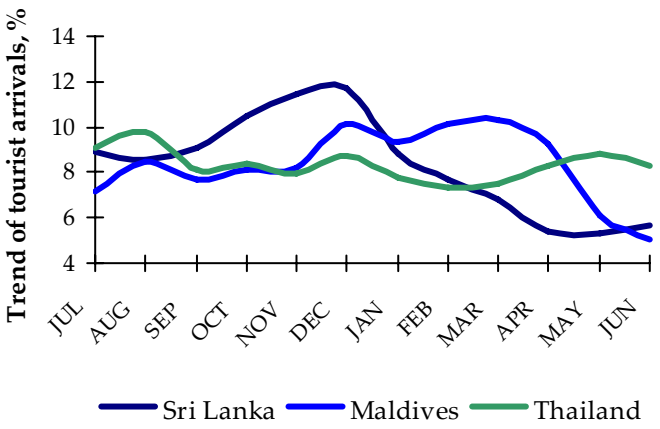
While reconstruction is underway, although with some problems related to reimbursement of insurance and construction limitations, recovery of tourism sales from foreign nationals has been slower than initially envisaged and most of the main tourism season of the year has already gone by. Losses in revenues for the sector have been accumulating and, with one exception, will be higher than estimated at the beginning of this year.

The degree and rate of recovery in the three countries that were affected in the tourism sector is different (See figure 3.6). In Thailand, bed capacity recovery is proceeding relatively well, but international tourism recovery to the disaster-affected provinces has not continued in the same accelerated trend of the first quarter of the year; it is now expected that full recovery will not be forthcoming until next year. In the Maldives, delays in receiving insurance reimbursements are slowing rehabilitation of the affected hotels, and losses in revenue are expected to be higher than initial estimates indicated. In Sri Lanka, the decline in tourism was significant during January and February, but revenues have steadily recovered since then and are now above the previous year figures (See figure 3.7). This recovery is due to the increasing volume of tourists from Asian countries that has compensated the decreasing absence of European tourist arrivals, even though their length of stay in the country is slightly shorter.

The total impact of the Indian Ocean disaster on tourism has been estimated as US$ 2,356 million, making this sector the one most affected in the region, despite the fact that it only affected three countries. Of that amount, US$ 726 million consists of damage to sector infrastructure (31% of the total) and US$ 1,630 million are the losses of revenue that are expected to occur until full recovery is achieved.

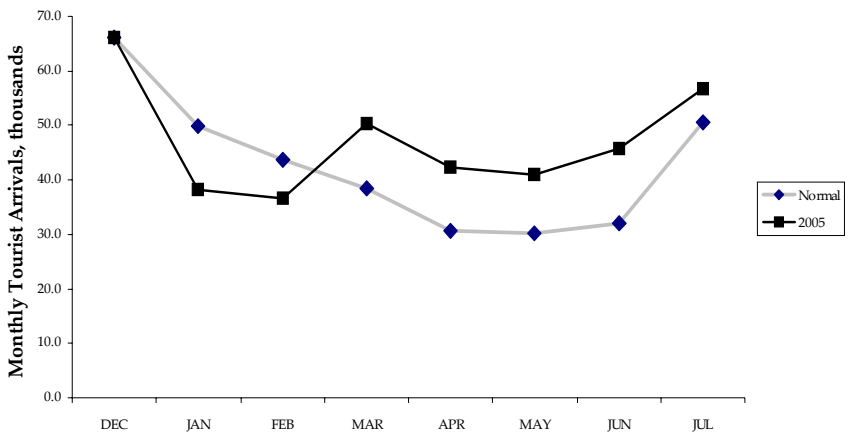
It should be pointed out that a sizable fraction of damage to assets was covered by insurance, and a smaller proportion of losses was similarly insured. Nevertheless, the negative impact on the sector is very significant. Worse still is the impact on the people who were employed by or related to the sector, as their income has been either lost or reduced significantly. Furthermore, the losses of tourism revenues will have a negative impact on the gross domestic product of the affected provinces and countries, the degree of which is higher in the smaller economies and in those where tourism plays a greater role in GDP, such as in the entire Maldives Republic and in some provinces of Thailand. In fact, reductions in GDP caused by the disaster have tourism impact as the main culprit.

Figure 3.6:
Seasonality of International Tourist Arrivals in Maldives, Sri Lanka and Thailand



Source: Respective National Tourism Authorities

Figure 3.7:
Post-Tsunami Recovery of Tourism Arrivals in Sri Lanka



Source: Sri Lanka Tourism Board

EJ ABO/ ADPC

infrastructure sectors

...the damage on roads, railroad and air travel subsectors, water supply and sanitation, electrical systems, drainage and flood control works and other physical assets, result in direct losses of revenue and increased costs

Infrastructure Sectors

Destruction and damage to infrastructure by the action of the earthquake and the tsunami was extensive along the coastal areas. It involved the road, railroad and air travel subsectors, water supply and sanitation, electrical systems, drainage and flood control works and other physical infrastructure. The total impact sustained by these sectors amounts to US$ 1,636 million, of which 1,136 million (69%) refer to physical assets and 500 million (31%) to losses of revenue and increased operational costs.

■ Water Supply and Sanitation

Water supply systems in both urban and rural areas were badly affected. A total of 7,835 urban systems and more than 122,449 wells in rural areas were affected, destroyed or contaminated with salt water. The electrical equipment required for the operation of pumps and other equipment were saturated with salt water and rendered useless. In addition, more than 38,600 latrines and septic tanks were destroyed in the rural areas, some of which overflowed discharging its contents in the surrounding areas, thus posing an additional health hazard to its users. In low lying coastal areas, especially in the case of the Maldives islands, seawater has further reduced existing fresh groundwater aquifer lenses. Alternative water sources will have to be tapped, repairing and expanding rainwater collection schemes and introducing seawater desalination plants, in spite of their high operational cost. Water supply and sanitary latrines were hurriedly built to provide minimum service to the temporary camps where many homeless people were concentrated after the disaster. Previous to that, drinking water was provided in plastic containers and bags, which involved very high delivery and distribution costs.

The total amount of impact for the sector has been estimated as US$ 119 million, of which 103 million are damage to the physical plant and 16 million are lower revenues and higher operational costs to the water and sanitation enterprises.

■ Electricity

No power plants were damaged by the disaster, but more than 162,000 individual electricity distribution systems and many more electrical substations were directly affected. Electrical poles and lines were brought down by the waves and the salt water induced corrosion in electrical and electronic components. The flow of electricity was interrupted to many cities, towns and tourism resort areas, and was slowly restored by the electric utilities.The electrical companies are also sustaining revenue losses due to the decreased demand arising from the absence of tourists and of persons that have been accommodated in temporary shelters, in addition to the foregone revenue of the days immediately following the disaster when no power was distributed to even larger segments of the electrical market. Moreover, some electrical utilities have incurred unexpected high costs for energy generation. These losses will continue to occur until full recovery is achieved in the tourism sector and when reconstruction of houses is completed, a period that will extend through 2006. The total impact on the electrical sector has been estimated as US$ 104 million, of which 94 million are damage to assets and 10 million more are losses in revenue.

