Report No. 39787-LB

REPUBLIC OF LEBANON
ECONOMIC ASSESSMENT OF ENVIRONMENTAL DEGRADATION DUE TO THE JULY 2006 HOSTILITIES

Sector Note

October 11, 2007

Sustainable Development Department
Middle East and North Africa Region

Document of the World Bank

Currency Equivalents

(Exchange rate effective May 15, 2007)

Currency Unit = Lebanese Pound (LP)

US$1.00 = 1,512 LP

Fiscal Year

July 1 – June 30

Vice-President:	Daniela Gressani
Country Director:	Joseph P. Saba
Sector Director:	Inger Andersen
Sector Manager:	Luis Constantino
Task Team Leader:	Maria Sarraf

ACKNOWLEDGEMENTS

This report was prepared by a team consisting of Ms. Maria Sarraf (Task Team Leader, MNSSD), Ms. Lelia Croitoru (Environmental Economist, Consultant MNSSD), Mr. Mutasem El Fadel (Sr Environment, Consultant), Mr. Karim El-Jisr (Environment Consultant, ECODIT), Mr. Erkki Ikaheimo (Coastal Zone Specialist, Consultant), Mr. Erich Gundlach (Oil Spill Specialist, Consultant), and Ms. Samia Al-Duaij (Operations Officer, MNSSD).

The team would like thank H.E. Mr. Yaccoub Sarraf (Minister of the Environment); Dr. Berj Hatjian (Director General, Ministry of Environment) as well as the whole team of the ministry of environment in Lebanon especially: Mmes/Messrs. Grace Rachid (Environmental Specialist); Ramzi Fanous (Statistician); Nabil Assaf (Forestry Officer); Hassan Bitar (Project manager ABQUAR); Samar Khalil (Project Manager); Ghada Mitri (Development Officer); Manal Mousallem (UNDP/MOE Early Recovery Coordinator); Adel Yacoub (Acting Head of the Department of Protection of Natural Resources); and Lina Yamout (Acting Chief of Service, Protection of Urban Environment);

The report benefited from input from a range of experts from Lebanon, the team would like to thank in particular: Mmes/Messrs.: Rami Abu Salman (IUCN-Mediterranean); Pierre Achkar (Syndicate of Hotel Owners); Paul Ariss (Syndicate of Restaurant Owners); Jean Bayrouthi (Syndicate of Maritime Establishments); Nabil Chemaly (Lebanon Water Policy Program); Nohal El Homsi (WHO); Farah El Jam (AUB); Carla Huijer (AUB); David James (FAO); Ghassan Jaradi (Palm Islands Nature Reserve); Gaby Khalaf (National Center for Marine Sciences); Hala Kilani (IUCN-WESCANA); Dany Lichaa El-Khoury (SETS); Rania Maroun (SETS); Darine Mawla (AUB); Lara Muallem (AUB); Manal Nader (University of Balamand); Amal Othmani (AUB); Alissar Rady (WHO); Marwan Rizkallah (AUB); Darine Salamoun (AUB); Mohamed el Sarji (Syndicate of Professional Divers); Mary Semaan (AUB) and Issam Sidawi (Palm Islands Nature Reserve). The team would also like to acknowledge the constructive comments provided by the staff of the Ministry of Finance and the Presidency of the Council of Ministers for providing constructive comments.

The authors would also like to thank Messrs. Sherif Arif (Regional Environment and Safeguard Advisor); Jan Bojo (Lead Environmental Economist, ENV); Hocine Chalal (Senior Environment Specialist); Sateh Chafic El-Arnaout (Senior Municipal Development Specialist); Sergio Margulis (Lead Environmental Economist, AFTSD) and Joseph Saba (Country Director, MNCO2) for providing constructive comments.

Financial support for the preparation of this study was partially provided by the Finish Trust Fund through a grant to the METAP program (Mediterranean Environmental Technical Assistance Program).

TABLE OF CONTENTS

ANNEXES

TABLES

ACRONYMS

AFDC	Association for Forest Development and Conservation
ALOFT	A Large Outdoor Fire Plume Trajectory
CDR	Council for Development and Reconstruction
C&D	Construction and Demolition
CEDRE	Centre de Documentation de Recherche et d'Expérimentations Sur Les Pollutions Accidentelles des Eaux
DALYs	Disability Adjusted Life Year
EC/MIC	European Commission/Monitoring Information Centre
FAO	Food and Agriculture Organization
GAC	Government Appointed Committee
GDP	Gross Domestic Product
GIS	Geographic Information System
GOL	Government of Lebanon
IAP	International Assistance Plan
ICRAM	Instituto Centrale di Ricerca scientifica e technologica Applicata al Mare
IFO	Intermediate Fuel Oil
IMO	International Maritime Organization
ITOPF	International Tanker Owners Oil Pollution Fund
IUCN	The World Conservation Union
MNSSD	Middle East and North Africa Sustainable Development Department (of the World Bank)
MOE	Ministry of Environment
MSW	Municipal Solid Waste
NCMS	National Center for Marine Sciences
NDO	National De-mining Office
NGO	Non Governmental Organization
PCM	Presidency of the Council of Ministers
REMPEC	Regional Marine Pollution Emergency Response
SLWA	South Lebanon Water Authority
TSP	Total Suspended Particle
UN OCHA	United Nations Office for the Coordination of Humanitarian Aid
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNICEF	United Nations Children's Fund
USD	United States Dollar
USEPA	United States Environmental Protection Agency
UXO	Unexploded Ordnances
WHO	World Health Organization

EXECUTIVE SUMMARY

The 34-day hostilities in Lebanon started on July 12, 2006 and continued until August 14, 2006, when the ceasefire entered in force. The hostilities killed close to 1,200 people, left more than 4,400 injured, displaced more than a quarter of the population, and damaged severely the country's infrastructure (GOL, 2006a). Beyond these tragic human and infrastructure costs, the conflict had a devastating impact on the country's fragile environment. The massive destruction of infrastructure left enormous amounts of debris and rubble. The bombing of a power plant in Jiyeh on July 13 and 15 caused the spill of about 12,000-15,000 tons of oil into the Mediterranean Sea. The widespread fires and oil burning deteriorated the air quality, especially in Southern Beirut. These damages affected significantly the country's economy, environment, and its public health.

Several damage assessments were carried out in the aftermath of the conflict (Table 1). The Government of Lebanon (2006a), through the Presidency of the Council of Ministers provided a total estimate for direct damages based on (i) each Ministry's assessment, (ii) an assessment undertaken by the consulting firm Khatib & Alami (2006), (iii) an assessment carried out by the Council for Reconstruction and Development on the physical damage to infrastructure, and (iv) an assessment of damage to housing and office units undertaken by the Order of Engineers. The World Bank (2006a) carried out an impact assessment on the country's major economic and social sectors. FAO (2006) focused on the physical damages and income losses to agriculture, fisheries and forestry. The European Commission (EC, 2006a) carried out a preliminary damage assessment. The assessment quantified the direct damage to public infrastructure and provided a descriptive assessment of indirect damage to various economic sectors. Overall, these assessments cover damages to social, economic and physical infrastructure. None of them focuses on estimating the impacts of the hostilities on the environment.

More recently, UNDP (2007) and UNEP (2007) carried out environmental assessments of the hostilities. While these studies shed light over several important aspects of the environmental damages (such as severity of environmental damage, localization, mitigation options, physical quantification, etc.), they do not measure the associated costs in monetary terms. Efforts to value these damages are direly needed to better understand the real magnitude of degradation and to identify the areas where environmental protection is especially needed.

Table 1 Selected damage assessments undertaken after the July 2006 hostilities in Lebanon

Institution	Type of assessment	*Estimate (US$ million)*
Government of Lebanon (2006a)	Direct damages to infrastructure and major economic sectors	2,800
World Bank / ESIA (2006a)	Economic and social impact assessment - Direct damages - Indirect damages	 2,400 700-800
FAO (2006)	Damages to agriculture, fisheries and forestry	280
EC (2006a)	Direct damage to public infrastructure only Damage to private houses	105 1,000 -1,800
UNDP (2007)	Rapid environmental assessment	n.a.[1]
UNEP (2007)	Post-conflict environmental assessment	n.a.[1]

Notes: [1] Monetary estimates are provided only for a few items, thus no final estimate could be calculated.

This report provides an order of magnitude estimate of the cost of environmental degradation caused by the July 2006 hostilities in Lebanon. Chapter 1 introduces the study's objectives, assumptions and valuation methods used. Chapter 2 provides an overview and valuation of the oil spill impacts. Chapters 3-7 estimate the impacts of the hostilities on waste, water, quarries, air and forests.

1. OBJECTIVE AND SCOPE

At the request of the Lebanese Ministry of Environment (MOE), the World Bank carried out the present study. It aims at assessing the cost of environmental degradation caused by the July 2006 hostilities in Lebanon. Its ultimate goal is to present the overall picture of environmental degradation and to identify the natural resources mostly affected by the conflict. While the study does *not* aim to examine the future needs for environmental protection, it reveals the main areas affected by environmental damage. It is hoped that its findings will further help the Government to raise awareness on the needs and on the priority areas for funding environmental protection in Lebanon.

The study estimates the **overall** damage costs of the hostilities' current and future impacts on the environment and refers them to 2006 as a base year for the analysis. This approach is different than that of previous studies undertaken by the Bank, most of which focused on estimating the **annual** costs of environmental degradation.

2. METHODOLOGY

Table 2 summarizes the valuation methods used in this study. The choice of valuation methods used was largely based on the availability of data concerning each impact. For more information on each method, one should refer to the recently published training manual on the cost of environmental degradation (Bolt, Ruta and Sarraf, 2005).

The report estimates the present value of current and future losses associated to the 2006 hostilities. Some impacts occur during one year e.g. water shortage, while others take place over several years, e.g. the oil spill and forest fires. Estimating the impacts that cover several years was based on a consistent discount rate of 4% throughout the study.

In many national-level valuation studies, estimating the environmental damages is unavoidably constrained by data scarcity. Data constraints usually impose the use of assumptions and simplifications, which gives rise to order of magnitude estimates rather than precise results. In this report, data constraints are even more severe than in other studies. Two reasons explain the problem: (i) its timeliness – less than one year after the hostilities occurred - makes it difficult to find accurate data in secondary sources; (ii) no events comparable to this one - in terms of hostilities inducing an oil spill - are available, except for the 1991 Gulf war, thus no past experience from similar studies exists.

Based on all the above, this study can be considered the first-time published attempt to estimate the overall environmental damages caused by the hostilities and the resulting oil spill. In many cases, the data constraints often imposed the use of assumptions to arrive at estimates. Every effort was made to use assumptions as realistic as possible and to reflect the degree of uncertainty through ranges of values. In other cases, data constraints prevented various damages to be estimated and included in the study. The main impacts not covered by this report and should be more comprehensively analyzed in the future include:

- The impacts of the oil spill on health (such as skin diseases or digestive diseases due to eating contaminated fish),
- The impacts of the oil spill on ecosystem services (such as habitat for spawning, potential groundwater contamination) and on marine biodiversity.
- The impacts of water degradation and damage to wastewater infrastructure on health.
- The impacts of short term exposure to air pollution on health;
- The impacts of unexploded ordnances in forest areas on people's livelihood;

Ideally, estimating the *net* losses would appropriately reflect the value of environmental damages. However, data limitations prevented the valuation of net losses for most categories of impacts[1]. Available information allows estimating only the *gross* losses for all impacts (even the valuation of gross losses is sometimes difficult and needs to be based on specific assumptions). To be methodologically consistent across valuations, this study estimates the ***gross losses*** for all impacts caused by the hostilities.

It should be noted that valuing gross instead of net losses leads to overestimating the real value of damage to a certain extent. On the other hand, the study fails to estimate several impacts, thus

[1] Except for the impacts on restaurants.

reflecting only partially the value of environmental degradation. Overall, all the valuations should be regarded only as *order of magnitude* estimates, and not as precise values.

Table 2 Valuation methods used

Impacts	*Method used*
1.Oil spill	
- Impact on birds and turtles[1]	Restoration cost model
- Beach resorts, hotels, restaurant, marinas, fishing, etc	Market price[2]
2. Waste	
- Impact of demolition waste on environment	Cost of transport and disposal
- Impact of UXOs on health	DALYs[3]
- Impact of UXOs on agriculture	Market price
- Impact of medical waste	Cost of disposal
3. Water	Cost of alternative sources
4. Quarries	Hedonic price method
5. Air	Not estimated
6. Forests	
- Impact on forests	Market price[4], substitute goods[5], cost-based methods[6]
- Impact on national reforestation program	Restoration costs

Notes: [1] in Palm Islands Nature Reserve ; [2] to estimate the income losses; [3] estimated through Human Capital Approach and Value of Statistical Life; [4] for firewood, charcoal, honey, wax, pine nuts, medicinal and aromatic plants; [5] for grazing; [6] for example, permit price for hunting and cost of protecting biodiversity.

3. FINDINGS

The overall cost of environmental degradation in Lebanon caused by the 2006 hostilities is estimated between US$527 and 931 million, averaging at **US$729 million**, or about **3.6% of GDP** in 2006 (Table 3).

A previous study (Sarraf et al., 2004) estimated the annual costs of environmental degradation in 2000 at about US$565 million or 3.4% of GDP[2]. A comparison between the two estimates shows that the damage caused by the 34-day hostilities is higher than that caused throughout a whole year in times of peace. It is also interesting to note that on average, the environmental damage caused by one day of hostilities is about US$21.5 million compared to US$1.7 million per day in times of peace[3].

Table 3 Overall cost of environmental degradation caused by the July 2006 hostilities in Lebanon

Impacts	*US$ million min*	*US$ million max*	*US$ million average*	*% of GDP[4]*
Waste	206.8	373.5	290.2	1.4
Oil spill	166.3	239.9	203.1	1.0
Water	131.4	131.4	131.4	0.6
Quarries	15.4	175.5	95.5	0.5
Forests	7.0	10.8	8.9	0.0
Air			n.a.	n.a.
Total environmental cost caused by hostilities	**526.9**	**931.1**	**729.0**	**3.6%**

Figure 1 Environmental damages by categories

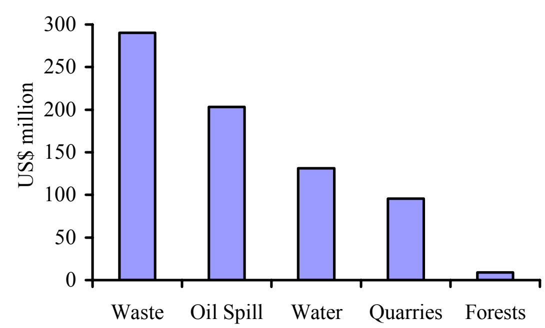


Figure 1 illustrates the main components of the estimated damage cost. Once again, the limited data availability implies that the estimated costs are only indicative for the true value of damages. Despite these limitations, the report shows that the largest estimated impact of the hostilities is on the waste sector, mainly due to the high costs of disposing the demolition waste and to the casualties and losses in agriculture production

[2] The study estimated the cost of environmental degradation due to air pollution to 1.1%of GDP to water degradation to 1% to land and wildlife degradation to 0.6% to coastal zone degradation to 0.7% and to waste management to 0.1% of GDP.

[3] Adjusted from 2000 to 2006 using the GDP deflator.

[4] Based on an estimated GDP for 2006 of US$20.5 billion (Economic Intelligence Unit, 2006)

caused by the unexploded ordnances in South Lebanon. The impact of the oil spill comes second in importance, and is mainly given by the high costs of cleaning the oiled waste, the cost of oil burnt and spilled and the income losses of coastal services (e.g. beach resorts). The third most important impact is on water, primarily reflected by the additional costs of getting water and repairing the water infrastructure damaged in South Lebanon. The effect on quarries is relatively significant, especially in terms of landscape damages due the non rehabilitation of quarries at the completion of excavation. The impact on forests seems the least important, though it should be noted that it was only conservatively estimated[5]. While the deterioration of air quality (due to the burning of fuel tanks in Jiyeh and in Beirut International Airport and the dust from demolition waste) has certainly affected people's health in certain neighborhood, unfortunately there is no dose response function that links short term exposure to high level of pollution to health impacts. Hence this impact has not been quantified in the study.

4. LOOKING FORWARD

Understanding the real importance of the environmental damage can be improved by comparing the hostilities' impacts on different sectors. Damages to the environment (estimated at US$729 million in this study) represent an additional 20 to 25 % to the value obtained from previous damage assessments[6]. This sheds light on the importance of the environmental damage caused by the hostilities and on the need of allocating substantial funds to environmental conservation in Lebanon.

The hostilities resulted in emerging environmental problems (such as the oil spill and large quantities of debris and rubble) and exacerbated long lasting environmental issues (such as waste management and quarrying activities).

With about 40 percent of the total estimated damage, Lebanon needs to pursue its effort of cleaning demolition and military waste. In addition, it needs to resolve its long lasting waste management issue by (i) agreeing to allocate land for sanitary landfills in different Mohafazats, (ii) enacting the *Integrated Waste Management Law* and implementing the *National Solid Waste Strategy* in a competitive and cost effective manner and (iii) providing incentives to municipalities to treat their waste (financial incentives such as carbon finance can alleviate the financial burden imposed by the waste sector).

While substantial efforts have been devoted to clean up the oil spill, the magnitude of the damage cost (about 24% of the total damage cost) suggests that fund-raising efforts to continue the oil clean-up and especially to deal with the oiled waste are particularly important.

The reservoirs and the water network in South Lebanon have been to a large extent rehabilitated; these efforts need to continue so as to provide water supply to all the communities affected by water shortage.

The reconstruction is likely to add more pressure on quarrying activities. Lebanon needs to address this long lasting issue by enforcing the recently enacted decrees[7] relative to the establishment and operation of quarries. It also needs to properly enforce the rehabilitation of quarries at the end of operation to avoid leaving behind huge environmental and landscape damage as was done in the past.

In view of the above, it is important that investment in the reconstruction of Lebanon takes into consideration the results of this study and allocate sufficient funds for mitigating measures to protect the environment.

---

[5] For example, the damages due to UXOs scattered in forests could not be valued due to limited information on the UXOs location at the time of data compilation.

[6] Government of Lebanon (2006a) and World Bank/ESIA (2006a)

[7] Decree 8803 of 2002 amended by Decree 16456 of 2006

Chapter 1. INTRODUCTION

1.1 BACKGROUND

The 34-day hostilities in Lebanon started on July 12, 2006 and continued until August 14, 2006, when the ceasefire entered in force. The hostilities killed close to 1,200 people, left more than 4,400 injured, displaced more than a quarter of the population, and damaged severely the country's infrastructure (GOL, 2006a). Beyond these tragic human and infrastructure costs, the conflict had a devastating impact on the country's fragile environment. The massive destruction of infrastructure left enormous amounts of debris and rubble. The bombing of a power plant in Jiyeh on July 13 and 15 caused the spill of about 12,000-15,000 tons of oil into the Mediterranean Sea. The widespread fires and oil burning deteriorated the air quality, especially in Southern Beirut. These damages affected significantly the country's environment and its people's health.

Several damage assessments were carried out in the aftermath of the conflict (Table 1). The Government of Lebanon (2006a), through the Presidency of the Council of Ministers provided a total estimate for direct damages based on (i) each Ministry's assessment, (ii) an assessment undertaken by the consulting firm Khatib & Alami (2006), (iii) an assessment carried out by the Council for Reconstruction and Development on the physical damage to infrastructure, and (iv) an assessment of damage to housing and office units undertaken by the Order of Engineers. The World Bank (2006a) carried out an impact assessment on the country's major economic and social sectors. FAO (2006) focused on the physical damages and income losses to agriculture, fisheries and forestry. The European Commission (EC, 2006a) carried out a preliminary damage assessment. The assessment quantified the direct damage to public infrastructure and provided a descriptive assessment of indirect damage to various economic sectors. Overall, these assessments cover damages to social, economic and physical infrastructure. None of them focuses on estimating the impacts of the hostilities on the environment.

More recently, UNDP (2007) and UNEP (2007) carried out environmental assessments of the hostilities. While these studies shed light over several important aspects of the environmental damages (such as severity of environmental damage, localization, mitigation options, physical quantification, etc.), they do not measure the associated costs in monetary terms. Efforts to value these damages are direly needed to better understand the real importance of degradation and to identify the areas where the environmental protection is especially needed. To help bridge this gap, this study provides an order of magnitude estimate of the cost of environmental degradation caused by the 2006 hostilities in Lebanon.

Table 1.1 Selected damage assessments undertaken after the July 2006 hostilities in Lebanon

Institution	Type of assessment	*Estimate (US$ million)*
Government of Lebanon (2006a)	Direct damages to infrastructure and major economic sectors	2,800
World Bank / ESIA (2006a)	Economic and social impact assessment	
	- Direct damages	2,400
	- Indirect damages	700-800
FAO (2006)	Damages to agriculture, fisheries and forestry	280
EC (2006)	Direct damage to public infrastructure only	105
	Damage to private houses	1,000 -1,800
UNDP (2007)	Rapid environmental assessment	n.a.[1]
UNEP (2007)	Post-conflict environmental assessment	n.a.[1]

Notes: [1] Monetary estimates are provided only for a few items, thus no final estimate could be calculated.

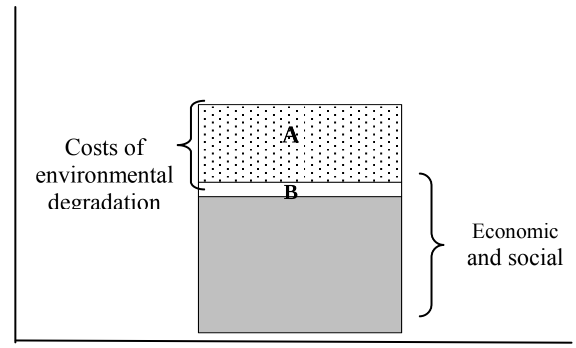
1.2 OBJECTIVE AND SCOPE

At the request of the Lebanon's Ministry of Environment (MOE), the World Bank carried out the present study. It aims at assessing the cost of environmental degradation caused by the 2006 hostilities in Lebanon. Its ultimate goal is to present the overall picture of environmental degradation and to identify the natural resources mostly affected by the 2006 hostilities. While the study does *not* aim to examine the future needs for environmental protection, it reveals the main areas affected by environmental damage. It is hoped that its findings will further help the Government to raise awareness on the needs and on the priority areas for funding environmental protection in Lebanon.

The study estimates the **overall** damage costs of the hostilities' current and future impacts on the environment and refers them to 2006 as a base year for the analysis. This approach is different than that of previous studies undertaken by the Bank, most of which focused on estimating the **annual** costs of environmental degradation.

To better understand the scope of this study, a comparison with the other assessments is useful (Figure 1.1). Some environmental damages covered by this report, e.g. the impacts of the hostilities on the oil spill, forests, quarries and waste, were not estimated elsewhere (Area A). In this sense, this study complements previous assessments by adding the environmental dimension of losses. Other environmental damages, e.g., the disruption in water supply, or the losses of agricultural production due to unexploded ordnances may have been partially estimated in other assessments[8] (Area B). In this light, the present study captures only the economic costs attributed to environmental damages.

Figure 1.1 Cost of environmental degradation vs. other economic and social costs associated to the hostilities[9]



The study attempts to separate the environmental damages caused by the hostilities from the economic, social and physical damages[10]. For example, it accounts for the ecosystem losses due to bombings (e.g. impacts on protected areas). It also considers the losses in human lives caused by explosion of unexploded ordnance (UXOs), because UXOs are considered an environmental waste; however, it does not account for human deaths caused by the bombings themselves, as this is a direct impact of the hostilities, with no relation to the environment. Similarly, it estimates the agricultural losses due to the UXOs, but not those directly caused by bombings (eg. of fish and cattle). One needs to keep in mind that the boundaries between these damages are sometimes unclear.

In the case of the oil spill, both the hostilities and the spill caused economic losses on the coast. To accurately single out the contribution of the oil spill to the overall damage on the coast is harder than in case of other impacts. For example, both the hostilities and the oil spill reduced the number of tourists during 2006-2008. How much of this reduction is due to the oil spill alone is difficult to measure, particularly on the beach resorts located north of Jyieh and affected by the oil spill.

The estimates obtained in this report reflect damages to the whole country. The only

[8] For example, World Bank (2006a) assesses the overall impacts of hostilities on agriculture at US$450 million. This estimate does not however disaggregate the cost per cause of damage. The present study quantifies the losses to agriculture due to unexploded ordnances only, at US$67 million. This sheds light over the contribution of the environmental damage to the total economic cost caused by the hostilities.

[9] The scale of the figure does not reflect the real value of damage in Lebanon, but only the conceptual distinction between environmental costs and other cost types.

[10] Which were estimated in other reports.

exception is the estimated impact of the oil spill, which only reflects losses on the coast. It is possible that these losses may be offset by induced benefits elsewhere in the country after the hostilities. For example, the reduced attendance in coastal restaurants could have increased that of inland ones[11]. In this case, the estimated impact on the coast would over-estimate losses to Lebanon as a whole. Accounting for such effects was not possible due to data constraints, but we believe them to be minor and not to affect the order of magnitude of the oil spill impacts. With this caveat, we assume that the overall estimates obtained in this report are indicative of total losses to the country.

1.3 METHODOLOGY

Table 2 summarizes the valuation methods used in this study. The choice of valuation methods used was largely based on the availability of data concerning each impact. For more information on each method, one should refer to the recently published training manual on the cost of environmental degradation (Bolt, Ruta and Sarraf, 2005).

The report estimates the present value of current and future losses associated to the 2006 hostilities. Some impacts occur during one year, e.g. that of water shortage, while others take place over several years, e.g. those of oil spill and forest fires. Estimating the impacts that cover several years was based on a consistent discount rate of 4% throughout the study.

In many national-level valuation studies, estimating the environmental damages is unavoidably constrained by data scarcity. Data constraints usually impose the use of assumptions and simplifications, which gives rise to order of magnitude estimates rather than precise results. In this report, data constraints are even more severe than in other studies. Two reasons explain the problem: (i) its timeliness - less than one year after the hostilities occurred - makes it difficult to find accurate data in secondary sources; (ii) no events comparable to this one - in terms of hostilities inducing an oil spill - is available, except for the 1991 Gulf war[12], thus no past experience from similar studies exists.

Based on all the above, this study can be considered the first-time published attempt to estimate the overall environmental damages caused by the hostilities and the resulting oil spill. In many cases, the data constraints often imposed the use of assumptions to arrive at estimates. Every effort was made to use assumptions as realistic as possible and to reflect the degree of uncertainty through ranges of values. In other cases, data constraints were so severe that no estimates could be provided. For example, the impacts of the deterioration of air quality, of the oil spill on health (e.g. skin diseases) and on ecosystem services (e.g. habitat for spawning) could not be estimated.

Ideally, estimating the *net* losses would appropriately reflect the value of environmental damages. However, the severe data limitations prevent the valuation of net losses for most categories of impacts[13]; the available information allows estimating only the *gross* losses for all impacts (even the valuation of gross losses is sometimes difficult and needs to be based on specific assumptions). To be methodologically consistent across valuations, this study estimates the ***gross losses*** for all impacts caused by the hostilities.

It should be noted that valuing the gross instead of net losses leads to overestimating the real value of damage to a certain extent. On the other

[11] In fact, this is the only service which could have been enjoyed elsewhere in Lebanon. Other services (beach resorts, chalets and public beaches, marinas sports activities, etc.) could be enjoyed only on the coast.

[12] To our knowledge, the 1991 Gulf war triggering an oil spill was the only similar case in recent history. An assessment of environmental damages was carried out. However, its economic analysis was limited only to estimating the costs of remedial approaches for each type of oil contamination. *Ref: Monitoring and Assessment of the Environmental Damages and Rehabilitation in the Terrestrial Environment and Marine and Coastal Resources" Public Authority for Assessment of Compensation for Damages from Iraqi Aggression, Kuwait. September 2005.*

[13] Except for the impacts on restaurants.

hand, the study fails to estimate several impacts, thus reflecting only partially the value of environmental degradation. Overall, the estimates should be regarded only as *order of magnitude* and not as precise values.

Table 1.2 Valuation methods used

Impacts	*Method used*
1.Oil spill	
- Impact on birds and turtles[1]	Restoration cost model
- Beach resorts, hotels, restaurant, marinas, fishing, etc	Market price[2]
2. Waste	
- Impact of demolition waste on environment	Cost of transport and disposal
- Impact of UXOs on health	DALYs[3]
- Impact of UXOs on agriculture	Market price
- Impact of medical waste	Cost of disposal
3. Water	Cost of alternative sources
4. Quarries	Hedonic price method
5. Air	Not estimated
6. Forests	
- Impact on forests	Market price[4], substitute goods[5], cost-based methods[6]
- Impact on national reforestation program	Restoration costs

Notes: [1] in Palm Islands Nature Reserve; [2] to estimate the income losses; [3] estimated through Human Capital Approach and Value of Statistical Life; [4] for firewood, charcoal, honey, wax, pine nuts, medicinal and aromatic plants; [5] for grazing; [6] for example, permit price for hunting and cost of protecting biodiversity.

1.4 THE PREPARATION PROCESS

The preparation of this sector note started in September 2006, immediately after the ceasefire. A team of bank staff and international and national consultants undertook the data collection and analysis. The preparation of the study was done in close collaboration with a team of experts from the Ministry of Environment.

The preparation of the study started with a review of relevant literature and documents concerning environmental damage in Lebanon. The team carried out two missions in Lebanon in October 2006 and March 2007 to collect data, conduct interviews and finalize the analysis. A substantial part of data was drawn from secondary sources. In their absence, information from interviews with third parties (e.g. universities, syndicates) was used, whenever relevant. When such information was not available, the team had to rely on specific assumptions, based on personal judgment and verified by local experts.

A first draft of the report was sent to the Ministries of Environment and Finance in June 2007. Comments were received from the Ministry of Environment, the Ministry of Finance and Presidency of Council of Ministers. The report was modified to take into account most comments received.

The remaining of this report presents a detailed analysis of the valuation efforts and of the results obtained. Chapter 2 provides an overview of the main oil spill impacts and estimates them in monetary terms. Chapters 3-7 value the impacts of the hostilities on waste, water, quarries, air and forests.

The results of this report should raise awareness at national and international levels on the social and environmental costs imposed by the hostilities on the Lebanese society.

Chapter 2. OIL SPILL

On July 13 and 15 2006 the bombing of Jiyeh power utility, located 30 km south of Beirut, led to serious burning and spilling of heavy oil into the Mediterranean Sea. This chapter discusses and estimates the impacts of the oil spill on the country's economy and the environment. It first provides an overview of the oil spill and a qualitative description of its impacts on biodiversity, ecosystems and water quality (Section 2.1). It then analyzes the main methodological issues encountered during the valuation (Section 2.2). Further, it estimates the costs of the oil spill and oil clean-up (Sections 2.3 to 2.11). Finally, the chapter summarizes the results and provides recommendations for a better ecosystem management (Sections 2.12-2.13).

2.1 OIL SPILL: BACKGROUND AND IMPACTS

The storage tanks of the coastal Jiyeh electrical power plant in southern Lebanon were hit by bombs on 13 and 15 July 2006 (Figure 2.1). In preparation for the summer needs, it was estimated that the storage tanks were fully supplied with approximately 44,000 tons[14] of stored Intermediate Fuel Oil (IFO)[15]. As a result of the bombings, part of the oil was burned while the rest was released to the environment, including into the Mediterranean Sea. The amount of oil that entered the marine environment is estimated by MOE at 12,000 to 15,000 tons. This section discusses the most important background information related to the oil spill and its impacts.

[14] Communication with MOE, August 2007

[15] According to tests done by CEDRE, the oil spilled appeared to be an Intermediate Fuel Oil (IFO) with a viscosity of 150 CentiStokes (cSt) at 50°C. www.cedre.fr

Figure 2.1. Jiyeh electrical power station and tank.

Before the bombings
Photograph courtesy of Google Earth

After the bombings
Photograph courtesy of MOE

2.1.1. Background

Initial Oil Movement: Because of the ongoing hostilities until 14th August, 2006 and the following air and naval blockade, limited mitigation was possible before 9th September, 2006[16]. The Lebanese Government asked technical support from the European Union, who facilitated the obtainment of MEDSLIK from the Oceanography Centre, University of Cyprus. This is a computer model able to calculate the oil spill trajectory and fate, developed for the eastern

[16] Despite the on-going hostilities and a difficult situation on the ground, teams from the Ministry of Environment along with other NGOs and volunteers were tracking the oil spill since July and started clean up operation (in Byblos for example) as early as August 2006.

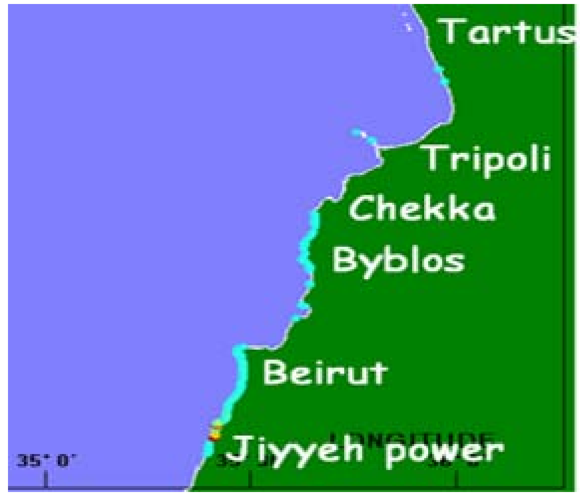
Mediterranean. The program was run from July 13th to August 3rd, 2006.

Winds for the period were dominantly from the west-southwest to east-northeast (onshore and to the north). Ocean currents, derived from the Cyprus Ocean Forecasting System, were very strong to the north for the same period. As oil transport is dominated by currents and winds, the spilled oil moved northward and onto the shoreline, with heaviest impacts occurring between Jiyeh and Beirut, between Byblos and Chekka by 18-19 July,2006, and onto the Palm Islands offshore of Tripoli by 29 July, 2006 (Figure 2.2). Other areas generally showed patchy impacts. Oil reached Syrian waters (3 August, 2006) and impacted the shoreline as observed at Tartus. The results of the computer model were, for the most part, confirmed by shoreline surveys overseen by MOE.

Offshore Oiling: As shown by the MEDSLIK model, satellite image analysis and aerial surveys by several parties, most of the oil remained relatively close to the shoreline, as summarized in Figure 2.3.

Shoreline Oiling: In spite of the ongoing violence, MOE completed an initial shoreline assessment between 18 July and 9 August, 2006, and developed a list of impacted sites (Experts Working Group, 2006, Annex 2). Surveys were again continued at the end of August and coordinated by MOE with international assistance. Reports from August/early September, 2006, indicate that heavy pooled oil existed in coastal coves and harbors, and that sand and gravel beaches south of Beirut and around Byblos to the north showed surface and buried oil.

Figure 2.2 Oil impact areas 15 July to 2 August 2006 (from the MEDSLIK oil spill model)



Map Courtesy of Cyprus Oceanography Center, University of Cyprus.

Figure 2.3. The presence of oil slicks based on 6 satellite images. The darker / red colors indicate an increased number of images where oil was observed between 21 July and 10 August 2006

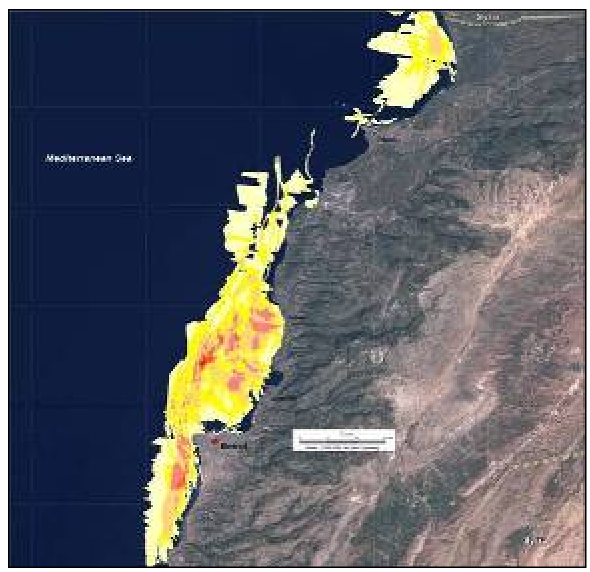


Image Courtesy of the Center for Satellite Based Crisis Information, Emergency Mapping & Disaster Monitoring, German Remote Sensing Data Center

Bottom Oil: It is relatively rare that spilled oil sinks to the bottom as most oils have a specific density less than water and stay on the surface. However, there are several observations of oil on the bottom during this spill, probably a result of (a) oil burning (which created neutrally buoyant to slightly heavier-than-water material) and (b) heavy oil concentrations mixing with sediment to form oil mats on the bottom. A similar occurrence was noted at the *Haven* spill of crude oil during which quantities of oil sank after the supertanker burned offshore of Genoa, Italy. Principal areas where bottom oil was observed are adjacent and offshore of the Jiyeh power plant (Figure 2.4) and offshore of heavily oiled coastal areas in Beirut and Byblos. The Italian Mission reported on 26 September, 2006, that the approximate density of the bottom oil was 1.2 g/cm^3 and had a 50% weight content of sand.

Figure 2.4 Example of bottom oil breaking into ropes.

Photograph courtesy of M. El Sarji

Oil Chemistry: Cedre (Centre de Documentation de Recherche et d'Experimentations Sur Les Pollutions Accidentelles des Eaux) analyzed several oil samples, including 6 from Syria (Cedre, 2006). The IFO 150 spilled is characterized (Table 2.1) as having high saturate levels (for an IFO) and low aromatics (>50% saturates, <28% aromatics). The oil shows a biodegradability of about 47%, after which non-degradable tars and resins would be expected to remain. Although biodegradation is not active on the remaining residues, physical weathering (e.g. movement by wave action) is likely to continue to remove portions of the remaining residue. In terms of the spilled oil analyzed from Syria, one sample was a close match to the Jiyeh oil, three samples were similar to it but could not be positively attributed to Jiyeh oil, and two samples were not related. The Jiyeh oil has relatively low toxicity because of its low aromatic content. Its toxicity is lower than that of the *Prestige* and *Erika* spills and to other fuel oils, according to Cedre analyses (Table 2.2).

Table 2.1 Analysis of samples from the oil spill and biodegradability

	2 Sample Average	Biodegradability
Saturates:		
n-alkanes	4.4%	4.4%
Iso-alkanes	1.15%	3.6%
UCM	45.3%	22.65%
Aromatics	0.75%	0.75%
Resolved UCM	26.9%	13.45%
Resins	12.8%	
Asphaltines	8.65%	3.25%
		45.65% (total)

Source: Cedre, 2006.

Table 2.2 Comparison of Jiyeh fuel oil to other spills and the Cedre testing fuel

	Saturates	Aromatics	Resins & Asphaltenes
Jiyeh (IFO 150)	50	28	22
Erika (heavy fuel no. 6)[a]	23	53	24
Prestige (heavy fuel no. 2 M100)[a]	22	56	22
Testing Fuel	20	53	27

Source: Cedre note by F. Merlin to MOE; [a] www.cedre.fr

According to the U.S. National Oceanic and Atmospheric Administration (Yender et al., 2002), this type of oil has relatively low impact potential on fisheries and invertebrates, due to the low content of (acute) toxic hydrocarbons. (McCay et al. 2004). Environmental problems linked to this type of oil are mainly caused by its physical properties, such as the tendency to stick to objects and surfaces (UNEP, 2007) (Table 2.3).

Table 2.3 Oil characteristics and potential for affecting seafood and other biota

Oil Type	Heavy Crude Oils and Residual Products (IFO 150)
Floats or Sinks	Usually floats but can sink if they emulsify or mix with sand and deposit in the nearshore.
Evaporation	Very little evaporation; will form persistent residues.
Viscosity	Very viscous to semi-solid; will not readily disperse or mix into the water column; can form stable emulsions.
Risk to finfish and other biota	Low risk of finfish contamination because of low water-soluble fraction; moderate to high risk of shellfish contamination where shoreline oiling is heavy; can coat gear and intertidal species.
Submerged oil	Where thick oil accumulates, could become a chronic source of moderate to high risk of contamination of benthic species because of coating and persistence of submerged oil.

Source: Modified from NOAA, 1997; Yender et al. 2002.

Mitigation Activities: Techniques to mitigate and/or reduce the environmental and social impacts of an oil spill commonly include containment and recovery of the oil at sea, dispersant use, use of shore-attached booms to protect sensitive shorelines, and skimmers, boom and sorbents for onshore oil recovery. Some mitigation efforts were launched in early August, such as cleaning of Byblos, Sporting Club and Chekka beach. However, due to the hostile conditions during hostilities and the lack of equipment, major mitigation efforts did not begin until September 2006.

The principal mitigation strategies are described in the International Assistance Action Plan (Experts Group for Lebanon, 2006) supervised by REMPEC (Regional Marine Pollution Emergency Response[17]). MOE priorities as set forth in the International Assistance Plan are shown in Table 2.4.

[17] Members of the experts group that assisted in the development of the Plan include UN OCHA (United Nations Office for the Coordination of Humanitarian Aid), IMO /REMPEC (International Maritime Organization), EC/MIC (European Commission/Monitoring Information Centre), ITOPF (International Tanker Owners Oil Pollution Fund) and ICRAM (Instituto Centrale di Ricerca scientifica e technologica Applicata al Mare).

Table 2.4 Mitigation priorities for the spill.

First Priority
1. Response techniques, information and training. 2. Aerial and site surveys. 3. Response to offshore drifting oil slicks after aerial confirmation of presence and location. 4. Protection of sensitive sites not already contaminated 5. Recovery of floating oil in ports and confined areas and pooled oil in any area. 6. Recovery of the bulk of oil on major amenity beaches or important tourist sites.
Second Priority
1. Recovery of stranded oil in sediments (sand, pebbles). 2. Clean up of ports and boats. 3. Clean up of secondary tourist sites and amenity beaches.
Third Priority
Final cleaning.

Source: IAP (Experts Group for Lebanon, 2006).

After the ceasefire on August 14th 2006, the Action Plan was implemented with international support. Following MOE priorities, the bulk and mobile oil in ports was recovered using skimmers (September/early October). Additional effort went to recover bottom oil and place booms to contain oil. By October 2006, only limited quantities of floating oil were present, and mitigation activities shifted to surf washing of oily beach sands and gravels, and high-pressure spraying of oiled rocks, seawalls, marinas, and boats. Outside of MOE supervision, heavy machinery was used at several beach areas to move oiled sand from the intertidal area. These efforts served to reduce the amount of oil in the environment and its potential environmental impacts. Photographs of typical mitigation measures taken are shown in Figure 2.5.

2.1.2. Spill impacts on biodiversity and ecosystems

The following describes each major biodiversity component and the likely effects of this spill on it. The major components include:

- shoreline biota
- subtidal bottom communities
- birds
- marine reptiles
- marine mammals
- fish
- nature reserves

Figure 2.5. Examples of mitigation measures: Top - oil booming and recovery in Byblos Port. Bottom – clean up of oil from sandy beaches in Ramlet El Baida

Photograph courtesy of MOE

Photograph courtesy of MOE

Impact on Shoreline Biota

The primary impact observed on shorelines is direct oiling and smothering of organisms on rock-dominated shorelines. Shorter-term impacts (weeks-to-months) may have occurred on sand and gravel beaches in heavily impacted areas. Natural cleansing by wave action, assisted by beach washing by the mitigation effort, aided the recovery on sand and gravel shorelines. Because this oil greatly adheres to rocky shorelines, natural cleansing in these areas is slow and mitigation efforts (high-pressure washing) are tedious and time-consuming.

The principal shoreline types in terms of biological communities are sandy beaches, gravel beaches, boulder beaches, low-lying rocky terraces, and sloping-to-vertical rocky shores. Rock-dominated (limestone) shorelines comprise approximately 80% of the coast, partially due to substantial losses of previously identified sandy shorelines (Dimirayak et al., 2001). The tidal range for Lebanon averages from 15 cm to 30 cm, with a maximum of up to 50 cm (IUCN/Green Line, 2006).

Common species in the supralittoral (spray) zone include snails (e.g. *Litorina, Ligia Italica, L.* oceanica) and lichens (black *Verucarria amphibia* and yellow-orange *Xanthoria*) (MOA-UNEP, 1996). In the intertidal (littoral) zone of the eastern Mediterranean, organisms include crabs, snails, amphipods, limpets, bivalves, and polychaete worms, depending on substrate stability (Barnes and Hughes, 1999). Table 2.5 describes each shoreline type and summarizes impact. Example photographs of oiling on each shoreline type are shown in Figure 2.6.

Table 2.5 Major shoreline types in Lebanon and injury to coastal organisms from the oil spill

Shoreline Type and Biota	*Effects of the Spill*
Sandy Beaches Crabs, amphipods and other infauna. (May be mixed with shells – *Donax, Glycimeris, Murex, Strombus, Tapes, Cardium)*	On heavy oiled beaches near the spill site, likely that some biota in the beach were killed. Crabs 2 months later showed normal rapid escape on oiled beach. No narcotization or death by oil concentrations in the water column reported.
Gravel Beaches Usually few to no organisms present because of substrate movement.	Probably little impact on organisms because gravel beaches generally low in fauna and attached organisms.
Boulder Beaches Some attached algae and organisms present where boulders remain stable. Most abundant populations are in the lower intertidal, generally below oil impacts.	Likely smothering where concentrations are heavy.
Low-lying Rocky Shores In mid-to-lower intertidal area, the substrate is may have attached algae, mollusks (e.g. limpets and snails) and crabs.	Under moderate-to-heavy concentrations, oil smothers attached organisms. Lower intertidal areas commonly remain free of oil because of wave washing.
Sloping to Vertical Rocky Shores Contain attached algae and mollusks.	Likely smothering of mid tidal attached organisms, extending to lower intertidal when oil comes ashore heavy and under calm conditions, but generally lower intertidal remains free of oil.

Source: Field observations and MOA-UNEP, 92.

As indicated in Table 2.5, the principal effect of the spill on the inter-tidal community is caused by oil coating and smothering, particularly on low-lying rocky terraces where oil had a chance to settle. Impacts due to oil toxicity are expected to be relatively low outside of the immediate spill source area because of oil type and weathering. On rocky shores most impacts are in the mid to upper tidal areas, above the biologically more productive lower intertidal zone. On sand and gravel beaches short-term losses to resident biota in heavily oiled areas was likely. The National Center for Marine Sciences (NCMS) conducted an impact assessment and sampling from different parts of the shoreline. The preliminary results indicate that microscopic inter-tidal organism present in sandy beaches (patella, periwinkles, mussels, algae, oysters, meiofauna) have been 90% polluted by the spill (UNDP, 2007).

Figure 2.6 Examples of oil impact on major shoreline types

Byblos oiled gravel beach being cleansed by wave action in active intertidal zone.

Oiled steeply sloping rocky shore at Enfe.

Photographs courtesy of E.Gundlach, Oct 06

Impact on Subtidal Communities

Impacts on the bottom communities is most evident where oil mats on the bottom smothered the resident organisms, as observed in the nearshore areas off the Jiyeh power plant, off heavily oiled Beirut. Other areas were free of oil and showed no obvious effects. There were no adverse observations of oil spill on bottom communities resulting from chemical toxicity in water column, commonly manifesting as dead organisms on the bottom or the shoreline stranding of numerous live but narcotized critters as at *Amoco Cadiz* (Gundlach and Hayes, 1978) and the *North Cape*[18] oil spills.

It appears that potential injury by smothering occurred only in the localized areas where large tar mats were present on the bottom. The Italian Mission observed some smothered sponges and corals (Madrepores) in the vicinity of the power plant. (Italian MOE report, 2006)

Oil covering the bottom in the Jiyeh area (Figure 2.7) was measured at 50,000 m^2 by the Italian Coast Guard which surveyed over 206,900 m^2 of the nearshore area (Guardia Costiera Italiana, 2006). The sunken oil is covered by a sand layer that makes it difficult to view; however the oil has occupied every space between the rocks. An active program using divers removed large amounts of bottom oil in Sept-Oct,06. The recovery of bottom communities is expected to be rapid after removal of the oil mat.

Figure 2.7 A diver removing bottom oil in Jiyeh

Photograph courtesy of M. El Sarji

[18] http://www.oil-spill-info.com/Photo%20Mainframes/Mainframe%20North%20Cape.htm

Impact on Bird

Shorebirds and marine waterfowl birds are likely to have been injured because the oil stayed fairly close to shore and oiled large sections of coastline where birds typically forage. Fortunately it was not the migratory season[19] and the resident bird population is relatively low.

During the major part of the spill (July to October, 2007), no dead or heavily oiled birds were reported. However, despite the measure of protection through the rapid clean up operation and the installment of bird deterrents, 92 oiled birds were observed following that period till April 2007 in the Palm Islands Nature Reserve. This is probably due to the oil resurfacing after winter storms on the Island, impacting the winter visitors.

The indirect effects of the spill are much harder to determine. While an oil-covered bird is clearly affected, partial oiling gives the appearance that the bird 'survived' the spill, only to have it die sometime later from oil ingested during preening or other complications. Oil ingestion may also occur as shorebirds scavenge oiled critters along the shoreline.

Other long-term injury to birds may occur as the food source (shoreline organisms and fish) of the bird is damaged by a spill, resulting in an inability to sustain the previous level of bird population. Such injury is particularly difficult to assess, as it may occur over a period of several years after the spill. A major reduction in the number of visiting birds on Palm Islands Nature Reserve has been observed by the Government Appointed Committee (GAC) managing the reserve due to the contamination of habitat and possible loss of access to food. Three contaminated rocky and sandy areas represent the feeding site of many marine and shore birds, whereas the rocky areas correspond to the breeding site of the Yellow-legged Gulls[20].

[19] The migration season along the coastal zone of Lebanon begins in September.

[20] Based on interview with Dr. Jaradi (Professor of ornithology and President of the Government Appointed Committee of Palm Islands Nature Reserve) April 2007.

In summary, although direct effects of the spill on birds were relatively minimal, indirect effects to some degree are likely to be felt for many years to come. Loss of wintering birds could result from the smothering and destruction of the fauna, which constitutes food for many of species.

Impact on Marine Reptiles (Turtles)

Marine turtles that are present in Lebanese waters are listed in Table 2.6. All marine turtles are classified globally as threatened species and are protected by most Mediterranean countries. Loggerheads are listed as Endangered while the Green Turtle is Critically Endangered (IUCN, 2006a).

Table 2.6 Turtle species present in Lebanese waters.

Species	*Distribution*
Green Turtle *Chelonia mydas*	Generally found in shallow waters along reefs, in bays and estuaries
Loggerhead Turtle *Caretta caretta*	Inhabit estuaries, lagoons, bays and ship channels in warm and temperate seas and oceans worldwide.
Nile Soft–shelled Turtle *Trionyx triunguis* .	Small populations found in Egypt, Lebanon and Syria.
Leatherback Turtle *Dermochelys coriacea*	No records of leatherback breeding in the Mediterranean, but sporadically observed in the Eastern Mediterranean.

Source: BTC, 2003; Dimirayak et al., 2001 ; MOA-UNEP, 1992 ; IUCN, 2006a.

Comparison of the oil impact areas to beaches having turtles in 2001 (Dimirayak et al., 2001) showed that three oiled beaches had turtle nesting (Jbail and Palm Islands Nature Reserve, Ramlat Al-Baida) (Annex 2). Other sites, for example Jiyeh and Damour, were oiled but it is unknown if that had active turtle nesting.

Turtle areas to the south of the spill site were not directly affected by the actual spill but rather by direct bombing of the conservation site at Mansouri Village, south of Tyre (UNDP, 2007). However, as of May 2007, some fuel patches were observed in Tyre Coast Nature Reserve. This could be the result of southern currents dragging some of the remains of the oil spill[21]. Hatchlings released from the nesting sites into the northward flowing nearshore waters would bring them in contact with the spill. Primary turtle feeding areas are in nearshore shallow waters around coral reefs, directly where the oil spill passed. There was a high potential for turtles to be in the area of the spill. Mating takes place in shallow waters and starts in late April in the Eastern Mediterranean. Nesting activity generally starts in May and lasts until late August, with a peak around mid-July, the time of the incident. Depending on the species and temperature, the hatching season generally ranges from late June / early July to September.