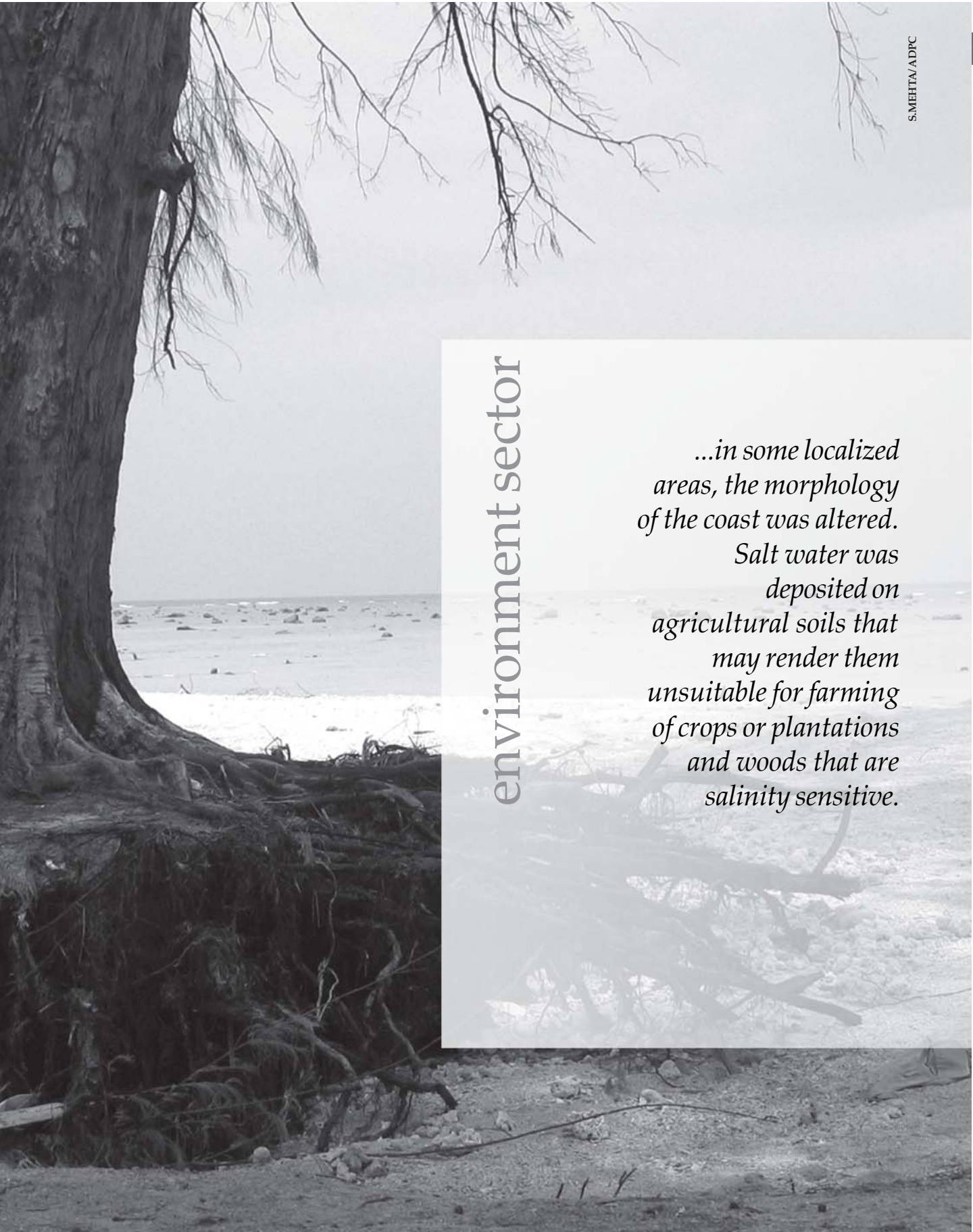
■ Transport Sector

The combined action of the earthquake and the tsunami inflicted heavy damage and destruction to assets in the transport and communications sector, including most of its components: road transport, railroad transport, water transportation including docks, air transport and telecommunications, as well as related drainage works.

In the case of road transport, several thousand kilometers of main, secondary and tertiary roads and nearly 490 bridges were damaged to a varying extent. In Indonesia the earthquake fractured many kilometers of road and the foundations of bridges that were later on carried away by the action of the tsunami. In other countries, the waves of the tsunami destroyed or eroded the roads, and destroyed bridges and culverts. More than 30,000 vehicles were destroyed or were subsequently rendered useless by corrosion from saltwater. Traffic was interrupted at river crossings and was diverted to longer or lower quality alternative roads, with the corresponding higher transport costs. In some cases, the cargo of perishable goods was lost due to the inability to reach markets in time. In other cases, producers resorted to the utilization of higher cost air transport options, thereby increasing the final price of the products. Similar effects occurred in railroad transport in Sri Lanka and India. In addition to the destruction or damage of railways and bridges, many trains were derailed and rolling stock was damaged. Traffic was interrupted. The railways sustained revenue losses while repairs were being made. Docking and port facilities used to facilitate water transport of cargo and persons, especially in Thailand and the Maldives, were destroyed or damaged. Until they were replaced or repaired, transport costs increased. In regard to air transport, a total of five airports located in Indonesia and the Maldives were affected either by the earthquake or by the tsunami. In Thailand, several airports are sustaining revenue losses due to the significant drop in tourist arrivals and in the services rendered to the airlines. Considering all these subsectors and components, total impact of the disaster on the transport sector was estimated at US$ 934 million, of which 749 million were damage to assets and 185 million were losses in revenue and increased operational costs.

■ Other Infrastructure

In addition, other infrastructure sustained significant damage that generated economic losses. These include drainage and flood control works, fixed line telecommunication systems, and general-purpose buildings located in coastal areas. Damage to these assets generated losses of revenue and increased operational costs. The total impact to these infrastructure works was estimated as US$ 480 million, broken down into 190 million in damage to assets and 290 in operational losses.



S.MEHTA/ADPC

environment sector

...in some localized areas, the morphology of the coast was altered. Salt water was deposited on agricultural soils that may render them unsuitable for farming of crops or plantations and woods that are salinity sensitive.

Environment Sector

The disaster caused extensive damage to environmental assets and to the services they render. The combined action of the earthquake and the tsunami impacted on the coastal area's natural and built natural resources. The earthquake was so strong that it caused subsidence in urban and rural areas of Indonesia's northwest coast located nearest to the epicenter of the earthquake, causing the loss of valuable lands. The waves of the tsunami destroyed or damaged the sea grass, coral reefs, and mangrove forests. Urban and rural lands, including beaches, were eroded. In some localized areas the morphology of the coast was altered. Salt water was deposited on agricultural soils that may render them unsuitable for farming of crops or plantations and woods that are salinity sensitive.

In so doing, the tsunami damaged the very sensitive habitat for fish and other marine species, which temporarily migrated, causing a further reduction in catch or increased costs in the landing of these products, as well as losses in their processing and marketing. Damage to coral reefs and to beaches has had a similar negative impact on tourism.

As indicated in the agricultural sector, the direct action of the tsunami waves destroyed the standing agricultural crop in coastal areas. The deposition of salts and its saltwater in soils will result in the impossibility of cultivating salinity resistant crops or at least in the reduction of agricultural yields until natural leaching occurs.

The damage from salinity to forest coastal areas will also have a negative effect on the amount of hydrocarbon reduction, as well as an impact on tourism.