The presence of oil on sand beaches having nesting sites has the following potential effects:

- Digestion / absorption of oil through food contamination or direct physical contact may lead to damage of the digestive tract and other organs.
- Irritation of mucous membranes leading to inflammation and infection.
- Egg contamination and injury to the developing turtle because of oiling of the nesting area.
- Injury to the newly hatched turtles as they cross over an oiled beach to reach the water after emerging from the nest.

At these beaches, egg-laying was observed by the Government Appointed Committee President during two periods: first before the spill arrived and then after the sand beaches was manually cleared of oil. Hatchling emergence similarly was fortunately timed and avoided oiling. No turtles or hatchlings were observed to be oiled. However, three loggerhead turtles were found dead on Palm Islands Nature Reserve.

While this was the case at this single locality, what happened at other sites is unknown. However, it is likely that there was contact between turtles and oiled beaches during the weeks of shoreline oiling. In addition, turtles, young or old, show no avoidance to spilled oil, and some may have been oiled during the weeks that oil was floating northward in the same waters used by the turtles. Furthermore, as hatchling turtles feed in driftlines which concentrate macroplanktonic prey (Carr, 1987), they are particularly likely to contact with floating oil and tar balls from the spill which also concentrate in the same driftlines. Therefore, even though few dead turtles were found, there is strong likelihood that many individuals were affected by the spill, possibly having a longer-term impact on the already low population in this area.

Impact on Marine Mammals

Mammals found in the eastern Mediterranean Sea range from dolphins to Sperm Whales, Fin Whales and the rare Mediterranean Monk seal. However, some of these populations are under severe pressure due to loss of habitat, illegal fishing and deliberate killing. No injured dolphins were observed in the area of the spill. Dolphins are commonly expected to take action to avoid contact with the spill. The presence of whales is rare in Lebanese waters and no injuries were reported. The Mediterranean Monk seal, a critically endangered species on the IUCN Red List, has been occasionally observed on Palm Islands Nature Reserve in the last decade (MOE, 2004). The Aegean Sea and the area between the south coast of Turkey and the north Coast of Cyprus are the most important areas for this species. While no injuries were reported, the movement of tar balls and other hydrocarbons from the spill with the currents might impact the already stressed population of remaining seals.

Impacts on Fish[22]

There were some reports in the media of a small number of dead fish or of fish eliciting unnatural behavior due to the oil spill. However, indirect effects may occur as the food source to the fishery was likely reduced during the spread of the spill. Data at this time are insufficient to determine if fish catch has been reduced by the spill because of insufficient baseline and the

[21] Interview with R. Abu Salman (IUCN, Mediterranean)

[22] The analysis of the impact on commercial fishermen is presented in Section 2.9.1.

naturally high variability inherent in fish statistics.

There are 650 species of fish recorded as present in the Mediterranean Sea. Annex 2.3 presents the primary species of Lebanon, the seasonality of capture and a summary of observed injury to fish and fisheries. In broad terms, and as indicated in other spill cases, fish larvae and eggs are the most sensitive phase of the fishery. Adult fish may be affected, particularly bottom fish in relatively shallow areas and where oil incorporates into the water column. Impacts to open water pelagic fish are less likely.

Although losses of fish larvae and eggs can lead to a reduction of the adult population, such losses are extremely difficult to detect. Fish stocks are difficult to monitor and influencing factors are not always apparent. Fish populations also historically vary to such an extent that minor perturbations such as caused by a limited oil spill are within the range of variability and, therefore, non-detectable.

Even if the species are not killed outright, there may be a chemical uptake of petroleum hydrocarbons in the fish. The Lebanese National Marine Center, aided by analyses from Ifremer, found no uptake in fish samples taken at five locations along the coast on 22 August (Ministry of Agriculture, 2006). Benzo(a)anthracene, benzo(b)fluorantene, ben-zo(k)fluorantene, benzo(a)pyrene, and dia-benz(ah)antracene were all at naturally expected levels. UNEP conducted further analysis of fish samples and found the petroleum hydrocarbon and polycyclic aromatic hydrocarbons levels to be normal for fish in the eastern Mediterranean (UNEP, 2007).

In summary, there were no observed direct effects of the spill on fish. However, damage to fish larvae and eggs, impacts to the nearshore breeding areas, as well as oil uptake during feeding, are likely to have injured individual fish and may have reduced the fish population in Lebanon on a short term basis.

Impact on Nature Reserves

There are two nature reserves along the coast of Lebanon, one at Tyre (south of Jiyeh) which remained unaffected by the spill, and the other at Palm Islands Nature Reserve to the north, parts of which were heavily oiled at the end of July 2006.

The Palm Islands Nature Reserve comprises of three low-lying rocky islands. The main island (Palm Islands) has two large sand beaches, also utilized for recreation. The island group has several important designated areas, including Important Bird Area, Ramsar site, and Mediterranean Specially Protected Area. It is protected nationally, both on the land surface and by restrictions on nearby fishing. It is noted for its high biodiversity, stopover for thousands of migratory birds (156 recorded species), nesting area for both the green and loggerhead turtles, potential refuge for the endangered monk seal, and refuge for numerous endemic and coastal plant species.

According to Palm Islands survey on 7th October , 2006, made by IUCN, Swiss Aid and Rempec/Cedre (Kremer et al., 2006) the status of oil pollution in islands was the following:

- Ramkin Island: a large polluted area on the south part of a small island which is on East side of Ramkin Island: about 30 to 50 m long x 5 to 10 m wide;
- Palm Island: between 6 to 10 crevices heavily polluted;
- Sanani Island: a large polluted area, about 50 m x 10 m.

A field visit undertaken on October 2006 as part of this report found that the sand beaches were free of oil but that many parts of the low-lying rocky shoreline were heavily coated (Figure 2.8). Damage done to the invertebrate community in Palm Islands Nature Reserve has been observed. The contaminated rocks lost Sea tomatoes (cnidarians), worms, sea urchins, sea cucumbers, crabs, small crustacean and a variety of mollusks. These constitute food source for many migrating birds which use the island as a stopover.

Plants on Palm and Sanani Islands were heavily impacted. Rocky Salicorn and Sandy Euphorb plants were contaminated to the extent that some were totally covered by oil. Four plant species on the reserve were affected (Ramadan-Jaradi, 2007):

- The Golden Samphire on Sanani Island;
- The Sea Spurge on the upper beach line;
- Glasswort on Sanani Island;
- Sea Purslane on Ramkine Island.

The toxins in the oil most probably killed the plants, which could lead to erosion. The GAC are containing the damage by only clearing the polluted parts of the plants and encouraging a process of regeneration (UNDP, 2007)

The Ministry of Environment and the Palm Islands Nature Reserve GAC, working with IUCN, has proposed a program to remove the remaining oil (primarily asphaltic mats and rock coating) from the islands. The first phase of clean up (involving manual cleaning of rocks using pressurized water) was completed in January 2007.

Figure 2.8 Sand beach free of oil (top) and polluted rocky beach (bottom).

Photograph courtesy of E. Ikaheimo

Photograph courtesy of MOE

2.1.3. Spill impacts on water quality

The calcareous coast of Lebanon is characterized by heavily fractured limestone. One of the potential impacts of the spill is contamination of groundwater through seawater intrusion, which occurs in densely fissured zones. While this is a natural occurrence, the over extraction of groundwater has emphasized this phenomenon. UNEP conducted laboratory analysis on groundwater samples collected from Mina Daliyi in Beirut and the coastal area immediately north of Jiyeh at Saadiyat, both known fracture zones, and did not discover high concentrations of soluble hydrocarbons. However, dense non-aqueous phase liquids (DNAP Ls) and the high volatility of hydrocarbons may cause the contamination to go unobserved (UNEP, 2007).

2.2 METHODOLOGICAL ISSUES AND ASSUMPTIONS

This section estimates the environmental damages caused by the oil spill on the coastal zone. It values the users' forgone benefits through the differences between the *expected* and *actual* benefits derived from activities on the coast. Expected benefits refer to the level of environmental benefits which would have been enjoyed, had the oil spill not occurred, whereas actual benefits are those currently provided after the outbreak of the conflict.

Valuing the impacts of oil spills has always been a challenge for analysis. Chas-Amil *et al.* (2004) report that valuation problems are related to a wide range of factors e.g. the types of goods and services in question, the space and time scale, the sectors affected, the poor quality of available statistics and the possible existence of irreversible and long-term effects. In the same light, Grigalunas *et al.* (1986) summarize the empirical and conceptual problems as follows:

- the extra-market pricing of government-owned resources and volunteer labor used in clean-up efforts;
- the determination of fisheries losses in absence of accurate biological data;
- the estimation of non-market losses to tourists;
- the decision on how or whether to account for the distribution of costs.

Efforts to estimate the impacts of the oil spill incidents worldwide have encountered most of these problems and the Lebanese case is no exception. While most valuation problems are dealt with in the subsequent sections, two issues deserve special attention, as presented below.

2.2.1 How long do the oil spill impacts last?

Estimating the time horizon during which the impacts of the oil spill are likely to occur is a complex issue. Examples of other oil spill incidents show that the time frame of damage may vary widely, depending on the type of oil, quantity spilled, type of ecosystem services affected by the oil spill, species affected, etc (Table 2.7). For example, in 1992, the damage provoked by the Aegean Sea oil spill (in Galicia, Spain) of 70,000t had not fully recovered after 10 years (Chas-Amil et al., 2004). It was also suggested that recovery of different species of shellfish would vary from a few months to more than 12 years. In 2002, the damage provoked by the Prestige spill of 64,000t of oil (in Galicia, Spain) had a severe impact on local biodiversity, and recovery would take between 2-10 years (Loureiro et al., 2006).

Table 2.7 Major Oil Spills since 1990

Year	Shipname	Type of oil	Location	Spill Size (tonnes)
1979	Atlantic Empress	Crude oil[a]	Off Tobago, West Indies	287,000
1991	ABT Summer	Crude oil[b]	700 nautical miles off Angola	260,000
1983	Castillo de Bellver	Crude oil[b]	Off Saldanha Bay, South Africa	252,000
1978	Amoco Cadiz	Crude oil[a]	Off Brittany, France	223,000
1991	Haven	Crude oil[a]	Genoa, Italy	144,000
1988	Odyssey	Crude oil[b]	700 nautical miles off Nova Scotia, Canada	132,000
1976	Urquiola	Kuwait crude oil[a]	La Coruna, Spain	100,000
1979	Independenta	Crude oil[b]	Bosphorus, Turkey	95,000
1975	Jakob Maersk	Iranian crude oil + Bunker C[a]	Oporto, Portugal	88,000
1993	Braer	Crude oil	Shetland Islands, UK	85,000
1989	Khark 5	Iranian heavy crude oil[a]	120 nautical miles off Atlantic coast of Morocco	80,000
1992	Aegean Sea	Light crude oil[a]	La Coruna, Spain	74,000
1996	Sea Empress	Light crude oil[a]	Milford Haven, UK	72,000
1992	Katina P	Crude oil[b]	Off Maputo, Mozambique	72,000
2002	Prestige	Heavy fuel no. 2 (M100)[a]	Off the Spanish coast	63,000
1989	Exxon Valdez	Crude oil[a]	Prince William Sound, Alaska, USA	37,000

Source: http://www.itopf.com/stats.html (except for [a] www.cedre.fr; [b] http://en.wikipedia.org/wiki/List_of_oil_spills)

Estimating the time frame of damage becomes even more complicated when unexpected impacts occur some time after the event. For example, the Exxon-Valdez oil spill in Alaska provoked a sudden death of fish population 3 years after the accident (Fall *et al.*, 2001). The Aegean Sea spill caused a 33% fall in catch no less than 6 years after the event (Chas-Amil et al., 2004).

In case of Lebanon's oil spill, no precise information on the time frame of its effects is yet available. This is partly because the short lapse of time between the accident and the undertaking of this study did not allow collection of long series of data related to damages. Available information suggests various time frames for the analysis. For example, UNDP (2007) reports that the oil spill had a serious impact on marine biodiversity which is expected to last for 10-50 years, and a catastrophic impact on the littoral, expected to last for 1-10 years. Local experts in Lebanon have other perceptions according to the resource affected by the oil spill. For example, the Director General at the Ministry of Tourism suggested that tourism recovery on the coast would take at least a few months (for national tourists), one year (for Arab tourists) and several years (for other foreign tourists)[23].

The World Bank team carried out two field visits to the Lebanese coast in October 2006 and March 2007. The objective was to do visual inspections of the coast and marine water and to have discussions with interested parties (hotel owners, managers of beach resorts, restaurants, fishermen) in order to get a realistic sense of the duration and intensity of the oil spill effects on the coast. The information collected during these visits indicates that:

- The strongest impacts of the oil spill on coastal activities covered the period between the ceasefire until the end of December 2006. The activities taking place in or closest to the sea were the most affected, e.g., sports activities of marinas (such as boating and diving), sea fishing and international tourism in Palm Islands Nature Reserve and Byblos World Heritage Site.

- In 2007, we can assume that the visual effects of the oil pollution will significantly subside, on condition that restoration and cleanup efforts will continue. This assumption appears credible when we observe that today (April 2007), there appears to be little or no oil in the water column and a good portion of sandy beaches has been cleaned. There is still evidence of isolated impacts of oil spill, provoked by the bottom oil which occasionally washes up on shore, and oily rocky surfaces not yet cleaned.

- In 2008 and after, the oil spill may still have impacts at site level, either because the environment was not appropriately cleaned or because the perception of the potential negative effects on health still persists. Less likely effects can take place in later years (eg. the sudden declines in certain fish populations).

Based on the above, this report adopts a 3-year time frame for the analysis, 2006-2008, during which the losses will gradually subside. This is a conservative time frame, as it does not capture potential effects not yet probed or that may occur over an extended period of time. Among the possible effects not covered by the study are the impacts of the oil spill on health (such as skin diseases or digestive diseases due to eating contaminated fish), on ecosystem services (such as habitat for spawning, potential groundwater contamination) and on marine biodiversity.

2.2.2 Oil spill contribution to loss

This chapter focuses on estimating the damage caused by the oil spill only although both the hostilities and the oil spill caused damage to the coastal zone. Moreover, the two factors are tightly linked: the oil spill is a direct consequence of hostilities themselves. Therefore, it is very difficult, if not impossible, to accurately separate the contribution of the oil spill to the overall damage on the coast.

A review of studies on other significant oil spill incidents such as Exxon Valdez (e.g. Cohen, 1995; Carson et al., 2003; Monson et al., 2000) Prestige (Loureiro et al., 2006), Erikka (Bonnieux and Rainelli, 2002), Amoco Cadiz (Grigalunas et al., 1986) indicate that none of them was related in any way to hostilities. Thus, available studies do not give any example or guidance on how to separate the extent of damage according to the cause, because no combined causes are involved. To our knowledge, there has been only one other case in recent history – the 1991 oil spill in

[23] Interview conducted by the study team with representatives from the Ministry of Tourism in October 2006.

Kuwait induced by the Gulf war - similar to the case of Lebanon. However the economic analysis was very limited[24].

Even if strong scientific information were available in relation to other oil spill cases, it would not necessarily apply in a similar way to this case. When hostilities are not an issue, the extent of the economic impact of an oil spill depends on several factors, e.g. the type of oil, the characteristics of the ecosystems affected and their economic use, the difficulties involved in clean-up operations and how long it lasts (Chas-Amil *et al.*, 2004). For example, French McCay et al. (2004) estimate that the potential impact of oil spills on natural resources may range from as little as 2% to as much as 50% of the total socio-economic, environmental and response costs, depending on the type of oil, volume percentile and other characteristics. This confirms once again the complexity of the valuation process due to the stochastic nature of the oil spills.

All the above suggests that there is inconclusive information on the contribution of oil spill to the overall coastal damage in not only Lebanon, but elsewhere too. In addition, this study relies only on secondary information and data collected through rapid interviews during October 2006 and April 2007. No primary surveys[25] were conducted for this study, neither were they available at the time of valuation. Because of that, the report had to rely on several assumptions in order to arrive at damage estimates.

Every effort was made to use assumptions as realistically as possible and to reflect the degree of uncertainty through ranges of values. Although they remain subjective and rough to a large extent, all efforts were made to ensure that they are made under conservative criteria, which were later validated by several expert opinions.

Table 2.8 illustrates the assumptions used to estimate the impacts of the oil spill on each activity on the coast. As more data were available for 2006 compared to successive years (eg. expected income or forgone benefits from coastal activities), the assumptions for 2006 rely on the baseline information we found and, consequently, vary from one activity to another. The subsequent sections explain them in detail.

By contrast, the scope of this study made it impossible to collect data for 2007 and 2008. Consequently, estimating the effects of the oil spill in this period was even harder. It is reasonable to consider however that the continuous clean-up efforts will lead to a gradual decline of these effects in future years. Accordingly, the report conservatively assumes the impacts of the oil spill to be about 5-10% of expected income in 2007 and 0-5% in 2008 for all coastal activities. These assumptions are based on the experts' best knowledge at the time of valuation.

Table 2.8 Damages caused by the oil spill

Impacts on:	2006		2007	2008
	Jul-Aug[b]	Sep -Dec	Jan-Dec	Jan-Dec
	% of expected income:			
Commercial fishing	0	50[a]	5-10	0-5
Shore-side fishing	0	50[a]	5-10	0-5
Hotels	0	10-20	5-10	0-5
Byblos World Heritage Site	0	25-50	5-10	0-5
Beach resorts and chalets	0	25-50	5-10	0-5
Palm Islands Nature Reserve	0	75-100	5-10	0-5
Restaurants	0	75-100	5-10	0-5
Marinas Sport Services	0	75-100	5-10	0-5

Note: [a] of forgone income instead of expected income. See explanation for the 2006 assumptions in the subsequent sections; [b] The significant impact of the oil spill during July-August was overshadowed by that of hostilities, which halted completed the recreational activities on the coast. Thus we assume that all losses during July-August are caused by the hostilities themselves.

[24] To our knowledge, the 1991 Gulf war triggering an oil spill was the only similar case in recent history. An assessment of environmental damages was carried out. However, its economic analysis was limited only to estimating the costs of remedial approaches for each type of oil contamination. *Ref: Monitoring and Assessment of the Environmental Damages and Rehabilitation in the Terrestrial Environment and Marine and Coastal Resources" Public Authority for Assessment of Compensation for Damages from Iraqi Aggression, Kuwait. September 2005*.

[25] Such as the Contingent Valuation Method (CVM) or the Travel Cost Method (TCM).

2.3 HOTELS AND FURNISHED APARTMENTS

The hostilities and the oil spill contributed to a decline in national and international tourism in Lebanon, which affected negatively the hotel industry. Before the hostilities, hotels were reporting 100% occupancy for the peak season (July-August). Within days after the start of hostilities, hotels were vacated and all summer bookings were cancelled[26].

In particular, the oil spill caused a drop in the occupancy rate of hotels and furnished apartments along the coast. In 2006, the reduction in occupancy rate caused by oil pollution was significant, mainly due to the visual signs of oiled beaches and contaminated water[27]. In April 2007, both tourism and hotel occupancy rates slightly recovered because of successful clean-up efforts; however, isolated polluted spots and concerns over the potential negative impacts of oil pollution on health are still obstacles in the full recovery of tourists on the coast[28]. For 2008, there is no valid information on tourism trends and recovery of occupancy rates in hotels. However, based on discussions during the first two field visits in Lebanon, it is reasonable to assume that, if efforts towards clean-up and political stability continue, hotel industry will be better off in 2008 and will fully recover in the following years.

The Syndicate of Hotel Owners (2006) lists 337 licensed hotels[29] in Lebanon. Of them, 54 hotels are located on the coast (either on or close to the beach) and count about 3,500 rooms. Room rates vary from US$40 to US$300/night, averaging to US$100/night, and additional hotel revenue is US$50/day for meals, phone and laundry. Thus, the average hotel income is about US$150/ person/day.

In addition, 97 furnished apartment establishments are located on the coast[30], totaling about 2,800 apartment units. The daily price per apartment varies highly, depending on the quality of services, number of bedrooms, the season, etc. For example, during low season, a one-bedroom apartment costs between US$55/night[31] and US$175/night[32], while a two-bedroom apartment cost between US$200 and US$450/night[33]. On average, we can assume that the net price of one furnished apartment is about US$220/night.

Based on the above data, the daily income of coastal hotels and furnished apartments is about US$1.1 million. Table 2.9 estimates the annual income during 2006-2008, using the expected occupancy rates for each season[34]. The income decline due to the oil spill is likely between 10-20% of the expected income in September-December 2006, as a result of the loss in occupancy rate. With a damage cost of 5-10% of expected income in 2007 and 0-5% in 2008, total forgone income due to the oil spill ranges between **US$23-60 million**, with an average of **US$41 million**.

Table 2.9 Hotels: foregone income from oil spill (million US$)

HOTELS	Min	Max
Expected income per day	1.1	1.1
Expected income:		
- in 2006 (Sept-Dec)[a]	87.0	87.0
- in 2007 (Jan-Dec)[a]	313.2	313.2
- in 2008 (Jan-Dec)[a]	313.2	313.2
Forgone income due to the oil spill		
- in 2006[b]	8.7	17.4
- in 2007[c]	15.7	31.3
- in 2008[d]	0.0	15.7
PV of forgone income	**22.8**	**59.6**

Notes: [a] Estimates based on expected hotel occupancy of 50% of full capacity in winter (Nov-Feb), 75% in spring (Mar-Apr), 100% in summer (Jun-Aug) and 75% in fall (Sep-Oct). [b] It represents 10-20% of the expected income. [c] represents 5-10% of the expected income. [d] It represents 0-5% of the expected income.

[26] Interview with a representative from the Syndicate of Hotel Owners, September 2006.

[27] As per observations and interviews made in Oct 2006.

[28] As per observations and interviews made in April 2007.

[29] There are about 18,000 rooms in one to five star hotels in Lebanon. About 7,000 are located in the Greater Beirut Area, and most of the remaining rooms are found in Mount Lebanon, North Lebanon, and Bekaa area (Interview at the Syndicate of Hotel Owners, September 2006).

[30] Ministry of Tourism, Internal Statistics.

[31] Savoy Suites, Raouche Beirut, April 2007.

[32] Lahoya Homes, Manara, Beirut, April 2007.

[33] Lahoya Homes, Manara Beirut, April 2007.

[34] ‘Expected occupancy or income reflects the occupancy/ income which usually occurs in times of peace.

2.4 BEACH RESORTS, CHALETS AND PUBLIC BEACHES

A clear distinction among beach resorts, chalets and public beaches is needed upfront. Beach resorts and chalets are both privately owned. Beach resorts are clubs with daily access to beach, pools and other recreational facilities, and no sleeping arrangements[35]. Chalets complexes are clubs that include privately owned chalets that can be rented on a seasonal basis[36].

Public beaches are beaches owned by the state, where access to public is free and non-excludable. As recreational services in these sites are directly influenced by the characteristics of beach and seawater, we assume that the oil spill affects the activities on beach resorts, chalets and public beaches with the same intensity in each of the three years.

2.4.1 Beach resorts

The hostilities and the oil spill affected heavily the activities on beach resorts. While beach resorts were full in early July[37], the outbreak of hostilities emptied them. Activities on beach resorts resumed at the beginning of September. However, the number of visitors was considerably low compared to previous years, due to concerns over personal safety, damaged roads, oiled beaches and contaminated water and people's perception about the negative effects of oil on health. As a result, many beach resorts made low income, while others closed for the whole season.

The Lebanese coast hosts about 68 beach resorts (Yellow Pages Tourism, 2006). According to discussions with the Syndicate of Maritime Establishments, there are about 500 daily visitors/beach resort during peak season and around 300 visitors/beach/day during the rest of the season. The daily spending per visitor averages US$20/day[38]. Accordingly, the expected income of beach resorts in September 2006 was estimated at US$12 million, while the expected seasonal income is about US$55.4 million (Table 2.10).

According to the Syndicate of Maritime Establishments, in September 2006, there were about 60 visitors/beach (instead of 300), i.e. 20% of the usual number in times of peace. In other words, the hostilities and the oil spill altogether caused a decline in the expected income of about 80% in September 2006. There is no documented information concerning the contribution of the oil spill to the income forgone from beach activities. It is however reasonable to assume that oil pollution of beaches and water affected substantially the recreational activities of nearby beach resorts.

The oil spill alone likely contributed a loss of about 25-50% to the expected income in September 2006. As in other cases, considerably lower share of 5-10% is assumed for 2007 and 0-5% for 2008. As a result, total forgone income due to the oil spill falls between **US$5-13 million**.

2.4.2 Chalets

Twenty-five chalet complexes can be found on the Lebanese coast, all located north of Jiyeh (Yellow Pages Tourism, 2006). The high season for renting chalets covers May-October, that is, 6 months. On average, each chalet complex has about 200 chalets, for which rent is about US$1,000/month[39]. Thus, the monthly income from renting chalets averages to US$5 million.

The chalets closed during hostilities and re-opened at the beginning of September 2006. The expected income after re-opening is estimated at US$10 million in 2006 and US$30 million in each of 2007 and 2008 (Table 2.10). Assuming that the oil spill contributes to the income decline

[35] Such as the Bamboo Bay resort in Jiyeh.

[36] Such as the Rimal complex resort in Jounieh.

[37] The beach season extends from mid-May to end of September, peaking between mid-July to end of August.

[38] It ranges between US$7/day (Syndicate of Beach Resorts, Interview, October 2006) and US$30/day (based on personal information).

[39] Based on interviews of a random sample of 10 chalet complexes outside Beirut, April 2007.

in a similar way as in the case of beach resorts, total forgone income to chalets is about **US$4 - 9 million**.