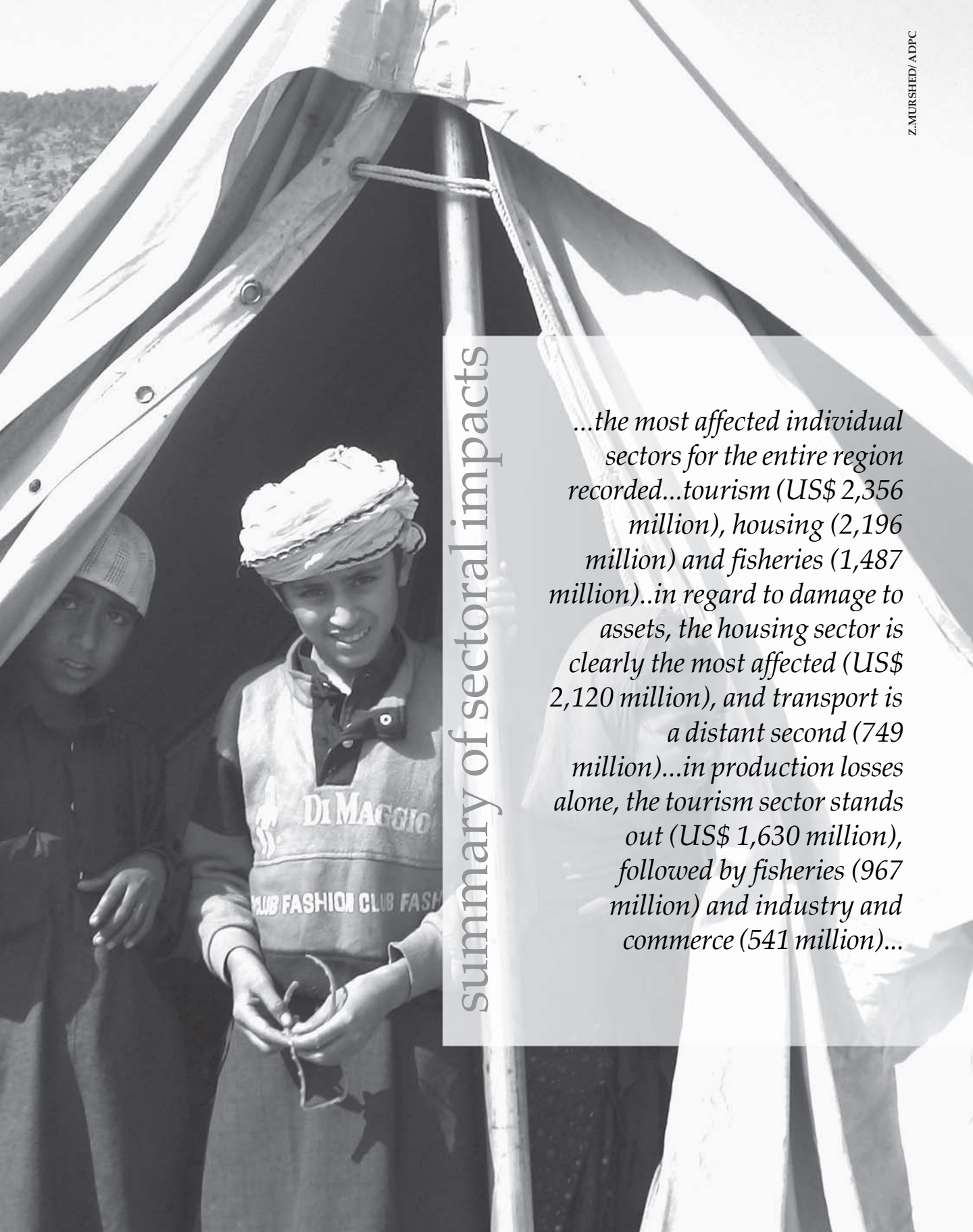
In some low lying coastal areas and islands the already precarious balance between fresh groundwater aquifers and lenses was broken, and saltwater has encroached into those scarce resources, rendering water supply for human consumption more expensive. In addition, open water wells, latrines and septic tanks were flooded with saltwater and destroyed. There exists the danger of contamination of groundwater with septic material.

The loss of lands to subsidence and erosion has a direct bearing on the human settlement sector as well as on agricultural production in the future. In addition the deposition of large amounts of debris caused by the destruction of natural and built physical assets has brought about a serious problem of removal and final disposal in both urban and rural areas.

The full valuation of these impacts in terms of destroyed assets and investments required for the restitution of environmental quality to pre-disaster levels and of the losses in environmental services was not undertaken in most cases. Only in the case of Indonesia was there sufficient quantitative information to undertake an assessment of impact to the environment. However, adding some partial information from other countries the estimated impact of the disaster on the environment was in the order of US$ 569 million.

■ Other Impacts

The disaster also caused other cross-sectoral damage and losses. They include damage to government buildings and losses of related services, as well as – in several cases – the estimated expense of relief and humanitarian assistance that was disbursed from official domestic sources.



Z.MURSHED/ ADPC

summary of sectoral impacts

...the most affected individual sectors for the entire region recorded...tourism (US$ 2,356 million), housing (2,196 million) and fisheries (1,487 million)..in regard to damage to assets, the housing sector is clearly the most affected (US$ 2,120 million), and transport is a distant second (749 million)...in production losses alone, the tourism sector stands out (US$ 1,630 million), followed by fisheries (967 million) and industry and commerce (541 million)...

Summary of Sectoral Impacts

A summary of total impact reveals that, by far, the most affected individual sectors for the entire region were those of – in order of decreasing magnitude – tourism (US$ 2,356 million), housing (2,196 million) and fisheries (1,487 million). In regard to damage to assets, the housing sector is clearly the most affected (US$ 2,120 million), and transport is a distant second (749 million). In regard to production losses alone, the tourism sector stands out (US$ 1,630 million), followed by fisheries (967 million) and industry and commerce (541 million). The breakdown of these results on individual sectors is given in table 3.15 below.

These impacts amount to US$ 205 million for the entire region and do not include the value of international assistance.

Table 3.15: Summary of Impact of Indian Ocean Disaster by Sectors *(Million US$)*

Sectors	Damage	Losses	Total Impact
Social Sectors	**2,531**	**122**	**2,653**
Housing	2,120	76	2,196
Health	199	28	227
Education	212	18	230
Productive Sectors	**1,559**	**3,308**	**4,867**
Agriculture and livestock	121	170	291
Fisheries	520	967	1,487
Industry and Commerce	193	541	734
Tourism	726	1,630	2,356
Infrastructure	**1,136**	**500**	**1,636**
Water and Sanitation	103	16	119
Electricity	94	10	104
Transport	749	185	934
Others	190	290	480
Cross-Sectoral	**371**	**403**	**774**
Environment	175	394	569
Government Administration	196	9	205
Total	**5,597**	**4,333**	**9,930**

Source: ADPC

Impact on Economic Performance

The post-disaster impact on economic performance of the countries may be estimated on the basis of the previously described sectoral losses, in combination with projections of reconstruction progress in the replacement of destroyed or damaged assets.

It has been estimated that there will be no measurable impact on national economic growth in India since the coastal areas that were affected by the tsunami have very little weight in the overall economic activity of the country. A similar situation should occur in the case of Indonesia due to the fact that the earthquake and tsunami spared the main production activities related to the oil industry that are in the Province of Aceh; nevertheless, a reduction of 0.2% in the projected rate of economic growth would occur. In Thailand, the losses sustained by the provinces affected by the tsunami represent only a small percentage of the country's production, which would lead to an estimated reduction of 0.3% in GDP growth. The impact on Sri Lanka's economy should be slightly higher, since the losses were spread out in a larger fraction of the country, so that a 0.6% reduction in GDP growth would be expected. Lastly, the most important negative impact of the tsunami on economic performance would occur in the Maldives, where the losses in tourism have been high and recovery is being slow, in combination with slow rates of reconstruction and recovery (See table 3.16).

In brief, with the exception of the Maldives–whose economic vulnerability is higher than that of the other countries – the impact of the disaster on economic growth rates will be limited this year. Once reconstruction and economic recovery programs attain full speed, economic growth rates should return to pre-disaster levels.

It must be emphasized that the estimated growth rates shown in table 3.16 are the ones that would be achieved considering only the shock caused by the disaster. However, other non-disaster related factors, such as rising international oil prices may have greater negative impacts, and the economic growth rates that are finally achieved at the end of the present year would be different than the projections based on the effects of the disaster alone.