Table 2.10 Beach resorts, chalets, public beaches, events - forgone income due to the oil spill (million US$)

	Min	Max	Notes
BEACH RESORTS			
Expected income:			
in 2006 (Sept, 30 days)	11.9	11.9	68*300*30days*$20/day
in 2007 (May 15-Sept, 108 days)	55.4	55.4	68*(500*47+300*61)* $20/day
in 2008 (May 15-Sept, 108 days)	55.4	55.4	68*(500*47+300*61)* $20/day
Forgone income due to spill:			% of expected income:
in 2006	2.9	6.0	25-50%
in 2007	2.8	5.5	5-10%
in 2008	0.0	2.8	0-5%
PV of forgone income to beach resorts	**5.4**	**13.3**	
CHALETS			
Expected income:			
in 2006 (Sept-Oct, 2 months)	10.0	10.0	$5mil * 2 months
in 2007 (May-Oct, 6 months)	30.0	30.0	$5mil * 6 months
in 2008 (May-Oct, 6 months)	30.0	30.0	$5mil * 6 months
Forgone income due to spill:			% of income:
- in 2006	2.5	5.0	25-50%
in 2007	1.5	3.0	5-10%
in 2008	0.0	1.5	0-5%
PV of forgone income to chalets	**3.8**	**8.9**	
PUBLIC BEACHES			
Expected income:			
in 2006 (Sept)	2.6	2.6	$2.6 mil * 1 month
in 2007 (Jul-Sep)	7.8	7.8	$2.6 mil * 3 months
in 2008 (Jul-Sep)	7.8	7.8	$2.6 mil * 3 months
Forgone income due to oil:			% of income:
in 2006	0.6	1.3	25-50%
in 2007	0.1	0.2	5-10%
in 2008	0.0	0.1	0-5%
PV of forgone income to public beaches	**0.7**	**1.5**	
EVENTS			
Expected income:			
in 2007 (May-Oct)	71.4	80.3	Equivalent to 6,000-6,700 events per season
in 2008 (May-Oct)	71.4	80.3	Equivalent to 6,000-6,700 events per season
Forgone income due to oil			% of income:
in 2006	0	0	0%
in 2007	3.6	8.0	5-10%
in 2008	0.0	4.0	0-5%
PV of forgone income to events	**3.3**	**11.0**	
PV of forgone income to beach resorts, chalets, public beaches and events	**13.2**	**34.8**	

Note: All estimates are explained in the fourth column of the table. More detail is presented in the text.

2.4.3 Public beaches

Based on discussions with the Syndicate of Professional Divers and the NGO Cedars for Care, there are about 15 public beaches[40] in Lebanon, covering a total length of 10-12 km. The peak season covers three months, from July to September. It is most likely that the oil spill affected only 9 beaches, ie. those located north of Jiyeh: Aabdeh, Tripoli, Batroun, Jbail, Tabarja, Jounieh, Ramlet el Baida, St. Simon and Rmeileh.

Ramlet el Baida is by far the largest and the most frequented public beach in Lebanon. Table 2.11 presents the number of visitors during peak season for Ramlet el Baida and for the other beaches. Based on these data, the average number of visitors on the 9 public beaches affected by the spill is about 8,400/day.

Table 2.11 Day-visitors per public beach

	Ramlet el Baida[1]	Other public beaches[2]	Total visitors/day[3]
Working days	1,500	150	2,700
Saturdays	5,000	500	9,000
Sundays	20,000	2,000	36,000
Average/day	4,600	460	**8,400**

Source: [1] Cedars for Care (NGO), April 2007; [2] we assume 10% of the number of day-visitors in Ramlet-el Baida; [3] based on averages in Ramlet el Baida and the other 8 public beaches.

As entrance is free, we assume that the individual benefit is about half of that enjoyed by visitors to beach resorts, i.e. US$10/day[41]. Thus, the expected monthly benefits from using public

[40] These are from North to South: Aabdeh (south of fishing harbour), Tripoli, Batroun, Jbail (north of Byblos sur Mer), Tabarja, Jounieh, Beirut, St. Simon-Ouzai, Rmeileh (south of Sands Rock), Saida (north of the city), Ghazieh (north of Zahrani port), Sarafand (south of Saida), Tyr (north of the city), Tyr (south of nature reserve) and Mansouri.

[41] This value does not actually reflect what is paid by individuals to visit public beaches, as these are usually free of charge. It rather reflects the economic value (willingness to pay, WTP) to enjoy the beach. As no information on the WTP for public beaches is available, we use data on the WTP for private beaches (US$20). Since the services provided by private beaches are of better quality than those on public beaches, we assume that the WTP for public beaches is around 50% of that of private beaches.

beaches during high-season amount to about US$2.6 million.

The public beaches closed during hostilities and re-opened at the beginning of September 2006. The expected income after re-opening is estimated at US$2.6 million in 2006 and US$7.8 million in each of 2007 and 2008 (Table 2.11). Assuming that the oil spill contributes to the decline in benefits from public beaches in a similar way as in the case of beach resorts, the present value of total forgone income is about **US$0.7-1.5 million**.

2.4.4 Events

Beach resorts and chalet complexes frequently organize weddings and other social events, from May to October. Customers are mainly Lebanese and Arab nationals with many guests attending from abroad. As these events are usually small-scale, no statistics are able to provide accurate information on their number or frequency per season. An interview at Jannah coastal resort in Damour (October 2006) revealed that social events usually count about 300 participants and cost US$40/person. Beach resorts can organize events during warm months (at least 4 events/week during 4 months), while chalets complexes can arrange such events during at least half of the year (at least 3 events/week during 6 months). This results in about 6,000-6,700 events per season, providing an income of about US$71-80 million per year.

Table 2.10 presents the expected income from organizing events. The resorts were fully booked at the beginning of July 2006 and closed during hostilities. They did not open immediately after the ceasefire due to the small number of visitors. This was primarily a result of security concerns and damaged infrastructure and, to a lesser extent, of visible oil signs in certain locations and of potential oil impacts on health. Because of this, we consider that the income decline in 2006 is due to hostilities rather than the oil spill.

Assuming that in 2007 and 2008 the oil spill contributes to the decline in the income from events in a similar way as in the case of beach resorts, the present value of forgone income to events is about **US$3-11 million**. Overall, forgone income to beach resorts, chalets, public beaches and events falls within **US$13-35 million**, with an average of **US$24 million**.

2.5 MARINAS SPORTS ACTIVITIES

Coastal waters of Lebanon are well suited for marine sports activities. Marinas usually offer recreational services to public such as boating, diving, water-skiing[42] as well as docking and maintenance of private boats.

The hostilities and the oil spill affected the well-functioning of marinas activities in different ways and periods. For example, the hostilities and naval blockade halted the marinas' recreational services until September 8th. Afterwards, oil pollution of seawater and equipment and concerns over possible impacts on health led to a decline in the public use of marinas' recreational services. In addition, oil pollution caused losses to private boats' owners in terms of forgone recreational value (from the ceasefire until the end of 2006) and additional costs of cleaning boats.

Figure 2.9 Oil pollution in the port of Daliyi

Photograph courtesy of MOE

---

42 Yellow Pages Tourism (2006) lists a total of 29 centers for boat rental and 15 centers for diving sport resorts, dealing with scuba diving and other sub-aquatic sports. According to the Syndicate of Beach Resorts, the coast hosts about 33 small licensed clubs offering diving, water and jet ski services, and some unlicensed clubs (Interview, October 2006).

2.5.1 Losses to marinas from boat rental and water sports

The Movenpick marina in Beirut was heavily polluted by the oil spill. An interview undertaken at this marina in October 2006 revealed information on the types of services provided and losses caused by the oil spill. The marina rents leisure boats (for fishing and boating) to the hotel and private companies and provides water jets and diving services to the public. In 2004, the marina's income was about US$150,000, accounting for renting boats and water jets.

The same interview indicated that three other marinas (Riviera, St. George and Dbayeh) have the same order of revenue and altogether represent about 60% of the total marinas' revenue in Lebanon. Consequently, the total revenue of marinas is about US$1 million per year.

Table 2.12 estimates the expected income for each year after the end of hostilities. The season for recreational activities covers May-October, peaking during July-August when about 50% of the income occurs. Lacking accurate information, it could be assumed that the income during May-June is equal to September-October, i.e. about 25% of total annual income. As recreational activities resumed in September 2006, the expected income for the rest of the year was US$250,000.

In 2006, oil pollution of seawater, boats and its effects on health prevented most marinas to resume their boat rental and water sports activities. It is safe to assume, therefore, that the oil spill caused about 75-100% drop in income in September-October 2006. The effects of the oil spill in 2007 and 2008 are very likely to be smaller than in 2006, given the ongoing cleanup efforts. However, existing concerns over the negative effects of oil spill may still result in forgone revenues. If we conservatively assume that this loss is about 5-10% of annual income in 2007 and 0-5% in 2008, the loss from recreational activities in marinas would range between US$0.23-0.38 million**,** with an average of US$0.3 million. This represents the loss to marinas from the decline in boat rental and water sports activities due to the oil spill.

Table 2.12 Marinas - forgone income due to the oil spill (thousand US$)

MARINAS	*Min*	*Max*
Expected income:		
- in 2006 (Sept-Oct)[a]	250	250
- in 2007 (May-Oct)[b]	1,000	1,000
- in 2008 (May-Oct)[b]	1,000	1,000
Forgone income due to oil		
- in 2006 (Sept-Oct)[c]	188	250
- in 2007 (May-Oct)[d]	50	100
- in 2008 (May-Oct)[e]	0	50
PV of forgone income	**238**	**377**

Notes: [a] 25% of annual income; [b] 100% of annual income; [c] It represents 75-100% of the expected income; [d] It represents 5-10% of the expected income; [e] It represents 0-5% of the expected income.

2.5.2 Losses to owners of private boats

The oil spill polluted also many private leisure boats docked in marinas as well as fishing boats docked in fishing ports. This limited the owners' benefits from using their boats in the period following the hostilities until the end of 2006 and imposed additional costs of cleaning the boats. The forgone benefit to private owners from not using the boats during September-December 2006[43] is estimated.

As no study valuing the recreational benefits of private boat owners was found, the cost-based approach is used for computation. The loss of the recreational benefit from private leisure boats is assumed to be equal to at least the value of the annual depreciation of the boat plus the maintenance costs (ie. cost of upkeep and docking in marinas). To estimate the loss due to oiled fishing boats, the annual maintenance costs are used as a proxy[44].

Estimating the total number of private leisure boats is difficult, as many of them are not

[43] The cost of boat clean-up is captured in the total clean-up costs in Section 2.11.

[44] The overall losses due to the oiled fishing boats are reflected through the loss in fish catch and the maintenance costs paid for one year (2006). As the loss in fish catch is already accounted for in Section 2.9, this section considers only the maintenance costs, in order to avoid double-counting.

licensed[45]. There are about 25 small, 5 medium and 2 large marinas on the coastal zone north of Jiyeh. From interviews with several marina managers, the following information was collected:

- Small-sized marinas (eg. Miramar and Las Salinas) have about 20-30 boats/marina, averaging 25 boats each;
- Medium-sized marinas (eg. Movenpick and Halat sur Mer) have about 80-100 boats/marina, averaging 90 boats each;
- Large marinas (eg. Dbayeh and ATCL) have about 300-400 boats/marina, averaging 350 boats each.

Based on the above information, the total number of boats in the marinas is estimated at about 1,775. As these belong to marinas north of Jiyeh, all of them could have theoretically been oiled. In reality, however, many marinas escaped the oil spill because of their orientation and sea currents. Available information does not distinguish between oiled and clean boats. In lack of any information, we assume that only 50% of the boats were actually oiled, i.e., 890 boats.

In addition to boats located in marinas, the spill polluted many fishing boats docked in ports located north of Jiyeh. However, accurate information concerning the number oiled fishing boats is not available. According to the MOE, docked boats at Daliyi port were oiled. Observations based on pictures taken during cleaning operations show some 20 boats oiled in Daliyi port.

Estimating the annual depreciation value of an average boat is based on its market price and lifetime. According to interviews at Power Marine and Dolphin Team boat suppliers in Mount Lebanon, boat prices vary between as little as US$10,000 to as high as US$500,000/boat, depending on its size, model, etc. The average price for the most common boat (6-12 m) is about US$30,000. Considering a lifetime of about 20 years[46], the annual value of a boat is US$1,500.

The cost of upkeep and docking in marinas also varies highly, as illustrated by Table 2.13. Conservatively assuming an annual cost of US$300/m/season and the average size of a boat of 9 m, the annual cost of upkeep and docking is about US$2,700.

The loss to owners of private leisure boats (890 boats) is based on the annual depreciation value and maintenance costs (US$4,200), totaling US$3.7 million (a). The loss to owners of oiled fishing boats (20 boats) is estimated on the basis of the annual maintenance costs (US$2,700); accordingly, it amounts to US$54,000 (b). Based on (a) and (b), the total loss to private owners of leisure and fishing boats is about US$3.8 million.

Table 2.13 Number of boats and cost of upkeep and docking

Marinas/Ports	**Number of boats/year**	**Cost of upkeep and docking (US$/meter/season)**
Marina Dbayeh	300	400-700[b]
Holiday Beach	150	300-400[c]
ATCL	400	20[d]
Movenpick	82[a]	2500-3000/season
Halat sur Mer	80-100	200/season
Daliyi port	20	n.a.

Source: Interviews at the five marinas

Notes: [a] It includes 60 boats of 6-12 m, 12 boats of 12-20 m and 10 boats longer than 20 m. [b] The unit cost depends on the characteristics of the boat. [c] It corresponds to the low (US$300) and high (US$400) seasons. [d]The price applies to members only. [e] It represents the observed number of oiled boats. n.a. = not available.

Adding up the above estimates, the overall losses to marinas' sports activities lie within US$4 to US$4.2 million, with an average of **US$4.1 million.**

[45] The boats that are not registered may still dock in Lebanese marinas, however they have to leave the country every six months to renew the entry papers.

[46] According to the interview at Power Marine and Dolphin Team, boat lifetime usually varies between 20-30 years. Because boats often become obsolete much before the end of their lifetime, it is reasonable to assume a time frame of 20 years.

2.6 PALM ISLANDS NATURE RESERVE

Palm Islands Nature Reserve is a marine reserve and a Mediterranean Specially Protected Area under Barcelona Convention (1995) and Ramsar Convention of Wetlands (1971). It is a popular destination for beachgoers, especially for people living in Tripoli.

Access to Palm Islands Nature Reserve was halted from the start of hostilities until the lift of naval blockade. The hostilities and oil spill reduced considerably tourism and associated revenues to local communities (e.g. transportation and other services) and affected the biodiversity (e.g. by oiling birds and turtles).

2.6.1 Loss of recreation

The oil spill played a major role in reducing the number of visitors to Palm Islands Nature Reserve especially after the end of the naval blockade. The loss to tourism in 2006 is estimated by the difference between the expected number of tourists (averaging 22,500)[47] and actual arrivals (about 1,700)[48]. The forgone benefits are the losses in revenues from boat transportation of individuals and groups to the islands and rentals of chairs and umbrellas.

During the past years, about 20% of the total number of visitors come by own boat, while the remaining 80% include individual visitors and groups coming by boats of Palm Island Nature Reserve. There are usually about 500 groups of around 15 people each on average[49]. Based on this information, Table 2.14 estimates the forgone number of individual visitors and groups that use the Palm Islands Nature Reserve facilities.

[47] The number of expected tourists varies between 20,000 and 25,000 according to the MOE statistics

[48] Interview with Dr. Jaradi (Professor of ornithology and President of the Government Appointed Committee of Palm Islands Nature Reserve), October 2006.

[49] See footnote above.

Table 2.14 Number of individual visitors and groups using the Palm Island Nature Reserve boats

Type of visitors	Number of visitors
Expected visitors in 2006: [a]	**22,500**
- individual visitors by own boat [b]	4,500
- individual visitors by PINR boats [d]	10,500
- groups by PINR boats [c]	500
Actual visitors in 2006: [e]	**1,740**
- individual visitors by PINR boats [f]	812
- groups by PINR boats [g]	62
Forgone visitors in 2006: [h]	**20,760**
- individual visitors by PINR boats	9,688
- groups by PINR boats	438

Notes: [a] The number of visitors varies between 20,000 and 25,000 (MOE statistics); [b] about 20% of the total number of visitors come by their own boat (Communication Jaradi); [c] There are about 500 groups of around 15 visitors/group every year (Communication Jaradi); [d] It represents the difference between the total number of visitors and the number of those (individuals and groups) using PINR boats; [e] Communication with Dr. Jaradi; [f] The number is based on the ratio of individual visitors/total visitors equal to that used in the case of the 'expected visitors'; [g] Based on groups of an average size of a5 visitors; [h] It represents the difference between the expected and the actual number of visitors.

The tourist season is about 13 weeks (July-September) of which only three remained after the end of blockade. Considering that tourists are evenly distributed in time throughout the season, and assuming that the oil spill will contribute to the forgone income between 75-100% in 2006, 5-10% in 2007 and 0-5% in 2008, the loss in tourism due to oil spill is estimated at about US$15,400-27,600 (Table 2.15).

Table 2.15 Palm Islands Nature Reserve: forgone income due to the oil spill (thousand US$)

PALM ISLANDS NATURE RESERVE	Min	Max	Notes
Forgone annual income[a] (13 weeks)	72.4	91.1	
Forgone income due to the oil spill			% of expected income:
- in 2006[b] (3 weeks)	12.5	15.8	75-100%
- in 2007[c] (13 weeks)	3.6	9.1	5-10%
- in 2008[d] (13 weeks)	0	4.6	0-5%
PV of forgone income	**15.4**	**27.6**	

Notes: [a] based on the forgone benefits associated to a drop in the number of visitors from 22,500 to 1,740; [b] It represents 75-100% of the expected income; [c] It represents 5-10% of the expected income; [d] It represents 0-5% of the expected income.

2.6.2 Loss of biodiversity

Birds. Around 92 oiled birds from 19 different species were observed in Palm Islands Nature Reserve[50]. Estimating the damage to birds is a complex task. No such estimates were found for Lebanon. This section presents two alternative ways of valuation. However, the data weaknesses prevent to arrive at any solid estimate of damage; consequently, the resulting values will not be incorporated in the final damage estimate.

Figure 2.10 Oiled bird

Photograph courtesy of Italian Task Force

One way to estimate the damage to birds is by using the benefits transfer[51] from other studies. Brown (1992) calculated the replacement value of lost wildlife for Exxon Valdez and Loureiro et al. (2006) for Prestige. These estimates were based on the costs of wildlife capture and transport by zoos and aquaria and the rehabilitation costs. Accordingly, Brown (1992) estimated a range of values from US$167/gull to US$6,000/peregrine falcon. Using benefits transfer, Loureiro et al. (2006) valued a cost of about US$250/dead bird. That would correspond to about US$60/dead bird in Lebanon, after adjustment to GDP ratio. Assuming that all oiled birds found in Lebanon would die, as in many other oil spill incidents (French et al., 1996, quoted by McCay et al., 2004), the total value of the 92 injured birds would be about US$5,500. However, because of the method's inability to reflect the specific biodiversity conditions in Lebanon, this estimate will only be considered as having indicative importance.

Alternatively, the damage to birds can be estimated based on a restoration cost[52] model, as developed by McCay et al. (2004)[53]. The sea bird restoration model is given by a log-linear regression relating the cost per bird to the average abundance per unit area:

$$y = 10{,}260 * e^{-0.0138*x}$$

where:
x: annual mean abundance (number/km^2),
y: cost per bird (US$), and
e=2.718

[50] These are: 7 Cory's Shearwaters, 1 White Pelican, 4 Squacco Herons, 3 Black-winged stilts, 2 Ringed Plovers, 2 Dotterels, 6 Little Stints, 10 Ruffs, 1 Whimbrel, 17 Redshanks, 9 Green Sandpipers, 4 Common Sandpipers, 5 Black-headed Gulls, 7 Lesser Black-backed Gulls, 4 Yellow-legged Gulls, 1 Nightingale, 2 Tawny Pipits, 1 Prinia Warbler and 2 Sardinian Warblers (Interview with Dr. Jaradi, President of the Government Apointed Commitee of Palm Islands Nature Reserve, April 2007). Most are winter visitors and are fairly common except the Squacco Heron which is rare (Ramadan-Jaradi, 2001).

[51] It should be noted that application of benefits transfer is accurate as long as the context is very similar (if not identical) with the original valuation context. However, when the original context of valuation differs from the areas where the results are transferred, the application of benefits transfer can often result in errors. Adopting specific measures to improve the use of benefits transfer has been recently discussed (Loomis and Rosenberg, 2006; Ready and Navrud, 2006).

[52] The replacement cost method generally provides valid estimates as long as: (i) the replacement service is equivalent in quality and magnitude to the ecosystem service; (ii) the replacement is the least costly way of replacing the service; (iii) people would be willing to pay the replacement cost to obtain the service (Shabman and Batie, 1978). However, if the estimated cost is too high (low) compared to the value of damage, it may easily overestimate (underestimate) it (Bishop, 1999).

[53] The authors presume that: (a) most oiled birds are to die based on the probability of encounter with the slick and mortality; (b) scarce birds are more valued by the public and are more expensive to restore, while common species are less valued and cheaper to restore. Wildlife mortality is directly proportional to area swept, probability of mortality and species abundance per unit area.

Table 2.16 Value of injured birds in Palm Islands Nature Reserve

Species	No/km^2	Number of injured birds	Unit cost (US$/bird)	Cost of injured birds (US$)
White Pelicans	3.5	1	9,800	9,800
Squacco Heron	3.8	4	9,700	38,800
Total				48,600

Source: MOE (2004) and Ramadan-Jaradi (2001) for the second column; our application of restoration cost model of McCay et al. (2004) in the third and fourth columns.

Table 2.16 presents data on observed rare bird species lost to the oil spill in Lebanon. Applying the restoration cost model to these species would result in a total damage cost of about US$48,600. Loureiro et al. (2006) estimates that typically only 15% to 50% of oil-killed birds are found and collected after an oil spill. Assuming the same figures also for the Lebanon case, the total damage cost associated with the oiled birds would range between US$97,200 and US$324,000, with an average of US$210,600. However, as no other studies valuing these particular species were found (thus, no basis for comparability is available) the result should be regarded with extreme caution.

Turtles. Three dead loggerhead turtles *(Caretta caretta*) were reported on Palm Islands Nature Reserve[54]. We found no studies estimating the dead or injured turtles in Lebanon. Available studies in other parts of the world suggest different estimates. For example, Whitehead (1993) found a willingness to pay (WTP) to ensure the continued existence of loggerhead sea turtle (*Caretta caretta*) in the United States of about US$11/year. In another study, Whitehead (1992) estimates the WTP for continued existence of turtles for next 25 years of about US$44/person. It is difficult however to apply these estimates in the Lebanon's case, as: (1) only a small (unknown) fraction of the total WTP can be attributed to the loss of the three loggerheads; (2) these estimates do not reflect the country's specific biodiversity conditions.

2.6.3. Cost of impact assessment and monitoring

MOE is executing an impact assessment study of the impact of the oil spill on the Palm Islands Nature Reserve biodiversity, including the benthic communities. The study is funded by the Italian Government through IUCN and implemented by the American University of Beirut. It aims to develop indicators for future monitoring. The estimated cost of this activity is US$27,000[55] .

In addition, a long term monitoring program is foreseen for the reserve and other ecologically significant sites affected by the spill. It includes the following activities: developing measurable indicators, setting guidelines for monitoring, analyzing data on a yearly basis and developing a set of guidelines for use in future incidents[56]. The monitoring effort would last for 7-10 years and would cost about US$1.2-1.7[57].

The total cost of the impact assessment and monitoring program is estimated at US$1.2-1.7 million. It is most likely that only a part of this cost is directly related to the oil spill damage, while the rest being an expression of WTP for future information. In absence of more accurate information, we assume that only 50% of the total impact assessment and monitoring cost is due to the oil spill damage, ie. US$600,000-850,000.

The overall impact of the oil spill on the Palm Islands Nature Reserve and other ecologically sensitive areas amounts to **US$0.7-1.2 million** (impact assessment and monitoring included). This figure does not cover either the clean-up cost already spent (US$85,600)[58] or that

[54] Based on interview with Dr. Jaradi (Professor of ornithology and President of the Government Appointed Committee of Palm Islands Nature Reserve), April 2007.

[55] Communication with Ms. H. Kilani (IUCN, Lebanon, April 2007)

[56] Based on interview with Dr. Jaradi ((Professor of ornithology and President of the Government Appointed Committee of Palm Islands Nature Reserve), April 2007.

[57] Communication with Ms. H. Kilani (IUCN, Lebanon, April 2007)

[58] It includes the clean-up cost of sandy beaches (US$1200) and of mousses (US$1700) undertaken by GAC and the cost

estimated for Phase II clean-up and monitoring operations (estimated at about US$1 million)[59]. Both of them are accounted for in Section 2.11[60], dealing with the total clean-up costs.

2.7 BYBLOS WORLD HERITAGE SITE

Built during Phoenician times, Byblos is considered the oldest inhabited city in the world and a World Heritage site. It is also one of the most important archeological sites of the Middle East. Hosting the Crusader Castle (dating back to the 12th century A.D.), the harbor and the ancient town, Byblos is one of the major cultural and historical sites in Lebanon.

The oil spill contaminated heavily the harbor, two medieval towers at its entrance and other ancient ruins located below the archaeological Tell in Byblos (UNDP, 2007). This reduced significantly the number of visitors and threatened the historical value of the ruins.

2.7.1 Loss of recreation-tourist value

The oil spill played a significant role in reducing the number of visitors to Byblos during September-December 2006. It is most likely that the oil spill will have a substantially lower impact on tourism in 2007 and 2008, as the harbor was largely cleaned[61]. The loss in recreational value is estimated in terms of forgone benefits to the oil spill during 2006-2008.

Visits to Byblos take place throughout the year and are usually organized both by tour operators and private individuals. According to the Ministry of Tourism, there are 22 tour operators in Lebanon, of which at least eight[62] organize trips to Byblos. The average number of visitors is about 300/year and the fee is about US$30/person if meals are excluded (Table 2.17). Accordingly, the annual income of tour operators from organizing visits to Byblos is about US$72,000 (a).

Table 2.17 Tours to Byblos World Heritage Site and other historic towns

Tour operators	Visit Details	Fee/person (US$/person)	Average number of visitors/year
Tania Travel	Full day, Byblos and Tripoli	60[a]	300
Kurban Tours	Half a day, Nahr el Kalb and Byblos	28[b]	350
Nakhal	Full day, Byblos and Tripoli	50[c]	300

Source: Interviews with tour operators.
Notes: [a] includes transportation, lunch, guide, entrance fee to Byblos fort; [b] includes transportation, guide, entrance fee; [c] includes transportation, guide, entrance fee to Byblos and Tripoli forts.

There is no information concerning visitors coming in private vehicles. However, Byblos' closeness to Beirut (only 40 km away) suggests that private excursions are the easiest option for many tourists. Thus, it is likely that more visitors come by private cars than by tour operators. Assuming that they are twice as many as those coming through tour operators and that the average spending is US$15/person[63], the annual income from individual trips would be about US$72,000 (b).

The annual income from all visits to Byblos is about US$144,000 (a+b). Assuming that the oil spill contributes only 25-50% of the September-December income in 2006, 5-10% in 2007 and 0-5% in 2008, the associated damage to tourism in Byblos and other historical towns ranges between **US$15,300-42,800** (Table 2.18).

of Phase I cleaning funded by the Swiss Agency for Development and Cooperation (US$82,700). (Dr. Jaradi, communication and SDC, 2007).

[59] According to MOE

[60] Table 2.25 includes the clean-up costs already spent and Section 2.11.3 accounts for the future clean-up costs.

[61] According to visual inspection during the field visit in April 2007.

[62] These are Tania Travel, Kurban Tours, Nakhal, Anastasia, Ariane, Rida Travel and Wild Discovery (Interviews with tour operators).

[63] This is the minimum that a person spends on souvenirs and boat rental (personal judgment of local experts).

Table 2.18 Byblos World Heritage Site: forgone income due to the oil spill (thousand US$)

BYBLOS	Min	Max
Expected annual income[a]	144.0	144.0
Forgone income due to the oil spill		
- in 2006 (Sept-Dec)[b]	9.0	24.0
- in 2007 (Jan-Dec)[c]	7.2	14.4
- in 2008 (Jan-Dec)[d]	0.0	7.2
PV of forgone income	**15.3**	**42.8**

Notes: [a] Includes income from tour operators and private visitors; b It represents 25-50% of the expected income during Sept-Dec 2006; [c] It represents 5-10% of the annual expected income; [d] It represents 0-5% of the annual expected income.

In addition to represent one of the country's main cultural attractions, the city of Byblos holds every year an international cultural festival during the summer. In 2006 the first two shows took place prior to the hostilities, the third one was scheduled to take place on July 15 and was canceled as a result of the hostilities. Although revenue losses were significant, the cancellation was mainly because of the hostilities, and hence losses in revenues will not be accounted for in this report. .

2.7.2 Loss of historical-cultural value

No studies estimating the losses of historical-cultural value of sites in Lebanon were found. Available surveys were undertaken elsewhere. Navrud and Ready (2002) make a comprehensive review of studies valuing the willingness to pay to conserve sites with cultural heritage, such as monuments and archaeological sites. Accordingly, the annual willingness to pay ranges from as little as US$0.6-1/household to preserve Bulgarian monasteries to as high as US$134/household to conserve the recreational value of aboriginal rock paintings in Nopimi Park, Canada. These estimates represent the willingness to pay to protect historical sites from air pollution damages, degradation, urban development (infrastructure) or to maintain them at present level. None of them reflect efforts to preserve sites from oil pollution. As such, none can be used as a realistic proxy to estimate the damages to historical sites due to oil spill.

In the absence of information on the willingness-to-pay, the computation for this report relies on restoration cost method. The mission undertaken by UNESCO team in Byblos in September 2006 declared that the most serious damages resulting from the hostilities, concerns the World Heritage site in Byblos. Accordingly, a special procedure to clean the archaeological remains covered by fuel was recommended. Assuming that the stones were cleaned manually with a specially prepared solution according to the components of the fuel, the total cleanup cost of operations would be **US$100,000** (UNDP, 2007). This figure is assumed as the minimum bound of the damage caused by the oil spill to archaeological sites.

Overall, the estimated damages to Byblos range between **US$115,300-142,800**, with an average of **US$129,000**.

2.8 Restaurants

Fish is an important food served in many Lebanese restaurants, especially those located on the coast. Both the hostilities and the oil spill affected negatively the activity of these restaurants. The hostilities reduced the number of tourists, which resulted in a decline in fish demand and consumption. The oil spill also contributed to this reduction, mainly due to fears of negative impacts of contaminated fish on human health.

According to the Syndicate of Restaurant Owners[64], there are about 5,000 restaurants in Lebanon. Most of them are either mixed or specialized in meat. To the extent that mixed restaurants could easily shift to meat products, the oil spill did not affect their businesses[65]. Only about 170 are specialized in fish, of which 150 are located on the seashore and the rest inland. The oil spill hit hard the activities of these restaurants, as most of them were emptied or their activities interrupted for the rest of 2006[66].

[64] Interviews, October 2006 and April 2007.

[65] In reality, they might have caused a decline in their income during the time that would have taken to fully adapt to meat products only. As it is most likely that this loss extends on only a few months, the damage would probably be quite low.

[66] It is most likely that many of them attempted to shift their supply from fresh domestic to imported fish. However, this

Based on the same source, the annual turnover of a fish restaurant ranges between US$200,000 and US$ 600,000, depending on the category of the restaurant. Consequently, it was assumed that the average turnover of a fish restaurant is approximately US$400,000 per year, or about US$33,000 per month. Accordingly, the expected income during September – December 2006 would be about US$133,000 per restaurant. Considering that the oil spill contributed about 75-100% of the expected income in 2006, the associated forgone benefits would be about US$17-23 million for the period September to December 2006 (Table 2.19).

In 2007, successful cleanup of oil and gradual return to normal life contributed to the recovery of fish restaurants activities. Yet, the perception of potential negative effects of the oil spill on human health still exist and may contribute to a small decline in the expected income of restaurants. Although no study on the impacts of this perception on human health was found, it is reasonable to believe that its effects have diminished substantially in 2007 and will gradually subside in the next years. The report assumes that the potential effects on human health reduce the restaurants' expected profits by 5-10% in 2007 and by 0-5% in 2008 (Table 2.19). Overall, the present value of forgone benefits to the oil spill ranges between **US$19.5-31.1 million** with average at **US$25.3 million.**

Table 2.19 Restaurants: forgone income due to the oil spill

RESTAURANTS	**Min**	**Max**
No. of fish restaurants	170	170
Annual turnover (000 US$/rest./ yr.)	400	400
Monthly turnover (000 US$/rest./mth.)	33.3	33.3
Expected income in Sept-Dec 2006 (000 US$/rest.)	133.3	133.3
Forgone income due to the oil spill		
- in 2006 [a] (million US$)	17.0	22.7
- in 2007 [b] (million US$)	3.4	6.8
- in 2008 [c] (million US$)	0	3.4
PV of forgone income to oil spill (million US$)	**19.5**	**31.1**

Notes: [a] It represents 75-100% of the expected income in Sept-Dec 2006.
[b] It represents 5-10% of the expected annual income in 2007.
[c] It represents 0-5% of the expected annual income in 2008.

2.9 FISHING

In Lebanon, fishing is usually artisanal and small-scale. It supports about 30,000 fishermen (IUCN/Green Line, 2006) who catch on average 8,000 ton of fish per year (FAO, 2006).

The hostilities and the oil spill hit strongly the fishermen' activities and welfare. On one hand, the hostilities damaged a large number of boats (about 330 boats were damaged in Ouzaii port only) and halted fishing activities until 8th September, 2006. On the other, the oil spill caused:

- *direct* damages: the boats and gears oiling often resulted in engine damage and ultimately, in a partial decline of fish supply (FAO, 2006);
- *indirect* damages: the actual fish contamination or the perception of its effects on health reduced the overall demand for fish consumption. This caused a decline of fish price and catch[67].

The following sub-sections analyze the impacts of oil spill on commercial and seashore fishing.

could not offset the public's fears of the impacts of contaminated fish, which were fuelled by the government's early warnings to avoid fish consumption. Thus, the reduction in fish demand very likely reduced the sales of both imported and domestic fish.

[67] For example, it led to a 50% decline of fish price during September-October 2006, which discouraged many fishermen to return to the sea (FAO, 2006).

2.9.1 Commercial fishing

FAO (2006) provides information on fish catch per season and total income from fishing in 2004. Fish catch varies largely across seasons, accounting for 30% of annual catch in spring, 42% in summer, 22% in autumn and only 8% in winter. Annual income from fishing is about US$31 million. Applying the seasonal catch factor (% of total catch) to the total income, Table 2.20 estimates the expected seasonal and monthly income from fishing in Lebanon. Accordingly, the expected fish income during September-December 2006 was US$7.4 million.

Table 2.20 Expected income from commercial fishing according to season

Fishing seasons	**Share of total catch** (%)	**Seasonal income** (million US$)	**Monthly income** (million US$)
Spring (Mar-May)	30	9.1	3.0
Summer (Jun-Aug)	42	12.9	4.3
Autumn (Sept-Nov)	22	6.7	2.2
Winter (Dec-Feb)	8	2.3	0.8
Total	**100**	**31.0**	**10.3**

Source: FAO (2006) for share of total catch per season and total annual income; own calculations for the rest (see text for details).

The impact of the oil spill on commercial fishing has not been widely surveyed. The only data is from a study undertaken by the University of Balamand[68] which conducted a small survey of about 200 fishermen from North Lebanon, aiming to find out the change in revenues from fish sales before and after the hostilities.

Annex 4 presents the results, according to different categories of income. Based on these data, it is estimated that the hostilities and oil spill caused the income of fishermen to drop by 45%. In the absence of accurate information, the estimates are extrapolated for all fishermen on the coast north of Jiyeh. Conservatively, assuming that only 50% of this drop is owing to oil spill, the associated damage cost in 2006 is about US$1.3 million. Table 2.21 estimates the losses in the next two years, assuming oil spill causing a 5-10% decline in 2007 and 0-5% in 2008. The present value of these damages falls between **US$3-6 million (a)**.

Table 2.21 Commercial fishing: forgone income due to the oil spill (million US$)

COMMERCIAL FISHING	**Min**	**Max**
Expected annual income[a]	31.0	31.0
Expected income during Sept-Dec[b]	7.4	7.4
Forgone income due to the oil spill		
- in 2006 (Sept-Dec)[c]	1.3	1.3
- in 2007[d]	1.6	3.1
- in 2008[e]	0.0	1.6
PV of forgone income to oil spill	**3.0**	**5.9**

Source: [a] FAO (2006). Notes: [b] It is equal to $2.3 mil.*3 +$0.8 mil. *1 (see Table 2.21 for monthly income). [c] It represents 50% of the total forgone loss, ie. 50% x 45% x $6 million (see text for more detail). [d] It represents 5-10% of the expected annual income. [e] It represents 0-5% of the expected annual income.

2.9.2 Shore-side fishing

Shore-side fishing is popular in Lebanon both for recreational and consumption purposes. No accurate information on the impacts of the oil spill on recreational fishermen is available, except that it reduced fish price and catch. Thus, the report assumes that the oil spill affected recreational fishermen in a similar way to commercial ones.

In the south of Lebanon, there are about 1,300 anglers[69] who account for one third of the total number in the country[70]. As the oil extended from Jiyeh towards the north, it is assumed that oil affected the remaining two thirds of the total number, ie. 2,600 anglers.

The value of shore-side fishing includes the consumption and recreational value of fish. Using an average catch of 2 kg/day for a minimum of 50 days and an average price of US$4/kg[71], the consumption value of fish is US$1 million/year.

[68] According to Dr. M. Nader at the Marine Resources and Coastal Zone Management Program, Institute of the Environment, University of Balamand

[69] Interview at the Syndicate of Fishermen, October 2006.

[70] Interview at the University of Balamand, October 2006.

[71] FAO (2006)

No information is available on the recreational value of anglers in Lebanon. Assuming it is similar to the value of recreation on public beaches (US$10/day[72]), the recreational value of anglers is US$1.3 million/year. Overall, the annual value of shore-side fishing is about US$2.3 million.

Considering that fish catch varies seasonally in the same proportion as in the case of commercial fishing, the seasonal and monthly income from shore-side fishing are estimated in Table 2.22. Accordingly, the expected fish income during September-December 2006 is about US$0.7 million[73].

Table 2.22 Expected income from shore-side fishing according to season

Fishing seasons	Share of total catch (%)	Seasonal income (million US$)	Monthly income (million US$)
Spring (Mar-May)	30	0.7	0.2
Summer (Jun-Aug)	42	1.0	0.3
Autumn (Sept-Nov)	22	0.5	0.2
Winter (Dec-Feb)	8	0.2	0.1
Total	**100**	**2.3**	**0.8**

Source: FAO (2006) for share of total catch per season; own calculations for the rest (see text for more details).

Estimating the impact of the oil spill on shore-side fishing uses the same percentages adopted for commercial fishing. Table 2.23 illustrates the estimates of losses for 2006-2008. Accordingly, the present value of forgone benefits ranges between **US$260,000-472,000 (b)**.

Table 2.23: Shore-side fishing: forgone income due to the oil spill (thousand US$)

SHORE-SIDE FISHING	Min	Max
Expected annual income[a]	2,340	2,340
Expected income during Sept-Dec[b]	700	700
Forgone income due to the oil spill		
- in 2006 (Sept-Dec)[c]	157.5	157.5
- in 2007[d]	117.0	234.0
- in 2008[e]	0.0	117.0
PV of forgone income to oil spill	**259.6**	**471.8**

Sources: [a] own estimate (see text); [b] It represents 50% of the total forgone loss (50% * 45% * $0.7 million); [c] It represents 50% of the forgone income during Sept-Dec; [d] It represents 5-10% of the expected annual income; [e] It represents 0-5% of the expected annual income.

Overall, the impact of the oil spill on commercial and shore-side fishing amounts to **US$3.2-6.5 million**, with an average of **US$5 million**.

2.10 Oil Fuel Burnt and Spilled in Jiyeh

In addition to the various environmental damages caused by the oil spill (and describe above), the loss of an estimated 44,000 tons of stored IFO 150 at Jiyeh electrical power plant (an estimated 12,000 to 15,000 tons have leaked into the sea and the rest has burnt) represent an economic loss.

The loss in resources due to the spill and burning of the Jiyeh fuel oil is estimated at around US$ 20 million (an estimated 44,000 tons of fuel oil at an approximate cost of US$450/ ton). In addition, the cost of hiring three floating tankers to replace burnt tanks was estimated at around US$ 4 million. Besides, the maintenance and operation of floating tankers, transfer of fuel from different plants to Jiyeh power plan and soil test of soil in burnt tanks' location was estimated at US$ 15 million. In total, the burning and spilling of Jiyeh fuel oil due to the hostilities resulted in a direct economic loss estimated at **US$ 39 million[74]**.

[72] See Section 2.4.3.

[73] It is equal to $0.2 mil.*3 + $0.1 mil.*1 (see Table 2.11).

[74] Based on correspondence with the Ministry of Environment dated August 2007

2.11 OIL SPILL CLEAN-UP OPERATIONS

Soon after the ceasefire, the MOE estimated the cost of oil spill clean-up in the range of US$137-205 million (MOE, 2007a), based on the average per-unit marine oil spill clean-up cost of US$13,800/t in the region (MOE, 2006a and b). The clean-up priorities set by the MOE include the following operations (Presidency of the Council of Ministers, 2007):

- Phase I: removal of free floating mobile oil from the sea and shore, as well as contaminated debris, including sand, pebbles, used equipment and garbage;
- Phase II: cleanup of polluted sites to a higher level of cleanliness, depending on the nature and the environmental and economic sensitivity of the site.

As of February 2007, the assistance that Lebanon received was less than 5% of the needed financial resources. However, with the available resources, removal of free floating oil was completed by October 2006 and removal of bulk amounts by January 2007.

To better understand the actual phase of clean-up, the report examined the associated costs and the proportion which has been already spent from the total needed. Mitigation costs are related to actions taken to reduce injury to the environment from the spill. These costs, specifically related to mitigating the effects of the spill, and not to 'pure' science or scientific assessment, include those associated with:

- Oil recovery – to reduce the amount of oil remaining in the environment;
- Chemical analysis of oil – to determine toxic potential for public warning;
- Chemical analysis of fish flesh – to ensure public of safe fish supplies and to enable the commercial fishing to return to normal;
- Aerial and underwater oil tracking surveys – to provide input to oil recovery effort; and
- Spill management – including operation of a coordination center to provide information to the public and to coordinate recovery activities;
- Waste handling and management – to properly dispose of oily waste and other spill-related materials.

2.11.1 Estimated clean-up costs already spent

As of April 2007, only a part of the necessary mitigation costs has been spent, within the limit of the available funds. The cost of these efforts is summarized in Table 2.24. Much of the financial support for mitigation was provided by the international community. In most cases, the provider does not list the value of equipment or other resources so the values listed are estimates completed by IMO-REMPEC in Lebanon or by this report based on the estimated valuation of the services or equipment provided. Some of the donated equipment can be reused in the event of another oil spill, so the re-use value must be deducted from the total mitigation cost. Approximately US$4 million was provided as equipment and materials. Considering depreciation from use with this oil type and that much of the material was provided as expendable supplies (protective clothing, sorbents, etc), an estimated 25% of the total supplied, or USD 1 million, will be available for use after this incident and therefore is deducted from the total mitigation cost.

Table 2.24 Estimated clean-up costs spent as of April 2007.

Organization	Activity	Estimated cost (US$)
Lebanon Ministry of Environment (MOE) [1]	Staff, organizational support, field assessments, and coordinating center facilities	200,000
Lebanese Military[1]	Oversight of oil removal	25,000
Local Authorities[1]	Relocation of oiled sand	25,000
GAC Palm Island Nature Reserve[6]	Cleaning sandy beaches and mousses of Palm Islands Nature Reserve	2,900
IMO-REMPEC[1]	Technical assistance + personnel	100,000
IUCN[5]	Field missions, Palm Islands surveys, expertise	200,000
UNDP[3]	Funding	200,000
UNEP[1]	Subtidal surveys (25 stations) and chemical analysis.	100,000
OPEC[2]	Funding	200,000
Canada[3]	Funding of operations	870,000
Cyprus[3]	Equipment	9,500
	Modeling and expertise	50,000
Denmark[3]	Equipment and Expertise	71,300
Finland[2]	Equipment	375,000
	Personnel and expertise	19,000
France[2]	Equipment, personnel, and expertise	875,000
Germany[3]	Personnel and expertise	18,700
German Remote Sensing Institute[1]	Satellite analysis and publication of oil spill movement.	250,000
Italy[2]	Vessels, air surveillance, personnel, expertise	3,750,000
Kuwait[3]	Equipment	60,000
Monaco[3]	Funding	18,700
Norway[2]	Equipment	1,480,000
	Personnel	6,400
Spain[2]	Equipment	1,000,000
Sweden[2]	Personnel and expertise	9,500
Switzerland[7]	Clean-up of Palm Islands Nature Reserve	82,700
	Clean-up of coastline Enfe-Tripoli	433,900
United States[2]	Operations: Byblos to Enfe.	5,000,000
NGO: Bahr Loubnan[4]	Shoreline and underwater oil recovery.	500,000
Other NGOs (Green Peace)	Assessment activities, Vessel.	200,000
	Subtotal	15,992,300
	Equipment reusable	1,000,000
	TOTAL MITIGATION	**14,995,800**

Source: [1] Based on field visit by oil expert E. Gundlach; [2]IMO-REMPEC [3]UNDP (2007), [4]M. Al-Sarji, Bahr Loubnan; [5]H. Kilani, IUCN, Lebanon; [6]G. Jaradi, GAC, Palm Islands Nature Reserve; [7]SDC, 2007.

2.11.2. The cost of oiled waste

It is likely that more effort will still be needed for the oil spill clean-up. One major problem is dealing with the wastes generated by the spill. The estimated amount of oiled waste generated by Phase I clean up operation is 1,030 m^3 of liquid waste and 6,250 m^3 of polluted waste such as: sand, garbage, debris and equipment (PCM, 2007). In addition, Phase II of oil spill clean up will generate a further 4,500 m^3 of solid waste, based on surveys of the remaining polluted sites conducted along the Lebanese coast between April and May 2007 (MOE, 2007b).

Figure 2.11 Containers of oiled waste

Photograph courtesy of M. El Sarji

Photograph courtesy of MOE

The Ministry of Energy and Water approved MOE's request to store temporarily in Zahrani's refinery the polluted waste extracted along the shores to the south of Beirut; and in Tripoli's refinery the polluted waste collected from the north of Beirut. In addition, the containers of waste extracted from Daliyi Fishermen's Wharf and the Raouche area in Beirut were transported to Bsalim's sanitary landfill for temporary storage (PCM, 2007).

This study estimate the cost of oil waste removed during Phase I of the oil spill cleanup, based on the waste management options considered by the

Ministry of Environment. Since there is no information on the management of oil waste that will be generated under Phase II, the later will not be accounted for in the study. Thus, the resulting estimate probably under estimate the total cost of managing and disposing oiled waste.

The on-going study "*Assessment and review of oil spill clean waste and review of possible treatment options*" commissioned by the Ministry of Environment is currently identifying options to manage and treat oiled waste. Based on the preliminary results of this study and the authors' own estimates the section below provide an estimated cost to manage and treat oiled waste.

If liquid waste (estimated quantity 1,030 m^3) is re-processed at Zahrani refinery it will cost about US$ 92,000.

Concerning the remaining non-liquid oil-polluted waste (estimated quantity: 6,250 m^3), options to treat low-to-medium contaminated sand are different from those to treat heavily contaminated sand and solid waste. The available information does not distinguish the quantities for each type of polluted waste. Most of it is however considered hazardous waste, due to the toxicity of the fuel (MOE, 2007). The report, thus, assumes that 25% of polluted waste includes low-to-medium contaminated sand and 75% represents heavily contaminated sand and pebbles.

The report also assumes that the 25% (or 1,550 m^3) of low-to-medium contaminated sand will be re-used in cement, construction or asphalt industries. At a unit cost of[75] US$10/$m^3$ and a transport cost of US$80,000, the total cost of transporting and treating the low-to medium contaminated sand is estimated at US$96,000.

The other 4,700 m^3 of heavily contaminated sand and pebbles is likely to be shipped under Basel convention. At a cost of[76] US$10,000/ m^3, the estimated total cost to ship and treat the heavily contaminated sand and pebbles would cost about US$47 million.

Based on the treatment options assumed above, the estimated cost of transporting and treating the oiled waste resulting from Phase I cleaning operation is estimated at **US$ 47.1 million**.

It is important to note that once the MOE study is completed and the final option to treat the oiled waste is selected, the actual costs of managing and treating oiled waste are likely to be different from those estimated in this report.

2.11.3. Estimated cost of monitoring operations

In addition to the estimated cost of oil spill clean-up already spent, more clean-up and monitoring efforts are needed along the Lebanese coast. Estimating the amount necessary for future operations would require a detailed analysis of the priorities to be dealt with. Such an analysis goes beyond the scope of this report, thus no overall estimate will be provided. This section only presents **some** future costs already estimated, based on MOE discussions.

Clean-up and monitoring of Palm Islands Nature Reserve. The MOE and Spanish Government are discussing Phase II of the clean-up and monitoring operations in Palm Islands Nature Reserve, which is estimated to cost about **US$1 million**.

Monitoring pilot sites along the Lebanese coast. The costs of sampling water, sediments, biota and fish species in 9 sites along the Lebanese coast (to test for total hydrocarbons, polycyclic aromatic hydrocarbons, heavy metals, pH, conductivity, temperature, and total suspended matter) was estimated at US$165,000 for one year in 2006. Sampling for a period of three years would therefore be estimated at about **US$ 0.5 million**.

Overall, the cost of oil clean-up, treatment of oiled waste and monitoring the Lebanese coast is estimated at **US$ 63.5 million**.

[75] UNDP (2007) indicates a cost of US$25,000 for treating 2,400 m^3 of low to medium contaminated sand and pebbles.

[76] UNDP(2007) estimates that shipping 100 m^3 under Basel convention costs about US$1,000,000.

2.12 SUMMARY OF DAMAGE AND CLEAN-UP COSTS

The overall damage and clean-up cost due to the oil spill is conservatively estimated at about **US$203 million**, or **1.0% of GDP** in 2006. This figure represents the lower bound of real costs, as: (a) it does not capture several damage costs, such as the effects on health (skin diseases), on ecosystem services (loss in habitat for spawning) and on marine biodiversity; (b) it fails to cover the cost of many clean-up operations to be performed in the future; (c) for many impacts, it tends to reflect only partially the real cost of the oil spill, as a result of the conservative assumptions adopted for valuation. However, the overall estimate and its breakdown per impacts should be regarded with much care, as many of the assumptions are subjective and to some extent, debatable, because of lack of accurate data.

Table 2.25 summarizes the estimated costs of damage and clean-up. Damage costs account for slightly less than 70% of the total and are mostly represented by the cost of oil fuel spilt and burnt, followed by the losses to hotels, beach resorts and restaurants. Relatively important damages occur to marinas, sports activities and commercial fishing. The least valued impacts (Palm Islands Nature Reserve and Byblos) are mainly a result of scarce data, and do not suggest the least important values.

The estimated clean-up costs form about 30% of the total. The dominant cost is treatment and shipment of oiled waste, as a result of the expensive shipping procedures under the Basel convention.

Table 2.25 Estimated costs of damage and clean-up due to the oil spill (million US$)

	Min	Max	Mean
DAMAGE COSTS			
- Hotels	22.8	59.6	41.2
- Beach resorts, chalets, public beaches	13.2	34.8	24.0
- Marinas sports activities	4.0	4.2	4.1
- Palm Islands Nature Reserve	0.7	1.2	1.0
- Byblos	0.1	0.1	0.1
- Restaurants	19. 5	31.1	25.3
- Commercial fishing	3.0	5.9	4.4
- Sea-shore fishing	0.3	0.5	0.4
-Cost of oil fuel burnt	39.1	39.1	39.1
Sub-total	**102.8**	**176.4**	**139.6**
OIL SPILL CLEAN UP:			
- Expenses already made	14.9	14.9	14.9
- Oiled waste	48.2	48.2	48.2
-Monitoring expenses	1.5	1.5	1.5
Sub-total	**63.5**	**63.5**	**63.5**
TOTAL	**166.3**	**239.9**	**203.1**

2.13 RECOMMENDATIONS TO IMPROVE THE ECOSYSTEM MANAGEMENT IN THE FUTURE

Along with the major economic and social losses on the coast, the Jiyeh oil spill resulted in injury to fish, coastal birds, intertidal and subtidal communities, and marine turtles. Marine mammals (dolphins) are less likely to have been injured. The following discussion describes the measures and their associated costs to restore the injured resources, concentrating on the key ecosystem components of birds, turtles and fish. It then focuses on the need for the country's adoption of an oil spill contingency plan.