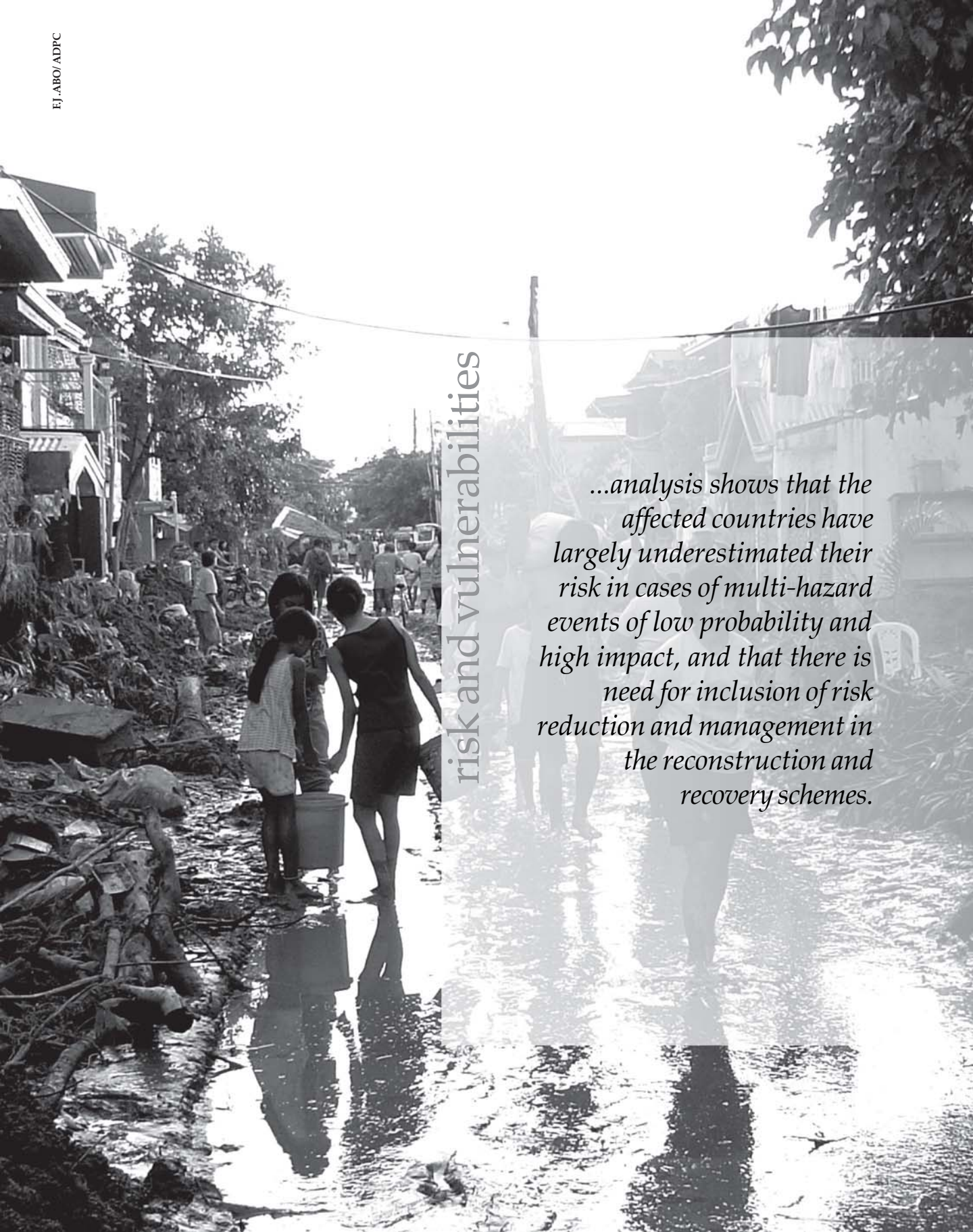
Finally, sufficient information was not available in order to attempt estimations of the impact of the disaster on the foreign sector or the fiscal budget for the five countries. However, it is anticipated that the external accounts would be affected due to declines in the export of affected products and to the need to import construction equipment and materials from abroad. In addition, the fiscal budget would be impacted negatively by the decline in tax revenues arising from reduced economic activity and by tax exemptions made to disaster-related activities, as well as by high and unexpected current expenditures involved in post-disaster rehabilitation and compensation programs set in place.

Similarly, no sufficient information was available to analyze the impact of the disaster on the evolution of prices and inflation rates. It is recognized, however, that the smaller the economy, the higher that inflation impact may be after disasters, and also that local increased price bubbles may have occurred.

Table 3.16:
Estimated Impact of Indian Ocean Disaster on Economic Growth

	India	Indonesia	Maldives	Sri Lanka	Thailand
Pre-Disaster forecasted GDP Growth, %	7.2	5.4	7.5	6.0	6.0
Estimated reduction in GDP Growth rate due to the disaster, %	..	**- 0.2**	**- 9.2**	**- 0.6**	**- 0.3**

Source: ADPC



E.J. ABO/ ADPC

risk and vulnerabilities

...analysis shows that the affected countries have largely underestimated their risk in cases of multi-hazard events of low probability and high impact, and that there is need for inclusion of risk reduction and management in the reconstruction and recovery schemes.

IV. Risk and Vulnerabilities

The 26 December 2004 Earthquake and Indian Ocean Tsunami brought to light existing vulnerabilities in the afflicted countries. The preceding estimation of disaster impact enables the identification of such vulnerabilities and the quantification of risk in the social, economic and environmental conditions of the affected countries as well as of institutional weaknesses in relation to disaster and risk management. The analysis shows that the affected countries have largely underestimated their risk in cases of multi-hazard events of low probability and high impact, and that there is need for inclusion of risk reduction and management in the reconstruction and recovery schemes.

In that regard, the value of total disaster impact represents the risk that results from combining the occurrence of the earthquake and tsunami and the prevailing vulnerabilities in the region.

It must be stated at the outset that in large impact disasters such as this one, which seems to have a relatively low probability of occurrence, the governments and the private sector share risk. The governments are expected to take care of public assets and the welfare of the citizenry, especially those in the lower income groups; the private sector is largely expected to take care of its damage and losses.

A description of vulnerabilities and estimation of risk – grouped under the headings of economic, financial, productive, physical and social – are included in this chapter, with a view to their consideration in the eventual design of a comprehensive risk management strategy.

A. ECONOMIC VULNERABILITIES AND RISK

The Indian Ocean disaster has brought to light the vulnerability of the countries' economies to this type of events. The human toll and the total economic impact (US$ 9,930 million) makes this disaster one of the most destructive world events in recent times, and certainly in the Asian region. The destruction of physical assets has been of significance in terms of its replacement value (US$ 5,597 million). The losses in economic flows arising from the damage (US$ 4,333 million), combined with the relatively slow reconstruction and recovery rates, are causing a not-negligible reduction in economic performance.

Economic risk in the affected countries is related to the value of damage and losses and to the size and diversification of the countries' economies. In general terms, the larger the size of the economy the lower reduction in economic performance arising from the disaster: the largest economy, India, will have a nearly zero impact on economic growth; the smallest economy of the Maldives will sustain the largest decrease in its expected pre-disaster economic growth (See table 4.1).

Another expression of economic risk and vulnerability is the degree of exposure of physical assets in the affected areas, and can be illustrated by the amount of damage caused by the disaster (US$ 5.6 billion). There seems to exist a correlation between the length of coastal area exposed to the tsunami and the concentration of invested capital in physical assets. The highest amount of damage was

Table 4.1:
Comparison of Size of the Economy and Economic Impact of Disaster in the Indian Ocean Region

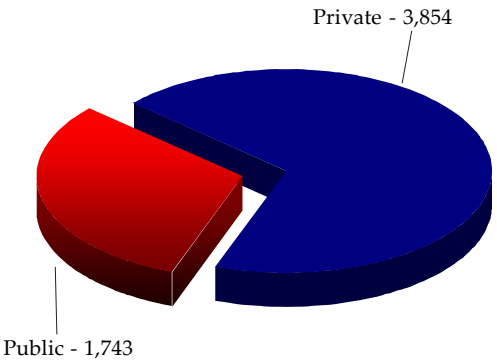
Country	GDP in 2004 US$ million	Total Impact vs GDP, %	Growth Rate Reduction, %
India	642,000	0.2	—
Indonesia	218,900	2.0	-0.2
Thailand	163,200	1.4	-0.3
Sri Lanka	20,200	7.6	-0.6
Maldives	720	83.6	-9.2

Source: ADPC

sustained by Indonesia and Sri Lanka, followed distantly by the other three countries; Indonesia having been affected by both the major earthquake and by the action of the tsunami. Most affected were assets in the sectors of housing and human settlements, transport (specially road and railroad transport), fisheries and tourism infrastructure, which are located in the coastal areas. This is illustrated in table 4.2 where the total value of damage is given for each country as well as for the most affected sectors.

An important issue to take into consideration as a risk factor is that of ownership of economic impact and risk between the private and public sectors. The value of destroyed assets is much higher for the private sector by a ratio of 7-to-3, as shown in figure 4.1. Nevertheless, since about 35% of the total amount of damage to assets refers to the housing sector, where there is a high concentration in housing belonging to the lower income strata of the population, the government's participation in this risk should be higher due to the need to compensate or to provide soft financing to the affected population.

Figure 4.1:
Ownership of Damage to Assets, between Public and Private Sectors (Million US$)



The value of losses provides an additional clear view of the economic risk in the affected countries, due to the exposure of production activities in the coastal areas where the disaster occurred. In that respect, Thailand and Indonesia show the highest economic risk (US$ 1,690 and 1,531 million respectively), followed by India (649 million), Sri Lanka (310 million) and the Maldives (153 million). There are significant differences among the countries in terms of their economic risk, though. The high values in Thailand and in the Maldives are due to the vulnerability of the tourism sector. Losses were more diversified in Indonesia and Sri Lanka, with a heavy concentration on fisheries and the agro-based industry and commerce. And India's losses were concentrated mainly on fishery activities. Table 4.3 below shows the value of economic losses for the countries and for the most affected sectors.