Specifics to each program would have to be further developed by local scientists and government administrators in conjunction with international experts and potential donors. Several concepts for monitoring work developed by the National Center for Marine Sciences (NCMS, 2006) are acknowledged and incorporated below. Inherent in each program is to develop sustainability between the resource and stakeholders, which includes outreach to the community and incorporation into long-term government programs.

2.13.1 Costs of bird restoration.

The recovery of coastal and marine birds can be assisted as follows:

- Field work on resident and migratory species to ensure that all important bird areas are designated.
- Work with international groups and Lebanese government officials on the designation and protection of important bird areas.
- Develop coastal protection strategy to ensure that coastal habitats remain available to resident and migratory species.
- Ensure marking and protection of coastal nesting sites.
- Work with local residents to ensure protection of important bird areas.
- Monitor populations of resident and migratory species to ensure that actions taken are sufficient.
- Purchase and protect important areas to nesting and migratory birds.
- Develop an oil spill response guide for Lebanese shorelines to assist bird protection in the future.

This work is outside that suggested for the Palm Islands Nature Reserve. The estimated cost of this effort is US$5 million[77].

2.13.2 Costs of turtle restoration.

The marine turtle population in Lebanon is not in good condition. Only in the Palm Islands Nature Reserve and Mansouri village located south of Tyre are turtles sufficiently protected and monitored (Tyre was not impacted by the oil spill). A multistage process will be needed to enhance resident populations. First a repeat of the 2001 assessment (Dimirayak, 2001) needs to be undertaken to determine if additional beach areas can be restored to nesting turtles. In the areas outside Palm Island where marine turtle nests can be reinstated, both a public awareness campaign and specific measures to protect the turtles and nests will be needed to increase the population. Land purchases are required to protect the area adjacent to the nesting beaches and to limit access during the nesting season. As a long-term project, the amount of debris coming into the marine environment and washing up on the beaches needs to be reduced by removal of eroding coastal landfills and development of controlled interior sites. The estimated cost of this effort is US$10 million[78].

2.13.3 Costs of Fishery Restoration.

Little is known regarding the level of fish stocks in Lebanon, although overexploitation of the resource is most likely. The first stage to assist restoration is therefore to undertake an assessment of the fish stocks present, including population trends and analysis of principal nursery grounds. Increasing the ability of fishermen, by larger boats or other means, may be counterproductive to increasing the fishery resource. Using the knowledge of the assessment, the second stage will be to design and implement recommendations to develop and increase the fishery on a sustainable basis working with commercial fishers. The estimated cost of this effort is US$10 million[79].

One of the effective tools in restoring and conserving marine resources and rejuvenating over-exploited fisheries along the coastline is to designate marine protected areas (MPAs) and construct artificial reefs in them where needed. UNDP proposed the use of part of the war rubble and decommissioned army transporters and tanks to construct artificial reef. This can be a technically sound option to mitigate a waste problem and provide an environmental service and source of income for the many affected fishermen. An environmental and socio-economic feasibility study would have to be conducted to asses the potential impacts of this option and confirm its suitability for the Lebanese environment. This would be followed by the identification of potential sites to construct the reefs, bearing in mind legitimate marine activities, and conducting baseline studies to

[77] Based on calculations undertaken by oil expert E. Gundlach, October 2006.

[78] Same as previous footnote

[79] Same as previous footnote

provide benchmark data such as tidal currents, water depth, and direction of currents. A monitoring program and fishery surveys would have to be in place for over six years to verify whether the management objectives are fulfilled and the anticipated net benefits materialized. The estimated cost of this effort is US$475,000 (UNDP, 2007).

2.13.4 Palm Islands Nature Reserve

Palm Islands Nature Reserve is the most important marine reserve in Lebanon. It has received support from IUCN to protect the area and to enhance its recovery from the spill in the future. One of the consequences of oil spill has been the acknowledgment of the lack of availability of any marine data for the reserve. This has hindered the ability of the experts to assess the damage to the actual marine environment of the Reserve. Therefore it is of vital importance that a full marine biodiversity assessment be conducted around the Reserve to better assess any potential damage, should a similar crisis happen again in the future.

Further mitigating activities recommended by UNDP on Palm Islands Nature Reserve include:

- Surveying the marine biodiversity of the site
- Assessment of stakeholder-resource interactions
- Marine centre concept and design
- Zoning of Palm Island for different uses

The estimated cost of these activities is US$ 705,000 with a timeframe of 30 months (UNDP, 2007).

2.13.5 An oil spill contingency plan

In critical situations such as oil spills, early and coordinated response measures will prevent the oil slick from encroaching on larger areas. The impact of the hostilities and the humanitarian relief effort most likely exhausted the available resources to combat an oil spill. However, the oil spill has also exposed the need for the development and implementation of sustainable oil spill preparedness and response systems. A national oil spill control and contingency plan should be in place and exercised periodically with the various government agencies and all relevant stakeholders. It would test the level of readiness and the effectiveness of the plan, including administrative and logistical problems, access and transport of necessary equipment across international waters and reveal any weakness in the communications and coordination arrangements. The plan should also include a join effort at capacity building by key stakeholders such as local industry, government and non governmental organizations to accommodate for local conditions.

Chapter 3. DEMOLITION, MILITARY AND MEDICAL WASTE

3.1 INTRODUCTION

The July 2006 hostilities in Lebanon caused extensive destruction to infrastructure, residential buildings, and livelihoods. The hostilities claimed close to 1,200 civilian lives; left more than 4,400 people wounded, and displaced more than a quarter of the Lebanese population (GOL, 2006a). It resulted in significant socio-economic and environmental damage throughout the country. This chapter focuses on the impacts of demolition waste resulting from the military aggression (section 3.2), the impact of unexploded ordnances- as environmental waste- on people's lives and sources of income (section 3.3) and the increase in medical waste associated with the humanitarian relief effort (section 3.4).

3.2 CONSTRUCTION AND DEMOLITION WASTE

During the July/August 2006 hostilities in Lebanon, the bulk of the military operations were concentrated in three areas, namely the Southern Suburbs of Beirut, the Districts of the South, and the Baalbek El Hermel region. Significant quantities of construction and demolition (C&D) waste resulted from the destruction of residential units in these areas. Typical C&D debris constituents can be grouped into three categories:

a. Primary inert fractions: asphalt, brick, cinder block, concrete with rebar/wire mesh, concrete without steel reinforcing, masonite/slate, tile-ceramic, glass, dirt/earth, plastic sheet film, plastic pipe, porcelain including bathroom fixtures, metal-ferrous, metal-nonferrous, electrical wiring, insulation-fiberglass, and plastic buckets/ containers.
b. High organic based fractions: ceiling tiles, corrugated shipping containers, insulation-treated cellulose, insulation-sheathing, pallets/spools/reels, pressboard/ chipboard, roofing materials (e.g., roofing felt, asphalt shingles), dimensional lumber and shapes (clean), plywood, particle board, oriented strand board, etc.
c. A range of composite materials (that may require special handling) such as: carpeting, carpet padding, gypsum wallboard (mainly gypsum with paper backing), electrical fixtures (metal, light tubes/ bulbs, ballasts), electrical switches, rubber hosing/conduits, tires (some with wheels), painted wood, pressure treated wood and wood composites.

In addition, furniture, electronic appliances and personal belongings constitute a considerable portion of the demolition waste resulting from destruction by military activities.

3.2.1 Generated quantities

Various field visits and assessments were conducted by government agency and international organizations to assess the extent of the physical damage in Beirut Southern Suburbs, the South and the Baalbek El Hermel region. Various sources provided different estimates on the generated quantities of demolition waste. This sub-section presents the available information to date and adopts the most recent government estimate as an input to the analysis.

In Beirut Southern Suburbs: UNDP reported that about 150 residential buildings were completely destroyed and that, on average, each building contained 30 units for a total of 4,500 units (UNDP, 2006a). Other buildings have been damaged or partially demolished

A joint effort between the Municipality of Haret Hreik and the Department of Architecture and Graphic Design at the American University of Beirut estimated the number of completely demolished buildings at 102, the number of partially blasted buildings at 28, and the number of damaged buildings at 70 in August 2006 (see Figure 3.1).

A rapid preliminary damage assessment undertaken by the European Commission's Joint Research Center and the European Union Satellite Center (EC, 2006b) indicated that the number of residential buildings either damaged or destroyed in the Southern Suburbs is 326 (of which 269 in Haret Hreik).

The order of Engineering in Beirut assessed the number of completely destroyed buildings to 200 and the number of inhabitable building to an additional 100 (GOL, 2006b)

.

Figure 3.1 Varying degree of damage to buildings in Beirut Southern Suburbs

(a) Buildings completely destroyed

(b) Partially blasted buildings

(c) Damaged buildings

Photographs courtesy of M.EL Fadel and team

In the South and the Baalbek El Hermel area: A field survey was conducted during the preparation of this study in October-November 2006. Based on interviews and records with heads of municipalities (see Annex 3) more than 8,790 housing units were reportedly demolished in the **South**. Most are concentrated in the Cazas of Marjeyoun, Nabatieh, Bent Jbeil, and Tyre, with relatively less destructions in the Cazas of Hasbaya and Saida. The distribution of demolished houses by Caza is detailed in Annex 3. As for **the Baalbek El Hermel a**rea, the field visit revealed that more than 6,000 housing units were affected, of which 375 totally destroyed, 400 badly damaged and the rest severely of lightly damaged. Based on these fields visit, the authors' own estimate of the quantity of demolition waste generated varies between 2 to 3.7 million m^3 (see Annex 3 for detailed estimate).

An initiative to assess the environmental damage of the July conflict, sponsored by UNDP, estimated the total volume of rubble resulting from the destructions to be within the range of 2.5 to 3 million m^3 (UNDP, 2007).

The latest figures from the Government indicate that the number of housing units destroyed in the South and the Baalback El Hermel area is distributed as follow[80]:

11,140 housing units destroyed
1,249 housing units partially destroyed
81,000 housing units lightly damaged

The actual volume of demolition waste transported to date was recently released by the Presidency of the Council of Ministers (PCM, 2007). The reported values reached a total volume of 5.75 Million m^3 (1.43, 3.32, and 1 M m^3 in Beirut, the South, and the Bekaa, respectively) thus indicating that previous calculations were very conservative and underestimated the actual volumes being removed. The most recent numbers reported by the PCM were used to calculate the environmental damage cost due to the hostilities.

[80] Based on communication with the office of the President of the Council of Minister in August 2007.

Table 3.1 Actual quantities of rubble and demolition waste as reported by PCM, 2007

Regions	*Quantities (million m3)*
Beirut Southern Suburbs	1.43
South	3.32
Bekaa	1
Total	**5.75**

To assess the environmental damage associated with the generated C&D waste, the study considered the impact of the actual handling of the waste as it happened after the ceasefire. As described below, the study accounts for the additional costs or damages generated by waste loading, transport, road depreciation, traffic delays, and disposal[81]. It is important to note that this analysis was undertaken between October 2006 and April 2007. Since then, changes in disposal sites have occurred –and may still occur in the future. This will entail a change in the estimated damaged costs.

3.2.2 Waste loading, transport and disposal

While C&D wastes are usually land filled, the corresponding landfills are generally not subject to the same regulatory procedures as municipal solid waste (MSW) landfills since such waste is mostly inert materials[82]. While the cost of C&D landfilling is relatively lower than MSW, some components of the C&D materials may be recycled such as concrete, asphalt, metals, and wood. In the case of Lebanon, immediate action for the removal and disposal of demolition waste was required to allow for reconstruction activities. Concerned municipalities, together with the Council for Development and Reconstruction (in Beirut), the Ministry of

[81] The potential treatment of C&D was not accounted for in the analysis as it did not enter the actual handling scenario. For information about options for C&D treatment and disposal, once can refer to the extensive analysis done by UNDP (2007) which is summarized in Box 3.1.

[82] In this case, this is not the situation because the C&D are resulting from military activities rather than a systematic well-organized effort that produces mostly inert C&D. Therefore, it can be easily associated with potential sub-surface pollution due to rainwater infiltration. However estimating such an impact would require extensive on-site surveys, which were beyond the scope and timeline of the present report.

Public Works and Transport (in Baalbek), and the Council of the South (in the Southern Districts), identified disposal sites for each region and contracted the excavation, hauling, transport, and disposal of the demolition waste.

In Beirut's Southern Suburbs the demolition waste collected has been disposed of at four sites, two in low-lying areas located by the sea and one on the other side of the road within the Choueifat cadastral area, and a temporary dumpsite along the Airport Road within the Bourj Al Barajneh cadastral area (Figure 3.2). The demolition wastes are dumped haphazardly into these areas (Figure 3.3). The slope of the deposited waste has almost reached a ratio of 1:1, which could pose a safety hazard in the absence of adequate stability control measures. Note that, with respect to the dumpsites located by the sea, sea encroachment has occurred but minimal. Wherever this encroachment occurs, the bulky nature of the C&D waste gives it a relatively good angle of stability, minimizing the likelihood of its collapse into the sea. While this invariably damages the coastal ecosystem, the impact is difficult to quantify monetarily.

Figure 3.2 Rubble disposal sites in Beirut

Photograph courtesy of M. Sarraf

Figure 3.3 Rubble disposal site along the seashore

Photograph courtesy of M. Sarraf

In the South, some municipalities, where not as much demolition waste was generated, are using this waste to fill some depressions in the roads or to use at other building sites. In towns where large volumes of demolition waste were generated, the waste is being disposed of on nearby lands (Figure 3.4). Such is the case of Al Khyam, where the municipality is throwing the rubble in a nearby valley, 300 m off the main road, facing the Israeli border. In Bint Jbeil, the municipality disposed of part of the wastes in a valley 2 km off the main road. However, the neighboring municipality of Aytaroun intervened and requested that the wastes be directed to their town so that they can fill a seemingly abandoned pond as shown in Figure 3.5. Also, the municipality of Maroun el Ras is sending its demolition wastes to Aytaroun.

The damage associated with the dumping of C&D waste in valleys and ponds goes beyond the cost of land to include ecosystem damage and visual intrusion. However, the latter are difficult to quantify monetarily. Impacts on hydrology and hydrogeology are equally difficult to quantify monetarily, but are expected to be limited since a good portion of the household hazardous material is being removed prior to transport to the dumpsites (UNDP, 2007). Similarly, the opportunity cost associated with land use as dumpsites is difficult to quantify, but yet is not expected to be high, particularly in Khyam, due to the site's proximity to the Israeli border.

Figure 3.4 Demolition waste dumped in Bint Jbeil

Photograph courtesy of M El Fadel & team

Figure 3.5 Aytaroun pond filled with C&D waste

Photograph courtesy of M El Fadel & team

In Baalbek El Hermel, the collected waste is being dumped in an abandoned quarry and in several other locations in the suburbs of Baalbek. Some waste is also being used to rehabilitate land depressions caused by the military aggression.

Field visits revealed that sorting of some material such as construction steel, asbestos mats and concrete bricks is taking place at the dumpsites, with the main purpose of recovering steel for recycling. Other waste components such as personal belongings, furniture and white goods could not be sorted due to the intensity of the destruction.

Note that asbestos mats were encountered mainly in Baalbek El Hermel area (Figure 3.6). No asbestos was found upon preliminary site assessment as part of the UNDP initiative in the Beirut Southern Suburbs and the South. No official reports on asbestos contamination of the waste have been published to date. Moreover, visual site inspections for asbestos containing materials suggest that asbestos contamination is not a major issue of concern (UNDP, 2007). As such, while friable asbestos poses a potential occupational hazard, the limited short-term exposure during the post-conflict period is not likely to allow the development of severe health implications among the workers. Again, it is difficult to assign a monetary value to such an impact, especially that it follows a short-term exposure.

Figure 3.6 Construction and Demolition waste in Baalbek El Hermel: Asbestos mats (top), construction bricks (middle) and steel (bottom).

Photographs courtesy of M El Fadel & team

The equivalent unit cost of hauling and transport of one cubic meter of C&D waste was estimated at US\$ 2.38/m^3, based on field visits and interviews (Table 3.2). Accordingly, the total cost of hauling and transport of the generated demolition waste is around US\$ 13.7 million. Note that the average hauling distance was about 2 to 3 kms whether in suburbs of Beirut, the South or the Bekaa. Therefore, contracts with hauling contractors, implicitly took the distance into consideration, and appeared to have been based mainly on the volume (m^3) hauled, set as a function of the capacity of trucks. This may explain the difference between the estimated volumes and the reportedly hauled volumes taking into consideration the density variations.

Table 3.2 Estimated cost of loading and transport of C&D waste (in 2006)

Description	*Rate*
Waste Hauling[a]	
Dozer charging rate[b] ($/day)	400
Filling capacity of 3 dozers[c] (Truck/day)	30
Daily volume of C&D waste loaded (m^3/day)	540
Cost of Loading each Truck per m^3 of DW ($/$m^3$)	**0.07**
Waste Transport[a]	
Truck charging rate[b] ($/day)	250
Daily number of round trips	6
Loading capacity per truck (m^3)	18
Daily Volume of DW Transported per Truck (m^3/day)	108
Cost of Transport per m^3 of DW ($/$m^3$)	**2.31**
Total Unit Cost ($/$m^3$)	**2.38**
Cost in Beirut S. Suburbs (millions $)	3.4
Cost in the South (millions $)	7.9
Cost in Baalbek El Hermel (millions $)	2.4
Total Cost (million $)	**13.7**

[a] Based on field surveys and expert opinion
[b] Including wage of driver
[c] Average number of dozers per site, based on field surveys and expert opinion

3.2.3 Road depreciation

Two sets of roads can be identified in terms of damage due to the movement of trucks transporting demolition waste: roads in the South and Baalbek El-Hermel, and roads in the Beirut area. Roads in the South or in the Baalbek El-Hermel areas were not significantly affected by the transport of demolition waste. Damage to the road infrastructure in these areas can be directly attributed to the military aggression. On the other hand, the road infrastructure in the Beirut area is expected to be negatively impacted by the high number of trucks required for the transportation of significant C&D waste volume concentrated in the Beirut Southern Suburbs. Based on GIS analysis, and given the estimations listed in Table 3.3, the cost of road maintenance in Beirut due to the damage caused by the transport of C&D waste was estimated to range between US$ 240,000 and 720,000. Note that the estimates are associated with a high level of uncertainty, as it is difficult to separate the type of damage as a direct result of the hostilities from the damage related to truck travel in the Beirut Southern Suburbs.

Table 3.3 Cost of road depreciation in Beirut (in 2006)

Description	***Rate***
Average road length (km)[a]	2-3
Average road width (m)[a]	6-8
Average road area (m^2)	12,000-24,000
Cost of road refurbishment ($US/ m^2)[a] 40 cm of compacted gravel 10 cm of asphalt	20-30[b]
Total cost of road depreciation (US$)	**240,000-720,000**

[a] Based on field surveys, expert opinion, and GIS analysis
[b] Range accounts for degree of intervention and thickness damaged

3.2.4 Traffic delays

The transportation of demolition wastes to the designated dumpsites caused traffic delays on the roads used for this purpose. In the Baalbek El Hermel area and in the South, such delays were not encountered due to (i) traffic management and rerouting away from the city center and (ii) the location of the dumpsite at the city outskirts. In contrast, the increased number of trucks on the congested roads in and around Beirut's Southern Suburbs has caused a large number of people using the southern corridor of Beirut to spend an extra 1 to 3 hrs in traffic. While it is difficult to differentiate between delays related to trucks transporting demolition waste and delays related to bombed roads in Beirut, it can be argued that had there been no truck movements, the delays would be much lower. Therefore, a delay of 2 hours per day was attributed to the transport of demolition waste. This delay is translated into an economic loss of about US$ 51 to 68 million, in terms of wages and fuel, as detailed in Table 3.4. A factor of 0.5 is used to account for opportunity vs actual cost, whereby it is assumed that half of the time lost due to traffic delays is productive. The other half could be translated into an impact on quality of life which was not accounted for in this evaluation (in terms of monetary value). It is worth noting that:

- The road structure (narrow width and quality) exacerbates traffic congestion.
- Trucks carrying debris were working around the clock with practically no alternate routes or sites particularly in the Southern suburbs of Beirut.
- Working off-peak was not an option even when the hauling schedule decreased to 12 hours or less.
- A proper public bus transit system does not exist in the area and the general traffic is dominated by passenger trips or shared taxis.

While the reconstruction is likely to extend for a longer period of 6-8 months, the main and most dense hauling activities would have ceased and traffic congestion due to reconstruction is likely to be managed easier

Table 3.4 Estimated cost of traffic delays (in 2006)

Description	*Rate*
Average extra time spent in traffic (hr/day)[a]	2
Average hourly wage (US$/hr)[b]	2.5
Number of working days per month[c]	22
Fraction of lost productive time[a]	0.5
Duration of waste removal (months)	6-8
Opportunity cost of time (US$/ person/6-8 month)	330-440
Average daily number of affected commuters[d]	115,150
Opportunity Cost of Time (US$ million)	**38-51**
Fuel consumption per hr in traffic (L/hr)[a]	1
Unit cost of fuel ($US/L)[a]	0.8
Cost of fuel spent per person per month ($US/month)	35.2
Number of affected vehicles[d]	60,000
Cost of gasoline spent per person per 6-8 months ($US/person)	211-282
Total cost of gasoline spent per 6-8 months ($US million)	**13-17**
Total cost of traffic delay (US$ million)	**51-68**

[a] Based on field surveys and expert opinion; [b] Based on a GDP of 5,300 US$/capita; [c] Peak travel delays are assumed to occur 22 working days/month; [d] Based on DMJM, HARRIS, 2003 (Refer to Annex 3)

3.2.5 Cost of land for waste disposal

Assuming that all the waste in each area is disposed in one equivalent landfill (conservative approach), and assuming a height of 25 meters (relatively high), and a buffer zone of 30 percent, the cost of land incurred would be around US$ 78 thousand in Baalbek El Hermel, US$ 1.7 million in the South, and US$ 74 million in Beirut as detailed in Table 3.6. These numbers are underestimated because the number of sites is larger and the height of the waste is often lower than 25 meters hence resulting in a need for larger areas.

The unit cost of land adopted in the estimations is average to low, to account for the fact that most sites selected are not prime locations. For example, in the case of **Beirut**, the unit cost of land by the sea ranges between US$ 2,000 and 5,000 /m^2. Yet, the selected sites are by the airport and hence of lower value. Disposing demolition waste on a land valued at around US$1,000/$m^2$ may seem enormous. But it is important to note that in the case of Beirut alternative sites were very difficult, if non-existent, to locate nearby the damaged sites. Hauling rubble from Beirut to cheaper sites in the Bekaa, the South, or the North of the country was not feasible at the time given that the infrastructure and most connecting bridges were destroyed. In addition, political pressure to keep the waste within the area of the southern suburbs of Beirut was mounting due to potential benefit from steel recycling. While the income from the latter should theoretically be deducted from the overall damage estimates, this was not possible due to lack of well-documented information about the recycling activities.

In the South, the pond and the valley are considered as prime lands, while road depressions have minimal direct cost. In Baalbek El Hermel, lands along the roads are of considerable value, while quarries are of lower value.

Table 3.5 Estimated cost of land for C&D waste disposal (in 2006)

Region	*Waste volume (000m³)*	*Landfill height (m)*	*Area of waste (000m²)*	*Landfill area (000m²)*	*Cost of land[1] ($/m²)*	*Cost of land (million $)*
Beirut	1,430	25	57.2	74.4	1,000	74.4
South	3,320	25	132.8	172.6	10	1.72
Baalbek	1,000	25	40.0	52.0	15	0.78

[1] Based on real estate information and expert opinion

3.2.6 Depreciation of land surrounding dumpsites

The disposal of rubble and debris in various dumpsites, especially dumpsites located along the coast, represent a health hazard to surrounding neighborhoods as well as a visual intrusion that affects the quality of life. Within the context of this study, it has not been possible to assess the damage done by the dumpsites on the value of surrounding land and property.

3.2.7 In summary

The actual damage by large quantities of rubble and debris was estimated to range between **US$ 142 to 159 million**.

Table 3.6 Estimated total damage cost of C&D waste

Parameter	**Damage cost (million US$)**			
	Beirut	**South**	**Baalbek**	**Total**
Waste hauling and transport	3.4	7.9	2.4	13.7
Road maintenance	0.2-0.7	-	-	0.2-0.7
Traffic delays	51 - 68	-	-	51 - 68
Land for disposal	74.4	1.7	0.8	76.9
Land depreciation	-	-	-	-
Subtotal	129-146.5	9.6	3.2	**142-159**

Box 3.1 Options for treating and disposing of demolition waste (UNDP 2007).

UNDP 2007 developed various options and scenarios for the treatment and disposal of C&D. The UNDP report assessed two main treatment scenarios: (1) treatment in a fixed recycling facility, and (2) on-site treatment with mobile equipment. Additionally, each scenario was evaluated for three levels of material recovery: (a) volume reduction with no material recovery, (b) typical levels of material recovery (30-40%) producing scrap metals and mixed aggregates for use in road-base or landscaping, and paving, and (c) full material recovery (85%) generating scrap metals, mixed aggregates, and clean aggregates for use in asphalt and other aggregate mixes.

Furthermore, each of the treatment alternatives was also assessed for different disposal options. In general, four alternative disposal options for demolition waste were considered:
(1) landfilling in an inert waste landfill (Bsalim),
(2) backfilling for quarry rehabilitation,
(3) donating to landfills to be used as daily cover, and
(4) donating to SOLIDERE for sea reclamation.

According to the various scenarios, the estimated cost for the treatment and disposal of C&D waste ranged from $US 4 to 33 million (Avg =17 million USD) for 1 million m³ of rubble in the Beirut Southern Suburbs and between $US 8 and 65.5 million (Avg =35 million $US) for 1.8 million m³ of rubble in the South and Baalbek El Hermel regions. The least cost alternative involves crushing for volume reduction of the waste at the temporary storage sites followed by disposal as landfill cover, while the most expensive option involves the transport and treatment of the waste at a central facility where 85 percent of recyclables are recovered followed by disposal as quarry fill.

3.3 MILITARY WASTE (UNEXPLODED ORDNANCES)

The latest updates on unexploded ordnances (UXOs) revealed 864 cluster bomb strike locations in South Lebanon (Figure 3.7), with an estimated **one million unexploded cluster munitions** on the ground, contaminating a total of 34 million square meters (E-mine, 2007). The removal of these bombs, in addition to other UXOs is a tedious process, costing around US$ 5.5 million per year[83]. A recent update on demining activities revealed that clearance of all known cluster bomb strikes is expected to be completed by December 2007 (E-mine, 2007). However, given the complexity of this process and its associated delays, a minimum period of two years is adopted in the economic valuation.

Unexploded ordnances are having two main impacts on the livelihoods of the residents in the South. They are claiming the lives of residents and causing casualties (especially children) and preventing access and exploitation of agricultural land, rangeland and forests. The sections below estimate the impact of UXOs on the lives of residents as well as the loss of income due to lack of access to agricultural land. A discussion on the impact of UXOs on the forestry sector is provided in Chapter 7.

3.3.1 Deaths and injuries

According to the Lebanese National Demining Office (NDO), the number of casualties caused by UXOs during the period extending from August 14 2006 to April 03 2007 reached 224, including 29 deaths and 195 injuries (MACCSL, 2007). The number of UXO casualties by the end of the two-year demining period was projected following the trend evident in the current UXO numbers (Figure 3.8). The distribution of the projected numbers (in terms of mortality, morbidity, age) was assumed to be similar to the current distribution. The damage cost of premature mortality and morbidity from UXOs was estimated using the Disability Adjusted Life Years (DALYs). This is a methodology that has been developed and applied by the World Health Organization (WHO) and the World Bank in collaboration with international experts to provide a common measure of the burden of disease for various illnesses and premature mortality[84]. Illnesses and weighted by severity so that a relatively mild illness or disability represents a small fraction of a DALY, while a severe illness represents a larger fraction of a DALY. A year lost to premature mortality represents one DALY, and future years lost are discounted.

For injuries resulting from UXO (leg or arm amputation) the disability weight adopted to assess damage cost is 0.3, (Murray and Lopez, 1996).

There are two approaches to valuing a DALY. The *human capital approach* values a DALY at the level of GDP per capita:if one year of a person's life is lost, society loses, at the very least, her contribution to production. This method provides a lower bound estimate of a DALY lost. An alternative method is the *Value of a Statistical Life* (VSL), which provides an upper bound monetary value of a DALY. It measures the willingness to pay to reduce the risk of death. It is based on observation of individual behavior when trading off health risks and money.

The value of a statistical life method exploits the fact that risk of death is implicit in everyday actions and decisions. So for example, when accepting a job offer, we are implicitly valuing all the features of the job such as salary, career development opportunities, friendliness of the work environment and the health risk inherent in performing the tasks assigned. It is not the same to work as florist or for a company producing explosives. Assuming that health risks are reflected in the job market, the information about salaries will implicitly disclose information about people willingness to pay for avoiding a small chance in the risk of death.

[83] Director of Lebanese Army National De-mining Office, April 2007

[84] See Murray and Lopez (1996) for a more detailed explanation of the DALY principle

The two elements needed for the calculations are the marginal Willingness to Pay for reducing the risk of death and the size of the risk reduction. The following equation is then used to calculate the value of a statistical life.

$$VSL = \frac{\text{WTP to avoid risk of death}}{\text{Reduction in risk of death}}$$

This method does not try to measure the WTP to avoid death with certainty, but uses statistical techniques to record human behavior in trading off risk of dying with money.

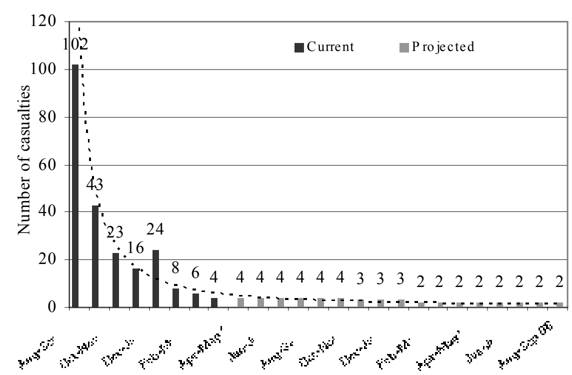
In this report the lower value of a DALY is estimated at US$5,300 (GDP per capita in 2006) and the upper value of DALY used is US$ 42,000 (based on the value of a statistical life divided by a time horizon of 25 years and discount rate of four percent)[85]. Table 3.7 details the calculation of the damage cost due to mortality and morbidity by age group. Accordingly, the estimated total damage cost of casualties resulting from UXOs ranges between **<u>US$ 14 and 109 million</u>** over a period of two years.

Table 3.7 Estimated damage costs of UXOs

Age group	*Current nb of casualties[a]*	*Current and projected nb. of casualties[b]*	*DALYs per case[c]*	*DALY ($ VSL)*	*Current & projected economic loss (million US$/ age-group)*
			MORTALITY		
0-12	2	2.5	33	5,300-	0.43 – 3.40
13-18	4	4.9	36	5,300-	0.94 – 7.43
19+	23	28.2	20	5,300-	2.99 – 23.72
SubTotal	**29**	**35.6**			**4.36 – 34.55**
			MORBIDITY		
0-12	24	29.5	9.9	5,300-	1.55 – 12.25
13-18	39	47.9	10.8	5,300-	2.74 – 21.72
19+	132	162.1	6	5,300-	5.15 -40.84
SubTotal	**195**	**239.4**			**9.44 – 74.81**
Total	**224**	**275**			**13.80 – 109.35**

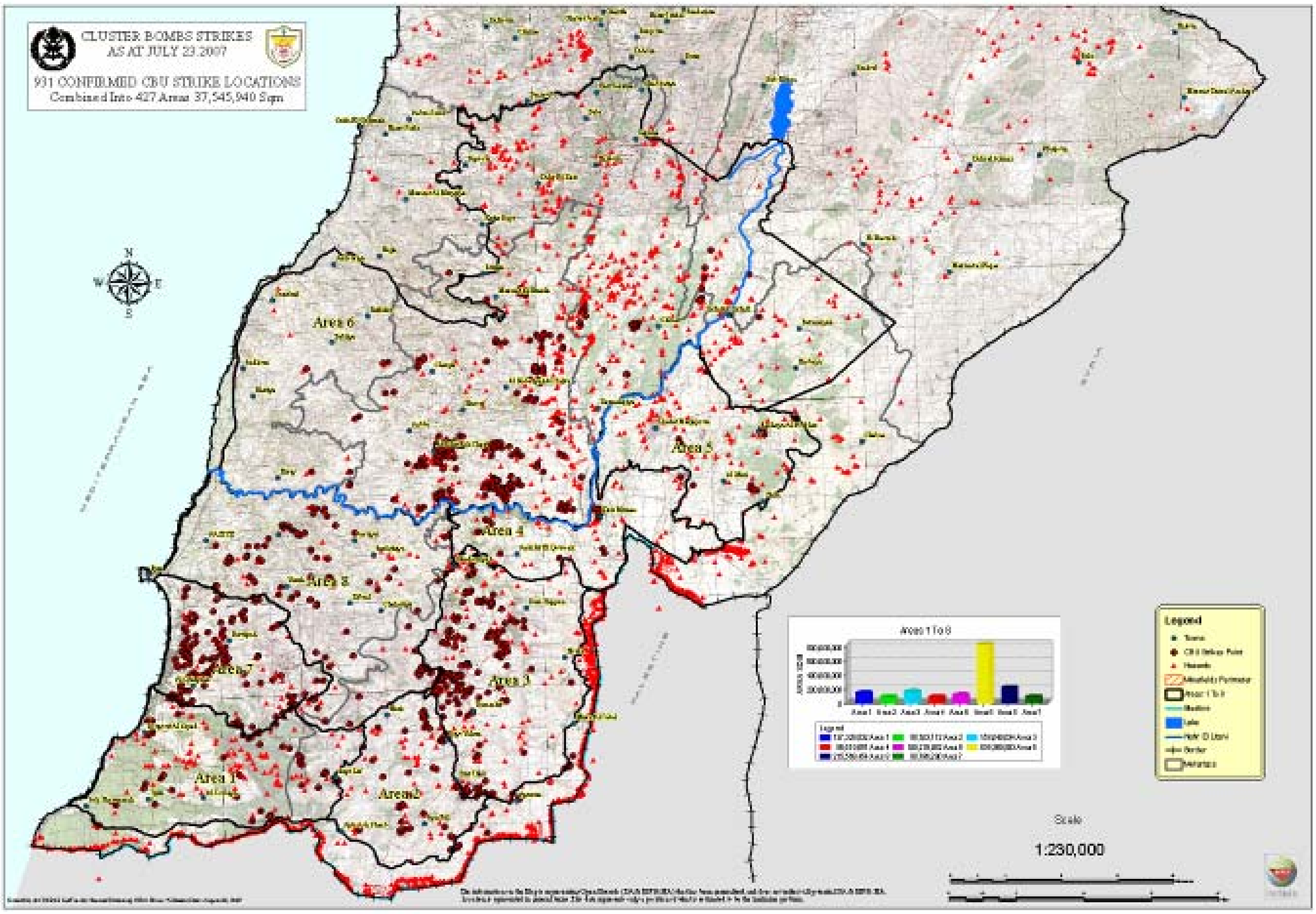
[a] MACCL, 2007
[b] Based on Figure 3.8 and the assumption that percent distribution of projected vs. current casualties is the same
[c] Murray and Lopez, 1996

Figure 3.8. Current and projected number of UXO casualties



[85] This is based on the meta analysis conducted by Viscusin and Aldy (2003) which suggest a value of statistical life between US$5.5 and 7.6 million in 2000. This value is than adjusted to Lebanon taking into account the GDP per capita differential and the inflation rate. It is than applied for a horizon of 25 years.

Figure 3.7 Map of cluster bombs strikes as of July 23, 2007



Map courtesy of Lebanon Mine Action Center

3.3.2 Access to agricultural lands

The limited access to agricultural lands in the South imposed by UXOs will have a significant impact on agricultural production and farmer livelihoods for at least two years. Farmers may behave in various ways in response to this crisis. They may burn their orchards to get rid of UXOs, losing their plantations in the process, they may do nothing and simply wait for their lands to be cleared from UXOs, or they may migrate to urban areas and add to the poverty situation in urban belts. Again, it is difficult to assign a monetary value on these types of behaviors. As such, the impact of the UXOs on farmers was valuated by assessing only the productivity loss due to lack of access to agricultural lands. As evident from Figure 3.7, cluster bombs are scattered throughout the South, which makes it difficult to quantify the total area of inaccessible agricultural lands. Accordingly, several scenarios were adopted to estimate the damage cost of agricultural productivity in the South. These scenarios assume that various percentages (10 and 25 percent) of the South and Nabatiyeh agricultural land - evenly distributed among crop categories in the two Mohafazas, South and Nabatiyeh- will be inaccessible during the first year, and 5 to 10 percent will be inaccessible during the second year. This will invoke a loss of the production that will likely take place in these lands, therefore a loss of the gross income value that these lands would have generated under normal conditions, based on statistics for the year 2004 (Annex 3). This loss was estimated to range between **US$ 40 and 94 million** over a period of two years.

3.3.3 De-mining

The Lebanese Army together with the UN Mine Coordination center and a number of NGOs have been working hard to clear an estimated 14 million m^2 affected by UXO (PCM, 2007) as of May 2007. Also according to PCM, 2007 cleaning agricultural land started around February 2007, after giving priority to clearing schools, public roads and housing areas. An annual budget of US$5.5[86] has been allocated to de-mining. In this study we will assume 2 years of operations until completion of de-mining activities (i.e. US$11 million).

Table 3.8 Estimated damage cost due to UXOs

	Damage cost (million $US)	
	Minimum	*Maximum*
Casualties	14	109
Loss in agricultural opportunities	40	94
De-mining	11	11
Total	**65**	**214**

3.4 MEDICAL WASTE

As a direct cause of the conflict, medical waste generation increased significantly due to increase in casualties and hospital bed occupancy numbers. According to GOL (2006a) the hostilities claimed 1,200 deaths and 4,400 injuries. Based on these figures, it is calculated that around 200 to 250 tons of medical waste were generated during the conflict period (UNDP, 2007). Healthcare waste can be grouped into two broad categories: non-risk and risk waste. The 'non-risk' waste, as defined by the World Health Organization (WHO), is estimated to constitute upwards of 75 percent of the total hospital waste stream, and in some cases it can reach 90 percent of hospital waste. This waste, which comprises general domestic waste components mainly generated from domestic and administrative services, is considered to represent no potential risk from infectious, chemical, or other properties associated with healthcare.

If waste separation-segregation is undertaken properly, non-risk waste can be disposed by similar means as municipal waste. The remaining 10 to 25 percent of hospital waste comprises those components, which are potentially contaminated with material, which are associated with infectious, chemical, or other hazardous characteristics. Waste with such characteristics is defined by WHO as 'risk waste' and must be handled and disposed of in such a manner as to minimize the potential for human exposure and contamination. Risk waste has been classified by the WHO into seven distinct environmental categories including infectious, pathological, sharps, pharmaceutical, chemical, pressurized containers, and radioactive wastes.

Due to the lack of data regarding the composition of the medical waste produced during the conflict period, and assuming no segregation is practiced and hence the generated waste (200-250 tonnes) is infectious, requiring sterilization (at about US$ 60/ton) followed by disposal with regular solid waste at an operational landfill in the country (US$ 15-120 /ton)[87], the cost of handling the medical waste generated during the period of the conflict (including treatment, transport, and disposal) ranges between **US$ 0.015 and 0.045 million** (for detailed information, please refer to Annex 4).

It is worthwhile noting that shipping of hazardous waste in accordance with the *Basel Convention on the Trans-frontier Shipment of Hazardous Waste* would cost US$ 10,000/ton. However, this option has not been considered in this analysis, since, to the best of our knowledge, shipment of infectious medical waste has never been practiced in Lebanon[88]. Given the large quantities of medical waste generated by the hostilities, if the option of shipping and treating medical is considered by Lebanon, the overall damage cost resulting from medical waste will be substantially increased.

In addition, Lebanon received about 502 tons of medicines and medical aid supplies (PCM, 2007)

[86] Director of Lebanese Army National De-mining Office, April 2007

[87] Based on current (2006) land filling charges at Zahlé and Nehmé landfills respectively.

[88] The American University of Beirut ships selected hazardous waste (but not infectious medical waste) on a periodic basis.

during and after the conflict. Medical aid included anesthetics, antibiotics, anti-convulsants, anti-depressants, anti-diarrheals, anti-fungals, anti-inflammatories, anti-retrovirals, heart medicines (anti-arrhythmic, anticoagulant, anti-cholesterol, anti-platelet & hypertension treatments), laxatives, stomach medicines (beta-blockers and H_2-antagonists), painkillers and tranquilizers. Pharmaceuticals may arrive past or near their expiry date, may be inappropriate for the needs, and be unrecognizable because they are labeled in a foreign language or may have been sent in unwanted quantities (UNDP, 2007). Safe disposal of unwanted or expired drugs often creates a major problem. However, since the quantity of unwanted and expired drugs was not known at the time of preparing this study, it was not possible to account for their disposal costs. Once this information becomes available, additional costs for managing this waste will need to be accounted for.

Due to the limitation mentioned above, the total estimated impact of medical waste (ranging between **US$ 0.015 and 0.045 million)** is likely to underestimate the full impact of medical waste on the environment.

3.5 CONCLUDING REMARKS

The assessment of the impacts of demolition, military and medical waste resulting from the military aggression during the July/ August 2006 hostilities in the Beirut Southern Suburbs, the Districts of the South, and the Baalbek El Hermel region were conservatively estimated to range between **US$ 207 to 373 million** (see Table 3.9).

It is important to note the above estimate is likely to underestimate the overall impact caused by the conflict on the waste sector as several potential impacts have not been quantified in this chapter due to the difficultly involved in their quantification within a reasonable degree of scientific certainty. In particular we can note the lack of estimate regarding the real estate depreciation that is surrounding the huge dumps site, as well as the health hazard generated by the manipulation of the demolition waste.

Finally, the potential cost estimated above could rise by 2 to 3 folds depending on control measures and timely implementation of corrective actions.

Table 3.9 Total estimated costs

	Damage cost (US$ million)	
	Minimum	*Maximum*
Construction & Demolition Waste	141.8	159.3
Military Waste (UXO)	65.0	214.2
Medical Waste	0.02	0.05
Total	**207**	**373**

Chapter 4. WATER DEGRADATION

With an annual water availability of 1,260 m^3/capita (AQUASTAT, 2002), Lebanon is one of the most water-endowed countries in the Middle East. Despite its abundance, water quality has continuously degraded even prior to the hostilities. This was primarily due to the disposal of untreated domestic, industrial and agricultural effluents in water streams. The main threat to water quality was the disposal of untreated domestic and industrial wastewater[89]. As most polluted water was discharged into the sea, the coastal and marine areas were probably the areas mostly affected by water pollution. However, the absence of a monitoring system allowed no measurements of the quality of surface and underground water on a systematic basis.

The hostilities added significant damage to water resources. The cost of damage to water and wastewater infrastructure was estimated[90] at about US$65 million (World Bank, 2006a). In many areas, the damaged pipelines disrupted water distribution and increased the risk of cross-contamination of sewage and drinking water supply. The following sections address the environmental and social impacts of the hostilities and attempt to estimate them in monetary terms within the limits of available information. It should be noted that the absence of a system to monitor water quality before and after the hostilities is a major constraint in estimating several impacts.

4.1 IMPACTS ON WATER RESOURCES

UNEP (2007) provides comprehensive information on the effects of the hostilities on water, based on field visits and sample analysis undertaken in October 2006[91]. As expected, strong impacts on water resources occurred in the areas mostly damaged by the hostilities: the southern suburbs of Beirut and South Lebanon. Important causes of damage include the strikes on industrial facilities, the bombings of water and wastewater infrastructure and the destruction of bridges over the main rivers, such as Litani.

Several impacts were observed. The strike on *industrial facilities* caused localized damages in the south of Beirut. For example, the damage of Choueifat industrial area (near Beirut) induced potential pollution of surface and ground water with waste residue, contaminated soil and ash. The Ghadir stream that traverses the Choueifat industrial area prior to discharging into the Mediterranean Sea was found to be especially threatened by pollution. Groundwater analysis detected contamination by heavy metals (eg. arsenic, selenium) and toxic benzene, which levels exceeded the standard environmental screening values.

The bombings of *water and wastewater infrastructure* affected mostly the southern suburbs of Beirut (the municipality of Haret Hreik) and South Lebanon (especially the districts of Tyre, Bint Jbeil, El-Khiam and Nabatieh). The bombings induced a high risk of cross-contamination and a disruption of water and sanitation services. This had potential impacts on health: water contamination supposedly caused several cases of severe diarrhea, as reported in Bayad (Nabatieh). It also imposed additional costs of getting clean water, as many villages had to rely on emergency tanks and bottled water provided by relief agencies[92].

The *destruction of bridges* over the Litani river caused the obstruction of flows. Wherever rubbled remained in the river, it caused a high risk of flooding the neighbouring areas, excessive erosion and destruction of stream banks. Other structural damages include irrigation canals, which

[89] In 1998, less than 60% of buildings in Lebanon were connected to sewage networks. In addition, wastewater treatment capacity is restricted to just one treatment plant (Ghadir) which provides only primary wastewater treatment prior to the discharge into the sea. (UNEP, 2007).

[90] UNEP (2007) reports that the cost of damaged water facilities was estimated by the Lebanese government at about US$80 million.

[91] This section relies on the information provided by UNEP (2007), if not otherwise indicated.

[92] UNICEF alone provided about three million liters of bottled water.

reportedly led to water losses and undermined irrigation of lands.

These are only some important impacts caused by the hostilities. Many other localized effects can be mentioned, such as the potential of water contamination by fuel leakage from damaged petrol stations in Baalbeck, or by agro-chemicals leakage from damaged storage houses in the South Lebanon and Bekaa[93] (UNDP, 2007).

Overall, the risk of toxic contamination seems to be low at the national level - and potentially significant at the local level only - due to the small chemical and hazardous pollutant sources targeted by hostilities. Instead, the damage to water infrastructure threatened the quality and quantity of water, imposing environmental and health concerns. The next section attempts to estimate these impacts.

4.2 DAMAGE TO WATER RESOURCES

4.2.1. Impacts on water quality

Estimating the impacts of the hostilities on water quality is very complex. It requires establishing a dose-response relationship between the changes in water quality caused by the hostilities (ie. pollutant loads) and their impacts on water users (ie. agriculture, domestic uses, etc). To quantify the 'dose', one should look at indicators of water quality measured on extended periods of time, before and after the hostilities. In this report, the difficulty of quantification arises from the lack of systematic monitoring of water quality in Lebanon[94]. As previously noted, many water courses were steadily degrading prior to the conflict, as a result of disposing untreated effluents. The lack of water quality measurements makes it impossible to determine the additional pollutant loads caused by the hostilities.

We attempted to look at the 'response' level, that is, the impact of polluted water on the main water users. In Lebanon, agriculture uses about 67% of total water consumption, while domestic and industrial uses account for the remaining (Republic of Lebanon, 2000). As of April 2007, there was no available information on agricultural yields from lands irrigated with polluted water before and after the hostilities. According to discussions with the MOE, in the aftermath of the hostilities, one major agricultural problem was the losses of yields due to scattered land mines in South Lebanon, rather than irrigation with polluted water (this is already accounted for in Chapter 3).

Limited information on food and water born diseases was available. The Ministry of Public Health (2007) provides information on the number of cases of food and water-borne diseases[95] reported monthly during January 2004 – April 2007 in the whole country and per caza. To estimate the effects of the hostilities on the outbreaks of water-borne diseases, we carried out a trend analysis by comparing the trend of cases during July-December 2006 with the average trend during July-December 2004/2005.

The comparison led to no significant differences in the number of cases, which could potentially be attributed to water quality. On one hand, this could be partially due to the large discrepancy between the reported and the total number of cases, which tends to be even larger in times of conflict (post-conflict)[96]. On the other hand, it should be also noted that despite claims of severe food and water-borne cases (such as in Bayad, Nabatieh; UNEP, 2007), interviews with representatives from the

[93] In addition, the bombings of the trout farms at Hermel in the Bekaa Valley caused losses of 300 t of fish to 30 farmers. At an average price of US$3/kg, the total loss was estimated at US$900,000 (FAO, 2006). We consider this loss as a direct damage from the bombings (similar to losses of cattle due to the bombings of agricultural lands), and not an environmental damage.

[94] UNEP (2007) argues that the results of sample analysis undertaken in October 2006 present just a static view of water conditions at a particular point in time. As such, they are insufficient to make a full assessment of the magnitude of conflict-related water pollution.

[95] Data refer to brucellosis, cholera, dysentery, food poisoning, hydatic cyst, parasitic worms, trichinosis, typhoid fever and viral hepatitis A.

[96] The Lebanon Early Warning and Response System (EWARNS) is aiming at ensuring timely response and control of outbreaks at national level and at monitoring the trend of communicable diseases in order to take appropriate public health actions (WHO, 2006).

South Lebanon Water Authority (SLWA) acknowledged no reports of outbreaks of water-borne diseases, except for a few sporadic cases. Consequently, as the available information did not evidence any water-borne disease outbreaks, no monetary estimate could be made regarding the impact of water quality on health.

4.2.2 Impacts on water quantity

The bombings destructed water infrastructure in South Lebanon, including wells, pumping stations and water reservoirs[97]. This damage resulted in a high shortage of water supply, lasting until the reservoirs rehabilitation was completed. In the meantime, many villages had to rely on alternative sources of water for drinking and other domestic uses. We consider the additional cost to get water from alternative sources and to rehabilitate the reservoirs as a proxy to estimate the value of damage incurred by society.

Water supply in South Lebanon is administered and controlled by the South Lebanon Water Authority (SLWA), one of the five water authorities in the country. According to the SLWA[98], the conflict damaged or destroyed 52 water reservoirs (surface and water towers) and hundreds of kilometers of water and wastewater networks. Out of the 700,000 people residing in South Lebanon, about 150,000 were directly affected by water shortage caused by the damaged water infrastructure.

After the hostilities, all damaged or destroyed reservoirs were out of service. Available information does not tell if the affected villages relied on these reservoirs as the only source of water. It is very likely that they used also private wells, water tanks and other water sources. In lack of more accurate information, we assume that these reservoirs provided about 50% of total water supply to the residents.

There is no information concerning total water supply provided to these villages. Ministry of Environment/LEDO (2001) suggests an average daily consumption in Lebanon of about 160 liters/capita. It is most likely that about 1 liter/capita[99] is used for drinking, and the remaining 159 liters/capita for other household uses. Based on the above information, it is estimated that water reservoirs used to provide about 50% of the total water consumption[100]: 0.5 liter/capita for drinking and about 79.5 liters/capita for other uses.

The period of time needed to restore reservoirs varies from one location to another. According to the SLWA:

- Rehabilitation of 48 reservoirs (serving 145,000 people) took about four months (Sept-Dec 2006). Despite rehabilitating the reservoirs, the remaining damages to water infrastructure (pipelines) prevented some people from receiving water during this period. It is estimated that only about 82,900 people were gradually served by these reservoirs during Sept-Dec 2006.
- The remaining 62,100 people were expected to be supplied with water in one year time. Thus, it is estimated that 62,100 people gradually received water during Jan-Dec 2007.
- As of May 2007, the rehabilitation of the remaining 4 reservoirs[101] (serving 5,000 people) was not yet completed. It is expected that 5,000 people will be served by June 2007.

For each of the three cases, we estimate the additional cost of getting water for drinking and other domestic uses. This represents the difference between the costs incurred by people to obtain water from alternative sources and the costs that would have been incurred in the absence of the water infrastructure damages[102]. The next

[97] For example, Fakhr-El-Din pumping station which supplies the town of Nabatieh with drinking water was targeted and two out of six well installations were damaged (UNEP, 2007).