Table 4.2:
Value of Damage to Assets, by Country and by Most Affected Sectors
(Million US$)

	Total Value of Damage	Housing	Transport	Fisheries	Tourism
Indonesia	**2,920**	1,398	409	102	—
Sri Lanka	**1.144**	412	225	108	250
India	**575**	193	35	230	—
Thailand	**508**	22	7	67	376
Maldives	**450**	94	73	14	100
Region	**5,597**	**2,120**	**749**	**521**	**726**

Source: ADPC

Table 4.3:
Value of Economic Losses, by Country and by Most Affected Sectors
(Million US$)

	Total Value of Losses	Tourism	Fisheries	Agro-based Industry and Commerce
Indonesia	**1,690**	**1,470**	**100**	**93**
Sri Lanka	**1,531**	**—**	**409**	**280**
India	**649**	**—**	**338**	**38**
Thailand	**310**	**24**	**114**	**127**
Maldives	**153**	**136**	**6**	**3**
Region	**4,333**	**1,630**	**967**	**541**

Source: ADPC

A last point to be stressed is the additional economic vulnerability that results from the concentration of production activities in a limited number of sectors, which increases the exposure to disasters. In that respect, the case of the Maldives – with a heavy dependency on disaster vulnerable sectors of tourism and fishery – and of some provinces in Thailand, should deserve special attention

B. FINANCIAL RISK

In view of the low probability of recurrence and resulting high impact of the Indian Ocean disaster, the level of financial risk for the countries is very high. This risk is borne by the governments and the private sector, with limited risk transfer mechanisms in place.

The governments bear several types of financial risks. On one hand, they have no *ex ante* financial instruments and provisions for meeting the financial requirements arising from this type and magnitude of disaster. These requirements go beyond and above the replacement value of public assets (estimated at US$ 1.7 billion), since direct compensation to individuals and soft-term financing to small and medium size entrepreneurs must be provided.

On the other hand, governments face increasing fiscal problems in view of lower revenues (due to decline in taxes from lower economic activity and to selected tax exemptions) and of unexpected relief and immediate rehabilitation and compensation expenditures. Then too, governments face additional financial pressures arising from the operational results of sectoral public enterprises that are now incurring into higher costs and receiving lower revenues in the provision of basic services, such as health, education, water and sanitation, electricity and transport. In addition, mitigation projects to reduce the significant exposure to multi-hazard conditions of the countries will require considerable investments that will have to largely depend on government resources.

As a result, *ex post* measures of external borrowing and loan conversions, drawing from international reserves, internal reallocation and increased transfer from regular budget resources must be adopted to meet post-disaster reconstruction and recovery. This results in a high opportunity cost to normal social and economic development, since the funds required to replace destroyed assets, at higher unit values than their original cost, now become unavailable for the originally intended and much needed programmed development activities. In addition, the capacity of the governments to undertake development becomes more limited as their fiscal position becomes compromised.

The financial risk in the private sector is no less important (US$ 7.6 billion) although it is qualitatively different. The large entrepreneurs – and the medium sized enterprises to a limited extent as well – do have some *ex ante* arrangements for financial risk transfer, through insurance of assets and revenues. Experience in this disaster has shown, however, that there were varying degrees of underinsurance of assets and that not all revenue losses were duly covered. The latter is certainly true of agriculture and fishery production and of small-scale commercial shops that have little or no insurance coverage. In addition, perhaps due to the unprecedented scale of this disaster, the exemption clauses in the insurance contracts and the lengthy claim procedures and discussions have caused delays in the actual delivery of insurance reimbursements, with a corresponding negative impact on the recovery of insured activities and in the expected performance of commercial operations.

To the above problem of underinsurance must be added the fact that affected individuals and micro and small-scale enterprises usually do not have insurance coverage at all. Replacement of destroyed assets and re-initiation of productive activities depend largely on compensation and availability of soft-term financing from the governments. Furthermore, the rates of government compensation are often insufficient so that income loss is usually high for these individuals. When that occurs, they often resort to private lenders to obtain funding, at very high interest rates.

The availability of informal social networks and self-help groupings – such as women in some fishing and rural communities – should be made use of as a tool for financial risk management at the local level.

C. PRODUCTION VULNERABILITIES AND RISK

With the benefits of hindsight and the results of this analysis, it can be said that the productive sectors of the five countries have significant vulnerabilities in both their physical assets and production that derive from their location in the affected coastal areas. The very high damage and losses (US$ 4.9 billion) they sustained is a reflection of this.

Asset vulnerability and risk – especially those belonging to the tourism and fisheries sector – derived from deficiencies in their original physical planning that did not take into consideration the probability of multi-hazard occurrence in coastal areas.

Production risk arises from the location of assets and from sector-specific vulnerabilities. In the tourism sector, the demand is very sensitive and vulnerable to the occurrence of external shocks such as the tsunami and health hazards (such as the recent cases of SARS and avian flu), which have resulted in a very high amount of losses. Few, if any, preventive and mitigation measures had been introduced to protect assets and production in the aquaculture and inland fishery sector, which by nature are located in low lying areas. In the case of agriculture, production of salinity-sensitive crops and plantations is carried out in the close vicinity of the coast. The food-based industry and commerce are highly dependent on the primary production of the agriculture, livestock and fishery sectors for their activities. No insurance on production losses is available for agriculture, livestock, fishery and agro-industry as well as on sales of food-related commerce.

The value of impact for the assets and output of the productive sectors for the region was estimated as US$ 1.5 and 3.3 billion, respectively, as shown in table 4.4. The highest risk of assets and output and revenues occurs in the tourism and fisheries sectors. The countries where risk in these sectors is highest are Thailand and Indonesia.

Table 4.4: Disaster Impact in the Productive Sectors
(Million US$)

	Region	India	Indonesia	Maldives	Sri Lanka	Thailand
Tourism	**2,355**	**—**	**—**	**236**	**274**	**1,846**
Assets	726			100	250	376
Production	1,630			136	24	1,470
Fisheries	**1,487**	**568**	**511**	**20**	**222**	**166**
Assets	520	230	102	14	104	67
Production	967	338	409	6	114	100
Industry and Commerce	**733**	**58**	**447**	**3**	**133**	**93**
Assets	193	20	167	3	6	—
Production	541	38	280	—	127	93
Agriculture	**291**	**38**	**225**	**12**	**7**	**10**
Assets	121	15	84	11	4	8
Revenues	170	22	141	1	3	2
Total	**4,866**	**663**	**1,182**	**271**	**636**	**2,115**
Assets	1,559	265	352	125	367	450
Production	3,307	398	830	146	269	1,665

Source: ADPC

D. PHYSICAL INFRASTRUCTURE VULNERABILITIES AND RISK

The vulnerability and risk of physical infrastructure and assets is very high in view of their location, for which physical and land-use planning did not fully take into consideration the probability of occurrence of this type of hazard, and to insufficiency of existing building standards and codes. Infrastructure sustained damage and losses of US$ 1.6 billion.

The location of roads and railways in low-lying areas near the coast provides for higher vulnerability and risk from this type of disaster, which is aggravated by the fact that there are no adequate alternative roads and railways for the population and cargo to use. Airports and runways located in coastal areas did not have adequate protection against a tsunami. Existing construction codes and structural design standards for all types of infrastructure works were not adequate to meet the stresses caused by the earthquake in Indonesia. In addition, the hydraulic design criteria for bridges, culverts and other drainage works were insufficient to meet the flow of saltwater brought by the tsunami waves. The ensuing destruction of infrastructure brought about higher transport costs to the population, arising from the need to utilize alternative, undamaged roads or modes of transport.

Water supply and sanitation systems for the human settlements located along the affected coastal areas reveal high vulnerability and risk, as they were flooded and destroyed by the waves, especially in the rural areas. In addition, the electrical components of these systems are very prone to damage by saltwater. A similar situation occurs when some components of the electrical and telecommunications systems are located very near the coast and are affected by the saltwater.

There is no insurance coverage on public infrastructure. Achievement of the Millennium Development Goals (MDG) has been made more difficult. The estimated value of impact for the assets and losses in infrastructure for the region was estimated as US$ 1.1 million and 500 million respectively, as indicated in table 4.5. The highest impact on assets and losses occurred in the transport and communications sector. The country where risk of infrastructure is highest is Indonesia, while Sri Lanka and India are distant second.

Table 4.5: Disaster Impact in Physical Infrastructure
(Million US$)

	Region	India	Indonesia	Maldives	Sri Lanka	Thailand
Transport	**934**	**36**	**558**	**73**	**252**	**16**
Assets	749	35	409	73	225	7
Losses	185	1	148	—	27	9
Water Supply	**119**	**—**	**30**	**45**	**40**	**4**
Assets	103	—	27	45	31	1
Losses	16	—	3	—	9	3
Electricity	**104**	**—**	**68**	**5**	**17**	**14**
Assets	94	—	68	5	17	4
Losses	10	—	—	—	—	10
Other Infrastructure	**480**	**244**	**221**	**—**	**—**	**15**
Assets	190	43	132			15
Losses	290	201	89			—
Total	**1,636**	**279**	**876**	**123**	**309**	**49**
Assets	1,136	78	636	123	273	27
Losses	500	201	241	—	36	22

Source: ADPC

E. SOCIAL VULNERABILITIES AND RISK

Table 4.6: Disaster Impact in Social Sectors
(Million US$)

	Region	India	Indonesia	Maldives	Sri Lanka	Thailand
Housing	**2,196**	**229**	**1,437**	**94**	**414**	**22**
Assets	2,120	193	1,398	94	412	22
Losses	76	35	39	—	2	—
Health	**227**	**24**	**120**	**12**	**60**	**12**
Assets	199	11	111	12	57	9
Losses	28	13	9	—	3	3
Education	**230**	—	**184**	**21**	**25**	—
Assets	212	—	166	21	25	—
Losses	18	—	18	—	—	—
Total	**2,653**	**252**	**1,741**	**127**	**499**	**34**
Assets	2,531	204	1,675	127	494	31
Losses	122	48	66	—	5	3

Source: ADPC

Social and human vulnerabilities were revealed by the disaster impact; they stem form the absence or inadequacy of social protection systems against disasters of this kind. Evidence of them is provided by the enormous loss of life and the extraordinary relief and temporary shelter requirements to accommodate those that were rendered homeless. This was due to the absence of an early warning system, coupled with a lack of a disaster prevention culture among the majority of the population under an appropriate multi-hazard framework. In addition, the civil defense organizations were not prepared for this type of low-recurrence, high-impact event; the size and magnitude of the required relief and shelter operations exceeded the domestic response capacity to reinforce which a generous response was provided by the international community.

People in the affected areas lost their livelihood and income. The majority of the affected persons belong to the lower income strata of the population, and many micro-, small- and medium-size enterprises sustained extensive damage and losses as well. Most have no credit worthiness or insurance on their assets, their production and income. The duration of this local negative impact depends on the rate of recovery of production operations where people were employed and on the amount and timeliness of compensation and assistance from the governments to replace destroyed productive assets and reinitiate income-generation activities.

From the estimated impact it is evident that houses, hospitals and education centers were not designed to withstand the impact of the high-magnitude earthquake in Indonesia and the action of the waves generated by the tsunami in all the countries. In addition, there is now evidence that land-use planning did not take into consideration this type of hazard, as many homes, hospitals and schools were located too close to the beach areas.

Furthermore, the design and construction criteria for the critical facilities of the health sector did not enable them to continue the provision of medical attention and health care after the damage they sustained. School buildings that are frequently used as temporary shelters in any type of emergency sustained similar damage and were not able to serve this additional purpose. The public sector infrastructure in health and education was not covered by insurance, so that the governments have had to bear the risk.

The total amount of impact to the assets and services in the social sectors was estimated as US$ 2,653 million, most of which refers to assets in the housing sector (See table 4.6). The relatively low value of impact in the health and education sectors should not be considered as the true measure of social risk, which is not normally measured in monetary terms but on the basis of availability of efficient and timely services. Indonesia and Sri Lanka are the countries having the highest social sectors impact.

F. ENVIRONMENTAL VULNERABILITIES AND RISK

The natural and built environmental resources located in the coastal areas are very vulnerable to the action of tsunamis and floods, and the land located in the vicinity of the boundary of the India and Burma tectonic plates is vulnerable to the action of megathrust earthquakes. This vulnerability is increased by man-induced environmental degradation that includes cutting of the mangrove and damage to coral reefs. The result is widespread destruction and damage to environmental assets and permanent or temporary decrease of the environmental services they provide.

Environmental assets were affected in different ways by the natural hazards that caused the disaster. The enormous energy released by the magnitude 9.0 earthquake when one tectonic plate subducted beneath the other, caused the subsidence of several thousand of hectares of commercially valuable urban and agricultural lands. The tsunami destroyed or damaged seagrass, coral reefs and mangrove located in the coastal areas; it also eroded and deposited debris in beach areas. Agricultural lands located in low relief areas near the coast were subjected to erosion and deposition of debris, along with deposition of saltwater, rendering them unusable or temporarily reducing their future productivity. In the same areas, the standing crop of rice and other annual crops was wiped out, and some permanent plantations were uprooted thereby producing the outright loss of the year's production and requiring replanting. Forest woods and other natural vegetation that are salinity sensitive have lost foliage.

In addition, island and coastal groundwater resources have been affected by salt-water encroachment. Their precarious equilibrium with seawater and extraction for human consumption was broken by salt water entering the aquifer through flooded wells, and in some cases became contaminated when septic tanks and sanitary latrines became flooded and over spilled. Rubble from the destruction of infrastructure caused by the earthquake and the debris brought by the tsunami waves was deposited in many urban and rural areas, thereby causing a serious problem for its removal and final disposal.

The above-described damage to natural assets has had negative effects on the environmental services they normally render. Seagrass, mangroves and coral reefs provide the habitat for fish; where extensive damage occurred, fish have migrated in search of a better environment. This has a negative impact on the landing of fish, reducing the catch and increasing operational costs. Damage to coral reefs and beaches disrupted recreation services for the tourism sector, which fact partially accounted for the reductions in that sector's revenues. Land subsidence will restrict human settlement development and agricultural production. The erosion and deposition of salt water reduced the future productivity of tsunami-flooded agricultural soils, or a period ranging from 2 to 4 years in some areas until natural drainage and leaching eliminates the salt. The carbon retention and soil erosion control capacity of affected woods and other natural vegetation afflicted by soil salinity, has been reduced and will also facilitate increased flooding in the lower lands. The flooding of water wells, sanitary latrines and septic tanks have worsened health conditions in rural areas, and are resulting in higher operational costs for provision of drinking water and for the sanitary disposal of excreta. The losses in fish landing and in agricultural output also have a down-the-line effect on the food-processing industries and commerce.

The above described damage and losses to the natural and built environment were not fully assessed due to lack of sufficient information, especially referred to the baseline of existing assets and services. However, a significant fraction of them is actually measured already as damage and losses in the sectors that make use of them, such as agriculture, fishery, industry and commerce and tourism. Their importance, however, cannot be underemphasized.

P. DANAO/ADPC

improved disaster risk management

...the existing strategy of disaster risk reduction and management in the countries which has been designed to encompass small to medium impact, high probability events, must now be expanded to include due considerations for high impact and low probability hazards such as the Indian Ocean earthquake and tsunami.

V. Improved Disaster Risk Management

A. GENERAL CONSIDERATIONS

The frequent and repeated occurrence of low to medium impact disasters in the Indian Ocean region has fostered the formulation and application of a strategy for disaster risk reduction and management in order to ensure the sustainability of social and economic development of the population. The ADPC has been supporting such effort by the countries involved.

The analysis of the impact of the 26 December 2004 Earthquake and Indian Ocean Tsunami disaster, described in the previous chapters, reinforces such need and makes it necessary to supplement the strategy to take into consideration the low frequency occurrence of such high risk events. That is to say, the existing regional strategy for disaster risk management should be supplemented with the incorporation of specific requirements arising from the Indian Ocean disaster.

To put it differently, the existing strategy of disaster risk reduction and management in the countries which has been designed to encompass small to medium impact, high probability events, must now be expanded to include due considerations for high impact and low probability hazards such as the Indian Ocean earthquake and tsunami.

In developing countries risk is usually shared and borne by the governments and the private sector. The latter partially takes care of its damage to assets and losses, and the governments address the damage to public assets and must also face the damage and losses of the lower-income, socially-vulnerable segments of the population. In that regard, it must be borne in mind that in low-impact frequent events the government's bearing of risk is normally attended through pro-active prevention and mitigation measures. However, in the case of medium to high-impact events, governments must be able to transfer risk through special financial instruments to ensure that the resulting damage and losses do not exceed their ability to cover them[19]. In addition, the private sector must also bear the consequences of the risk it constructs, by observing existing standards, regulations and plans (such as construction codes, land zoning and land use regulations). Thus, it is a matter of public policy to define the private sector◎s responsibility in risk generation and the level of "acceptable risk" (expressed in terms of the "design events" for which those regulations, standards and codes are designed).

The existing disaster risk management strategy for the Indian Ocean countries must then be supplemented to include a special component related to financial risk transfer in the case of high impact, low frequency disasters. In addition, the vulnerabilities and weaknesses that are specific to the 26 December 2004 earthquake and tsunami should be included and addressed, to the point where they are cost effective[20].

The following sections outline the additions that would be needed to supplement to existing strategy for disaster risk management in the region. In them, financial risk management is dealt with first due to the fact that it would seem to be the most neglected component so far in the case of high risk and low probability events.

B. FINANCIAL RISK MANAGEMENT

Present Situation

The financial instruments portfolio that countries use to meet reconstruction requirements after disasters has been addressed up to now to the case of relatively low-risk, frequent events. There are significant differences between those used by the private sector and those adopted by the governments. On the one hand, large private entrepreneurs partially utilize *ex ante* insurance protection that is usually reinsured abroad; middle income private individuals and many medium sized enterprises actually adopt a policy of self financing of damage to assets and coping with losses; and lower income individuals and small and micro entrepreneurs that have no savings or sufficient income to acquire insurance, actually transfer their risk to governments, expecting compensation or restitution to face the negative impact of disasters. Governments rely mostly on *ex post* measures that include, *inter alia*, regular budget internal reallocations and diversion or reallocation of existing development loans, which have the disadvantage of deferring the solution of existing development needs and problems[21]. The usual response to disasters of this kind involves the provision of government compensation and soft loans to individuals and small and medium size entrepreneurs, as well as the provision of private sector – both international and domestic – grants.

---

[19] See Miller, Stuart and Keipi, Kari,
Strategies and Financial Instruments for Disaster Risk Management in Latin America and the Caribbean, Inter-American Development Bank (IADB), Washington D.C., 2005.

[20] It should be recognized that not all risks can be covered, and that there is always a residual risk that is impractical or not cost effective to transfer or finance.

[21] In fact, as pointed out by Miller and Keipi (2005) existing-loan reallocation or reformulation involves a transfer of risk whereby the original loan beneficiaries in fact provide post-disaster assistance to the new recipients. Then, too, if the funds are not replaced to its originally-intended goals, the development objectives of the loan would not be achieved.

In some cases of major, high risk and not-too-frequent disasters the governments have also resorted to such *ex post* measures as acquiring fresh loans and to drawing from international reserves, to meet reconstruction financial needs. Needless to say, this leads to an increased debt burden for the country and represent a high opportunity cost to normal development.

Future Requirements

The above-described situation must evolve towards a more *ex ante* approach of financial risk transfer that would limit the debt burden and the opportunity costs to development. This approach would entail the adoption of a number of additional policies that cover a wide spectrum of subjects (such as more strict infrastructure building standards, land zoning, and legislation) and financial instruments and schemes.

On the side of the private sector, large enterprises should consider upgrading their insurance policies to provide better coverage of damage to their assets and of production and revenue losses. The necessary efforts to expand insurance schemes coverage of individuals and small to medium-size entrepreneurs' assets and losses should be undertaken. In this respect, weather-related agricultural and fishery production insurance schemes should be developed and made available.

The insurance market in the countries is not very developed as there is no culture for prevention and mitigation among the population, leading to a general situation of underinsurance, self insurance and damage and loss transfer to governments. Given this limited and shallow market of insurance, the resulting premiums are high. Breaking this vicious circle is essential to reduce the prevailing self-coping mechanisms that presently result in the deterioration of personal well being after disasters and the negative externalities of transferring the impact to the state.

On the part of the governments, *ex ante* provisions of risk transfer should be adopted to complement the *ex post* ones that should remain en force, but would be relied upon in a decreasing manner in the future. These would include resorting to insurance and reinsurance of public infrastructure and services, which are presently not covered; and the issuing of international securities such as catastrophe bonds (CAT bonds) and weather derivatives, together with the above mentioned legislative and normative changes required to promote the reduction of negative externalities from the private sector.

Insurance of government assets, coupled with the policy measures, can be attractive to large insurance and reinsurance companies and provide for attractively low premiums. Collective negotiation at the regional or subregional level for this type of scheme may result in additional reductions in annual cost of insurance.

Equally attractive is the use of securities provided by international capital markets, as it would enable the governments to achieve several objectives: the sharing or spreading financial risk beyond the geographical boundaries of the countries and the region; eliminating the need to await the full development of domestic insurance schemes[22]; and enabling risk to be transferred into the future. Issuing international securities and insurance acquisition should be done concurrently, however, as neither one is sufficient by itself to fully meet financial risk transfer requirements[23].

The Structure of CAT Bonds[24]

Catastrophe (CAT) bonds are a recent financial derivative traded in the world markets. They emerged in the mid-1990s as an initiative to facilitate the direct transfer of reinsurance risk associated with natural catastrophes from corporations, insurers and re-insurers to capital market investors. CAT Bonds are specifically referred to as insurance-linked securities (ILS). The basic structure of CAT bonds can be summarized as follows:

The sponsor establishes a special-purpose vehicle as an issuer of bonds and as a source of re-insurance protection;

The issuer sells bonds to investors. The proceeds from the sale of are invested in a collateral account.

The sponsor pays a premium to the issuer; this and the investment of bonds proceeds are a source of interest paid to investors.

If the specified catastrophic risk is triggered, the funds are withdrawn from the collateral account and paid to the sponsor; at maturity, the remaining principal – or if there is no event, 100% of principal – is paid to investors.

There are three types of ILS triggers: **indemnity, index and parametric**. An indemnity trigger involves the actual losses of the bond-issuing insurer. An industry index trigger involves an index created from property claims service loss estimates. A parametric trigger is based on, for example, the Richter scale readings of the magnitude of an earthquake.

[22] For further information on this matter, see Andersen, T., Innovative Financial Instruments for Natural Disaster Risk Management, Inter-American Development Bank (IADB), Washington, D.C., 2002.
[23] See Lewis, C.M., and Murdock, K.C., The Role of Government Contracts in Discretionary Reinsurance Markets for Natural Disasters, Journal of Risk and Insurance 63 (4), 1996.
[24] Taken from Burnecki, K., et al, Pricing of Catastrophe Bonds, in Cizek, Pavel et al, Statistical Tools for Finance and Insurance, Xplore-Stat, March 2005.

CAT bonds have been initially used and issued by the international insurance and reinsurance industry as a protection against eventual insolvency in cases of very large catastrophes arising from natural events (See Box). CAT bonds are in fact contracts between the issuer (the insurance companies in this case) and international investors. The investors put up sums of cash at the start of the period of coverage of the bonds, and the funds are held in escrow by a neutral party, to be invested in low risk short term securities until a catastrophe occurs or the period of the bonds expire, whichever occurs first. Governments have recently been entering into this international security market to reduce their financial risk after major disasters.

After a catastrophic event occurs (such as a major earthquake, hurricane, typhoon or flood) the affected government would immediately receive cash resources from the escrow account that holds CAT bond funds. The affected government needs not pay this inflow of money back, whether a catastrophe occurs or not. If no such event occurs during the coverage period of the bond, the investor receives the escrowed amount; when a catastrophe happens, the funds flow to the government without obligation to repay it.

The attractiveness of CAT bonds is very clear especially in the case of developing nations that must face heavy financial reconstruction requirements after a catastrophic disaster, and that either have a heavy debt burden or which may have entered into restriction agreements on additional debt acquisition. And even if no such debt burden or limitations are present, these funds have a very low cost to the countries and are available to meet the most urgent needs after the disaster occurs.[25]

Weather derivatives are financial instruments designed to hedge against climate risk, to cover against relatively low-impact but frequent events, such as seasonal weather variations, on agriculture production and water related activities such as hydropower production. Weather derivatives are a good complement to CAT bonds as they are designed to address the lower risk and more frequent disasters.

C. OTHER RISK MANAGEMENT CONSIDERATIONS

Described below are additional components – besides the financial risk dealt with above – that, with the benefit of hindsight after the 26 December 2004 Indian Ocean disaster, are considered essential for inclusion in the existing strategy for disaster risk management for the region. In addition, these issues should be taken into consideration in the reconstruction after the Indian Ocean disaster.

Social Risk Management

The awareness of the population in regard to hazards and vulnerabilities should be increased to reduce risk. A culture of prevention and mitigation should be adopted involving formal education at all levels and special awareness campaigns.

The present lack or insufficiency of social protection systems should be addressed. The on-going establishment of a regional tsunami early warning scheme should be combined with effective means of alerting and evacuating the population at risk to pre-designated areas. Civil defense capabilities should be strengthened to be able to meet the requirements of low-probability and high impact disasters, including the possibility of increased cooperation among countries of the region in times of major disasters.

Improvements are needed in regard to the financial and livelihoods vulnerability of lower income population, progressively increasing resilience and ability to cope and adapt. Existing government compensation systems and criteria should be updated and expanded to cover, *inter alia*, household furnishings and equipment. Access of the general public to insurance and to credit financing should be promoted.

Emphasis should be placed on the need to ensure that hospital and other health care centers have the ability not only to withstand the force of extreme natural events, but also to continue to deliver health care and services after any type of disaster. Schools should de retrofitted to increase their safety against natural hazards and to facilitate their utilization as temporary shelters.

---

[25] For further information on the matter, see Croson, David and Richter, Andreas,
Sovereign Cat Bonds and Infrastructure Project Financing , in Risk Analysis, Vol 23, No 3, Society for Risk Analysis, 2003. In addition, see Linnerooth-Bayer, Joanne et al, Insurance-Related Actions and Risk Assessment in the Context of the UNFCCC, May 2003. See also the proceedings of the OECD Conference on Catastrophic Risk and Insurance (22 to 23 November 2004, particularly the presentation on Financing Catastrophic Risk in Emerging and Developing Countries: Challenges and Perspectives, by Reinhard Mechler, IIASA:

Human Settlements and Infrastructure

Land use planning criteria and construction codes should be modified to take into consideration low probability and high-risk events. Anti-seismic codes should be revised in light of the earthquake magnitude, and hydraulic design criteria for bridges, drainage and flood control works should be updated. Location of human settlements and infrastructure – including roads, railways and bridges, and airports – in flood-prone areas should be revised. Complementarity and redundancy of individual transport systems and means should be fostered to reduce transportation cost increases after floods. The design of water supply and sanitary disposal facilities in the rural areas should be revisited and modified to reduce their vulnerability to flooding. Protection against salt-water intrusion of electronic and electric components in water supply and sanitation, electrical and telecommunications systems should be standardized. Insurance against service interruptions and revenue losses should be considered by service utilities to reduce negative impact of disasters.

Productive Activities

Land use and production planning should be revised to include protection against the negative impact of tsunamis. In that respect, production of salt-sensitive crops in areas close to the coast should be discouraged; instead, a shift to other salt-resistant crops or to less salt-sensitive varieties of the existing crops should be fostered. Flood protection measures should be considered for aquaculture facilities. The tsunami early warning system should include a scheme for the timely evacuation of fishing and tourism and general-purpose boats and vessels to safe heavens so that their destruction and damage may be avoided or reduced significantly. A similar scheme should be designed for the opportune evacuation of major livestock to safe areas in cases of tsunami and large floods. Fishing boats and engines should be replaced bearing in mind the possible need – at least in some countries – to enable operations in more distant locations where fish may have migrated in search of a better environment.

The use of production insurance – for agriculture, livestock and fisheries – should be encouraged. Governments may wish to start such insurance schemes and obtain re-insurance to cover their risks against seasonal weather irregularities.

The case of the tourism sector is highly sensitive to this type of disasters[26] due to its high dependency on the natural and environmental resources of coastal areas which are, in turn, very vulnerable. Special schemes must be adopted to ensure its speedy recovery. On the one hand, structural mitigation measures are required, and reconstruction should take into consideration not only the vicinity of and access to coastal environmental and landscape considerations, but disaster mitigation and prevention criteria in land-use planning as well. On the other hand, non-structural measures to reduce tourism vulnerability are required. These refer to the upgrading and expansion of insurance coverage of assets and revenue, and to improving the sector's capacity for submitting the necessary information to promptly obtain insurance reimbursements. They also include expanding and improving promotion campaigns in the main international tourism markets abroad to regain the trust and confidence of tourists, taking into full consideration the success of individual national schemes as well as the possibility of obtaining economies of scale through regional or sub-regional cooperation.

Environment

The high exposure and vulnerability of environmental and natural coastal resources to tsunami, floods and actions by man must be reduced. In that respect, mangroves should be replanted, rainwater collection systems to meet drinking water needs of coastal and island environments should be upgraded and expanded, and artificial recharge of groundwater schemes should be analyzed and considered. Additional coastal protection works – such as dikes and seawalls – may be found appropriate for certain areas, given their topography and exposure.

Other subjects are to be given due consideration. The links between hazards and environmental management has been amply studied and conceptualized, but it remains to be operationalized in a more systemic and systematic fashion, namely in respect of economic instruments that correctly price the services rendered by the environment, in terms of risk reduction. The problem in this respect lies in the fact that both sustainable development and well managed risk are perceived as public goods by societies, which results in that they have a imperfect markets and pricing mechanisms[27].

Reconstruction Weaknesses

To expedite assets replacement and repair as well as economic recovery, that have become evident after the Indian Ocean disaster, some institutional weaknesses must be addressed. These refer to slow and cumbersome insurance processing and reimbursement procedures that are preventing cash-strapped entrepreneurs in the tourism sector from expeditiously conducting reconstruction and repairs to their resorts and hotels. They also include bureaucratic constraints and delays arising when requesting and obtaining construction permits. And, finally, there exist limitations in construction sector capacity, especially in some countries, that derive from insufficiency of skilled labor, and construction equipment and materials.

---

[26] In this regard, the volatility of international tourism in response to the impact or possible impact of natural and man-made disasters is to be given due consideration, as attested by the recent negative impact of the SARS and avian flu outbreaks and of civil unrest.

[27] This leads to the private internalization of benefits and to negative externalities being transferred to society at large and to governments whenever sustainability of development is jeopardized or when risk is expressed in terms of specific and concrete disasters.

In this respect, the governments may wish to consider the application of special and urgent measures to expedite the reconstruction process, including the provision of bridge financing to tourism entrepreneurs until insurance and reinsurance proceeds arrive, the liberalization of construction permit processes and the facilitation of the temporary import of foreign construction capacity.

These measures would have a positive impact on recovery of economic activities and growth.

Improved Capacities for Disaster Impact Assessment

The assessment of impacts – damage to assets and disruptions of economic flows – is essential for the estimation of financial needs for both reconstruction and economic and social recovery programs, as well as for the assignation of spatial and sectoral priorities in post-disaster activities.

There is need to adopt unified procedures and common methodologies to undertake this following all disasters in the region, that would enable the identification and quantification of disaster impact at all levels and for all sectors, at an early point in time after the event has occurred so that appropriate policies can be adopted and enacted. These should enable governments to assess impact to public and private assets and production /revenue losses, at the national, State, provincial and local levels; and to estimate the direct impact on individual and family income and livelihoods as well as the specific gender related issues arising from the disaster. For the latter, special field surveys may be required to complement indirect estimates using production-to-income relationships.

Annual updates of the assessment, using updated information, could be used as a reconstruction and recovery monitoring and management tool, and for re-orienting both public policies and reconstruction and recovery programs.

Asian Disaster Preparedness Center
P.O. Box 4 Klong Luang Pathumthani 12120 Thailand
Tel: (66 2) 516 5900-10 Fax: (66 2) 524-5360, 5366
website: www.adpc.net