[98] Interview with Mr. Ahmad Nizam, President of SLWA, May 2007 and Nizam (2006).

[99] Based on a survey undertaken in Canada (Jones et al., 2006).

[100] the rest being supplied by other water sources such as individual wells, which are not linked to reservoirs

[101] of Aita Jabal, Aalmane, Houla, and Rab Talateen

[102] The cost of getting water from alternative sources is a cost to society. Thus, even if a certain quantity of water was

paragraph provides a detailed description of the valuation efforts for the first case.

To estimate the additional costs of getting water, we assume that the reservoirs are gradually restored each month (Table 4.1). Consequently, the population short of reservoir water is gradually declining from 82,900 to 0 in four months. These people switched from reservoir water to alternative sources of water for drinking and other household uses.

a. Cost of drinking water. Alternative sources of drinking water commonly include bottled water and water tanks[103]. It is likely that about 16% of population switched to bottled water, and 84% to water tanks[104]. The quantity of water to be replaced from reservoirs is about 0.5 liters/capita/day. At an observed market price of US$0.7/liter of bottled water and US$0.06/liter from water tanks, the total cost of drinking water is estimated at about US$487,000.

b. Cost of water for other household uses. The most common alternative for household uses is water tanks. About 87.5 liters/capita need to be supplied every day. At an observed market price of US$0.06/liter, total cost of water for all household uses amounts to US$28.6 million.

c. Cost of water if hostilities had not occurred. As previously assumed, the damaged water reservoirs used to supply about 50% of the total water consumption in South Lebanon. Thus, if the hostilities had not occurred, the population would have relied on tap water provided by water reservoirs for 50% of the daily needs (80 liters/capita). The observed cost of tap water is about US$0.0006/liter. Consequently, the total cost of water would have been US$302,000.

Based on the estimates obtained at points a, b and c, the additional costs of acquiring water by 82,900 people who were gradually served by the reservoirs during September-December 2006 is estimated at about US$28.8 million (Table 4.1).

Table 4.1 Additional costs of getting water during September-December 2006

	Sep	*Oct*	*Nov*	*Dec*	*Total*
Population affected (000)	83	62	41	21	
Cost of bottled water [a] ($/liter)	0.7	0.7	0.7	0.7	…
Cost of water tanks[a] ($/liter)	0.06	0.06	0.06	0.06	…
No. days	30	31	30	31	…
Cost of drinking water[b] ($million) **(1)**	0.2	0.1	0.1	0.1	0.5
Cost of water for other uses[c] ($million) **(2)**	11.3	8.7	5.6	3.0	28.6
Cost if hostilities had not occurred[d] ($million) **(3)**	0.1	0.09	0.06	0.03	0.3
Additional cost ($million) **(1)+(2)-(3)**	11.4	8.8	5.6	3.0	**28.8**

Notes: [a] market price observed during the field visit (April 2007); [b] based on a drinking water consumption of about 0.5 liter/capita/day; 16% of population relies on bottled water and the remaining on water tanks; [c] based on a consumption of 79.5 liters/capita of water for other uses; all population relies on water tanks; [d] assumes that 50% of the daily consumption would have been satisfied by water reservoir.

Similarly, Annex 4 estimates the additional costs of getting water at: (i) US$64.4 million, for the other 62,100 people, expected to gradually receive water during Jan-Dec 2007; (ii) US$6.2 million, for the remaining 5,000 residents, expected to be served by June 2007.

Based on the above, the total additional cost of getting water is about US$99.4 million. In addition[105], according to SLWA, the costs of

distributed for free from NGOs, this report accounts also its value.

[103] The bottled water and water tanks originate from unpolluted sources of water, thus it is assumed that their use does not trigger any potential negative effect on people's health.

[104] A recent National household survey (Ministry of Social Affairs et al., 2004) indicates that about 32% of Lebanese population consumes mineral water. However, most of this population lives in Beirut (and other large cities) and relies on bottled water to avoid the polluted tap water or the perception of its negative effects. The communities living in South Lebanon are usually poorer than the country's average. It is thus reasonable to assume that perhaps only 16% of South Lebanon's population will switch to bottled water to compensate for the shortage of reservoir water.

[105] If water infrastructure had not been repaired, the damage to water resources would have been greater, mainly because the people short of water would have suffered from the lack of water for a longer period of time. Thus, estimating the overall damage to water resources includes both the value of the actual damage and the additional cost of repairing the water infrastructure. (The same idea applies in Section 2, when adding the cost of oil spill clean-up to the actual damage caused by the oil spill).

repairing the water infrastructure are estimated at approximately US$33 million[106], as of May 2007. Overall, the additional costs of getting water and the cost of reservoir rehabilitation are valued at **US$131.4 million**. This figure underestimates the real value of the damage cost linked to water resources, as it does not include the impact of water degradation on health.

---

[106] It is interesting to note that World Bank (2006a) indicate that the damage to water and wastewater infrastructure is estimated at US$65 million. This is substantially higher than the $33 million damage estimated for water infrastructure in this report. The difference between them could be explained by the fact that (i) the former estimate covers both the damage to water supply (US$52 million) and wastewater infrastructure (US$13 million), while the latter refers only to water infrastructure; (ii) the former covers the damage to the whole country, while the latter is limited to only South Lebanon; (iii) the former reflects the overall value of damage, while the latter refers only the expenses made so far for its rehabilitation.

Chapter 5. QUARRIES

5.1 BACKGROUND

Prior to 2002 the quarry sector in Lebanon had been plagued by political interference and a conflict of prerogatives. The exploitation of more than 700 quarries with little consideration for the value of landscape, land and human settlements in the surrounding areas has resulted in the dramatic disruption of Lebanon's unique landscape, that can be visually seen from almost anywhere in the country.

In an attempt to regulate quarrying activities, the government enacted in 2002 Decree no. 8803 (and its amendment decree 16456 dated 27 February 2006). However, enforcement of regulations remains weak. Most quarries are either unlicensed or extract aggregates in volumes that exceed the terms of their licenses. Additionally, very few operators rehabilitate the site during and/or after quarrying.

In an effort to implement Decree 8803 and its amendment, Lebanon's National Council for Quarries (established by Decree 9222, dated October 4, 2002 and presided by the Ministry of Environment) began to shift quarrying from Mount Lebanon (facing the Mediterranean Sea) to the eastern mountain chain (Anti-Liban). The government did not issue new licenses, but old and expired licenses were extended using so-called *short administrative extension*. After the July 2006 conflict, *short administrative extensions* were renewed one more time in a move to anticipate a surge in the demand for construction materials[107].

5.2 METHODOLOGY

The destruction caused by the July 2006 hostilities will, without any doubt, put pressure on quarrying activity to supply the needed aggregate and sand for the reconstruction. In the context of this study, we will attempt to measure the damage to the environment that such a pressure will cause. The methodology is outlined below:

- We estimate the amount of aggregate and sand needed for the reconstruction, based on the amount of debris and demolition waste;
- We estimate the distribution of quarrying activities by Mohafazah;
- We estimate the impact of (a) quarrying activities during operation on the surrounding environment and (b) the impact of non-rehabilitating quarries after completion of exploitation on the surrounding environment.

Further detailed explanation about the methodology and various assumptions made are provided below.

5.3 AGGREGATE AND SAND NEEDED FOR THE RECONSTRUCTION

Based on the amount of debris and ruble generated by the hostilities (1.43 million m^3 in Beirut Southern Suburbs, 3.32 million m^3 in the South and 1 million m^3 in the Bekaa)[108], the quantity of aggregate and sand was generated using the formulas indicated in Table 5.1.

Table 5.1 Estimated aggregate and sand needed for the reconstruction (in m^3)

Location	*Aggregate and sand (m^3)*	
Beirut		
Demolition waste generated [a]	1,430,000	
Of which agg&sand (35-50%) [b]	**501,000**	**715,000**
Of which concrete (35-50%) [b]	501,000	715,000
Equivalent in agg&sand [c]	**356,000**	**508,000**
Sub-total (i)	*857,000*	*1,223,000*
South and Bekaa		
Demolition waste generated [a]	4,320,000	
Of which agg&sand (30-40%) [b]	**1,296,000**	**1,728,000**
Of which concrete (40-60%) [b]	1,728,000	2,592,000
Equivalent in agg&sand [c]	**1,227,000**	**3,568,000**
Sub-total(ii)	2,523,000	3,568,000
Average sub-total (i)+(ii)	4,086,000	
Total Aggregate & Sand (adding 15% loss of raw material at quarry)	**4,700,000**	

[a] *PCM, 2007;* [b] *UNDP, 2007*
[c] *1 m^3 of concrete contains about 0.71 aggregate (UNDP, 2007)*

[107] Government decision no. 6 dated January 4, 2007

[108] Presidency of the Council of Ministers, 2007

Based on Table 5.1, it was estimated that about 4.7 million m^3 of aggregate and sand will be needed for the reconstruction. A more accurate estimate of the needed aggregate and sand would have been obtained by estimating the number of housing units and infrastructure that will be rebuilt. However undertaking such an exercise would have required a large amount of detailed information (such as number of buildings to be rebuilt, number and size of apartments in each building, number of individual housing units to be rebuilt, etc) that was not yet available at the time of completing this study.

5.4 DISTRIBUTION OF QUARRYING ACTIVITIES BY MOHAFAZAH

Aggregate and sand needed to feed the reconstruction effort is likely to be retrieved from quarries located near the affected areas (mainly the South, Nabathieh, Bekaa and Baalback). Precise estimate on quarry locations and the amount of aggregated needed could not be obtained. Therefore, this study attempts to estimate the above based on the distribution of *short administrative extensions* that were granted between the end of the hostilities and the end of April 2007. The number of *short administrative extensions* that was granted by the Ministry of Interior and Municipalities according to the council of ministers decision #6 dated January 4, 2007 is as follow:

– South & Nabathieh	32%
– North & Akkar	24%
– Bekaa &Baalback Hermel	31%
– Mount Lebanon	14%

As no information on the scale of excavation expected from each quarrying operation was available, it was assumed to be evenly distributed according to the *short administrative extensions* granted in each Mohafazah.

Based on the above assumption, the distribution of aggregate and sand will be as follow:

– South & Nabthieh	1,494,000 m^3
– North & Akkar	1,105,000 m^3
– Bekaa &Baalback Hermel	1,447,000 m^3
– Mount Lebanon	654,000 m^3
Total	**4,700,000 m^3**

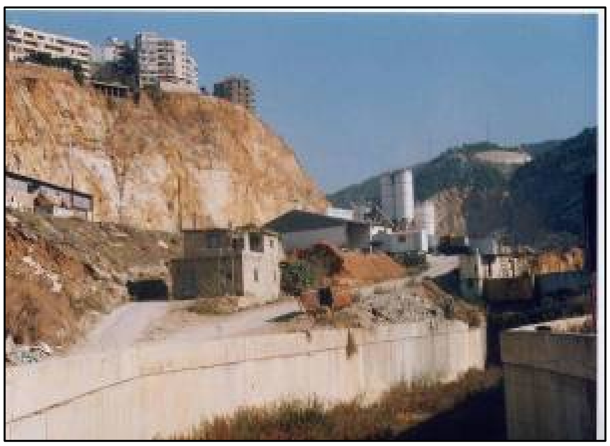
5.5 ENVIRONMENTAL IMPACTS OF QUARRIES IN MOUNT LEBANON

Quarrying activities cause various threats to the environment during their operation. These include the destruction of natural vegetation and habitats, air pollution from dusts, noise pollution, traffic from trucks quarrying aggregates, deterioration of road condition, etc. In addition to the impact during operation, if the quarries are abandoned at the end of operation with minimal or no rehabilitation (such is the case of almost all quarries that have operated in Lebanon until now) there is an additional irreversible and long term visual/aesthetic impact.

A survey undertaken in 2002 by Owaygen M. (Sarraf. et al. 2004) used the hedonic price method to estimate the impact of quarries on the environment. This method consists of using the change in land and property prices around the quarry as a proxy for the impact of the quarry on the environment. The hedonic model expresses the market value of some composite good (in this case land or apartment) as a function of its various intrinsic and environmental attributes. The house or land price reflects the combined buyers' and sellers' willingness to pay and be paid for the defined attributes. The price is likely to reflect the intrinsic value of the property along with any visible environmental damage (such as aesthetic impact from quarrying activities, noise and air pollution during quarrying excavation, etc.). To the extent that other damage (such impact on hydrology, soil and geological stability) are visible and detectable to the buyer, they will be reflected in the price of the property. If the latter impacts are un-known or undetectable to the buyer they will not be reflected in the price. Hence, this method will tend to underestimate the overall impact of quarrying activities on the environment.

On site surveys and interviews were conducted in 4 quarry sites, all located in Mount Lebanon: Nahr Ibrahim, Shnannayer, Abou-Mizan and Antelias. Based on the survey, it was possible to estimate the depreciation in real estate price resulting from quarrying activities for the Nahr Ibrahim quarry. For the other three quarries it was possible to estimate the change in property price due to the non-rehabilitation of quarries at the end of operation.

Figure 5.1 Example of quarrying activities in Mount Lebanon



Photograph courtesy of M. Owaygen 2002

Based on the size of each of each quarry surveyed, it was possible to estimate the land and property prices depreciation per cubic meter of aggregate and sand excavated. In addition, prices of 2002 were adjusted to 2006 using the Consumer Price Index (EIU, 2006). The results are presented in Table 5.2 and Annex 4.

Based on the survey of 2002 and the case of the Nahr Ibrahim quarry, it was possible to estimate the impact of quarrying activities without proper consideration to the environment (traffic jams, overdose explosions that can cause structural cracks in houses, dust, noise pollution, etc) on land prices to about US$4 /per m^3 of aggregate and sand extracted. Based on the Shnaanayer, Abu Mizan and Antelias quarries, it was possible to estimate the impact of the non rehabilitated quarries after completion of operation on land prices between US$ 0.13 and US$40 /$m^3$ of aggregate and sand extracted and on apartment prices between US$0.4 - 5.0/$m^3$.

5.6 Relative Price of Land and Apartments by Mohafazah

Since the 2002 survey considered quarries operating in Mount Lebanon only, while quarrying activities for the reconstruction is likely to be located in the South and the Bekaa, it was important to adjust the price of land and apartments by Mohafazah in order to derive a slightly more accurate measure of the impact.

By doing this exercise it is very important to note that even within each Mohafazah prices of land and apartment vary widely depending on their location, nearby amenities, land topography etc.

Nevertheless, land and apartments prices for more than 90 districts in Mount Lebanon, 15 districts in the Bekaa, 41 districts in the North and 10 districts in the South were compiled to derive an estimated relative price of land per Mohafazah. The results are summarized in Table 5.3 and detailed data are provided in Annex 4.

Table 5.2 Impacts of 4 quarries in Mount Lebanon on land and property values

Quarry 1 Nahr Ibrahim (Impact during operation)	
Estimated quarry area (m^2)[a]	96,830
Estimated excavated volume (m^3)[b]	4,115,000
Land area affected by the quarry (m^2)[c]	2,000,000
Decline in Land price (US$/$m^2$) in 2002[c]	7.0
Decline in Land price (US$/$m^2$) in 2006[d]	8.2
Total decline in land price 2006	16,400,557
Decline in land price US$/ m^3	**4.0**

Quarry 2 Shnanaayer (Impact after closure)	
Estimated quarry area (m^2) in 2 locations [a]	48,370
Estimated excavated volume (m^3)[b]	2,056,000
Land Area affected by the quarry (m^2)[c]	600,000
Decline in Land price (US$/$m^2$) in 2002[c]	125
Decline in Land price (US$/$m^2$) in 2006[d]	146
Total decline in land price 2006	87,860,125
Decline in land price US $/ m^3	**43**
Apartments affected by quarry (m^2)[c]	36,000
Decline in apartment price (US$/ m^2) in 2002[c]	225
Decline in apartment price (US$/ m^2) in 2006[d]	264
Total decline in apartment value 2006	9,488,894
Decline in apartment value US$/$m^3$	**5**

Quarry 3 Abu Mizan (Impact after closure)	
Estimated quarry area (m^2) in 3 location[a]	276,930
Estimated excavated volume (m^3)[b]	11,769,525
Land Area affected by the quarry (m^2)[c]	175,000
Decline in Land price (US$/ m^2) in 2002[c]	8
Decline in Land price (US$/ m^2) in 2006[d]	9
Total decline in land price 2006	1,537,552
Decline in land price US $/ m^3	**0.13**

Quarry 4 Antelias (Impact after closure)	
Estimated quarry area (m^2) in 1 location [a]	51,577
Estimated excavated volume (m^3) [b]	2,192,000
Land Area affected by the quarry (m^2) [c]	100,000
Decline in Land price (US$/ m^2) in 2002 [c]	50
Decline in Land price (US$/ m^2) in 2006 [d]	59
Total decline in land price 2006	5,857,342
Decline in land price US$/$m^3$	**3**
Apartments affected by quarry (m^2) [c]	7,500
Decline in apartment price (US$/ m^2) in 2002 [c]	100
Decline in apartment price (US$/ m^2) in 2006 [d]	117
Total decline in apartment value 2006	878,601
Decline in apartment value US$/$m^3$	**0.40**

[a] *Information provided by the Ministry of Environment*
[b] *Based on a approximate height of exaction (face cut) of 100m multiplied by the approximate quarry area and divided by 2 (to account for mountain slope)*
[c] *Sarraf et al., 2004*
[d] *Consumer Price Inflation (EIU, 2006)*

Table 5.3 Relative price of land and apartments per Mohafazah in 2006

Mohafazah	*Relative price of **land***	*Relative price of **apartments***
Mount Lebanon	1	1
Bekaa	0.19	0.58
North	0.68	1.03
South	1.11	0.99

See Annex 4 for more details

5.7 LIKELY IMPACT OF QUARRYING ACTIVITIES FOR THE RECONSTRUCTION

Based on (a) the estimated aggregate needed in each Mohafazah, (b) the impact of quarrying activities on land and apartment prices in Mount Lebanon and (c) the relative price of land and apartments between Mount Lebanon and other Mohafazah, it was possible to estimate the impact of quarrying activities that are likely to take place to fulfill the demand in aggregate and sand for the reconstruction on the environment. This impact is summarized in Table 5.4.

An observation is warranted. The estimated damage costs have been computed as if all impacts were to happen in 2006, while in reality the reconstruction, of housing units especially, is likely to take a longer time. Hence the impact should have been spread over a few years and than discounted back to 2006 (using a 4% discount rate). Spreading the impact over time would also have required taking into account the inflation rate (varying between 3.5 and 4.8%). Hence the overall impact is likely to have been the same as if it was computed for 2006 only.

The overall damage caused by the added pressure on quarries to supply needed aggregate and sand for the reconstruction is estimated to range between **US$ 15 and 175 million (or an average of US$95.5 million)**.

Table 5.4 Estimated impact of quarrying activities per Mohafazah after the reconstruction

Mohafazah	min	max	average
South & Nabatieh			
Needed aggregate (million m^3)			1.5
Impact during quarrying operation on land price (million US$)			6.6
Impact of non rehabilitating quarries on land price (million US$)	0.2	71.0	35.6
Impact of non rehabilitating quarries on apts price (million US$)	0.6	6.8	3.7
Sub Total			***46.0***
North & Akkar			
Needed aggregate (million m^3)			1.1
Impact during quarrying operation on land price (million US$)			3.0
Impact of non rehabilitating quarries on land price (million US$)	0.1	32.3	16.2
Impact of non rehabilitating quarries on apts price (million US$)	0.5	5.3	2.9
Sub Total			***22.1***
Bekaa & Baalback Hermel			
Needed aggregate (million m^3)			1.4
Impact during quarrying operation on land price (million US$)			1.1
Impact of non rehabilitating quarries on land price (million US$)	0.0	11.9	6.0
Impact of non rehabilitating quarries on apts price (million US$)	0.3	3.9	2.1
Sub Total			***9.2***
Mount Lebanon			
Needed aggregate (million m^3)			0.7
Impact during quarrying operation on land price (million US$)			2.6
Impact of non rehabilitating quarries on land price (million US$)	0.1	27.9	14.0
Impact of non rehabilitating quarries on apts price (million US$)	0.3	3.0	1.6
Sub Total			***18.3***
TOTAL	**15.4**	**175.5**	**95.5**

Chapter 6. AIR POLLUTION

6.1 INTRODUCTION

The July/August 2006 hostilities in Lebanon resulted in extensive air pollution. While exploded ammunitions, ignited fuels, forest fires and demolished buildings were immediate causes that have contributed to significantly deteriorate air quality in certain neighborhoods. The levels of Particulate Matter (PM) are significantly higher than international standards and will impact health adversely.

However, despite their high levels, the increase in particulate matters caused by the hostilities - in particular, the demolition waste - will likely persist for a short duration. However to the authors' best knowledge, the relationship between short-term exposures to PM and health effects has not be scientifically determined and no studies were found in that regard. In addition, no significant increase in reported cases of air borne diseases, which could potentially be attributed to the hostilities, was found. This might be caused by the poor accuracy of reporting due to the hard war conditions, and by the fact that air-borne diseases may occur years after exposure to pollution. As a result, the impact of air pollution on health could not be estimated in monetary terms at the time of conducting this report.

6.2 SOURCES OF AIR POLLUTION

The atmosphere is significantly affected by bombings. In general, air quality can deteriorate due to dust emissions from collapsed buildings, air pollutants generated by fires as well as those generated by the explosion of ammunitions. However, most direct impacts on air quality related to war are usually temporary in nature. Indirect impacts on air quality can nevertheless last longer because of dust generated at re-construction sites and increased emission of air pollutants by the transport sector due to reduced average speed in affected roads or highways. Sources of air pollution caused by the hostilities include (UNDP, 2007):

- Dust from reconstruction sites and quarrying activities;
- Increased emissions from transport sector due to reduced average speed in affected roads or highways;
- Emissions from burning of petroleum products (mainly heavy fuel oil, kerosene, gasoline, and diesel);
- Emissions from forest fires;
- Emissions from damaged industrial facilities;
- Emissions from exploded weapons and ammunitions.
- Other sources of air pollution such as those generated by waste disposal and burning of dead carcasses, rotten vegetables/fruits, municipal and health care waste

6.3 AIR QUALITY IMPACT ASSESSMENT

The UNDP (2007) report assessed the impact on air quality from various sources of pollution during the July conflict.

Air pollution from site clearing and removal, hauling, transport, and disposal of demolition wastes in the Beirut Southern Suburbs was estimated using the Fixed Box Model with the findings that Total Suspended Particulates (TSP) concentration range from 190 $\mu g/m^3$ under typical scenario to 860 $\mu g/m^3$ under worst-case scenario (UNDP, 2007). Both values exceed the Lebanese, EU, USEPA, and WHO 24-hour standards (120 $\mu g/m^3$, 300 $\mu g/m^3$, 75 $\mu g/m^3$, and 150 $\mu g/m^3$ respectively). Furthermore, emissions from the transport sector due to decrease in average vehicle speed associated with damage to road infrastructure and transport of construction and demolition waste were estimated to increase by a factor of 6 to 7, particularly at hotspots in the northern and southern entrances of Beirut (UNDP, 2007).

Figure 6.1 Fuel oil burning at Jiyeh power plant.

Photograph courtesy of MOE

The report also estimated the air pollution resulting from the burning of around 60,000 m^3 (55,764 tonnes) of fuel oil at the Jiyeh Thermal Power Plant over a period of 12 days. Pollutants generated during the fire and carried through the plume include sulfur dioxide, nitrogen oxides, carbon monoxide, soot, particulate matter, semi-volatile organic compounds including polycyclic aromatic hydrocarbons (PAHs) and dioxins and furans, volatile organic compounds, such as benzene, and other compounds resulting from incomplete combustion of the oil and oil products. The quantities of released pollutants were calculated (Table 6.1) and the generated plume trajectory was estimated using the ALOFT-FT (A Large Outdoor Fire Plume Trajectory- for Flat Terrains) model. The model indicated that the particle concentrations, as expected, are at their highest concentrations near the pool of fire, reaching approximating 34 mg/m^3 (vertical elevation 0 m). The concentrations drop to 217 – 295 $\mu g/m^3$ at 1 to 4 km downwind and vertical elevation of 695 m. The concentrations at 20 km downwind indicate a range of particulate concentrations between 21 and 29 $\mu g/m^3$ (vertical elevations 780 m and 350 m respectively).

Table 6.1 Emission factors and estimated emissions from the Jiyeh oil fire

Pollutant	*Emission Factors*	*Estimated Emissions*
Sulfur dioxide (SO_2)	40 g/kg	2.2 Gg[a]
Nitrogen oxides (NOx)	5 g/kg	0.3 Gg
Particles	15 g/kg	0.8 Gg
Soot	5 g/kg	0.3 Gg
Organic carbon	8 g/kg	0.5 Gg
Polyaromatic hydrocarbons (PAHs)	0.8 g/kg	0.04 Gg
Polychlorinated Dibenzodioxins (PCDDs)	2.6 µg TEQ/TJ[b]	6 mg TEQ
Volatile organic compounds (VOCs)	7 g/kg	0.4 Gg
Carbon Monoxide (CO)	5 g/kg	0.3 Gg

Source : UNDP, 2007 [a] 1 Gg = 1,000 tonnes; [b] TEQ/TJ = Toxic Equivalents/ Terajoule

Similarly, the report estimated the air pollution resulting from the burning of 40,000 tonnes of kerosene at the Rafiq Hariri International Airport. Pollutants released into the atmosphere include, nitrogen oxides, particulate matter, formaldehyde, volatile organic compounds, and polycyclic aromatic hydrocarbons. The quantities of released pollutants were calculated (Table 6.2) and the generated plume trajectory was estimated using the ALOFT (A Large Outdoor Fire Plume Trajectory- for Flat Terrains) model. The model indicated that the particulate matter concentrations, as expected, are at their highest concentrations near the pool of fire, reaching almost 3.1 mg/m^3 (vertical elevation 0 m).

Figure 6.2 Burning of Airport Fuel at Rafik Al Hariri International Airport.

Photograph courtesy of K. El Jisr

Table 6.2 Emission factors and estimated emissions from the Airport tanks fire

Pollutant	*Emission Factors*	*Estimated Emissions*
Nitrogen oxides (NOx)	11 g/kg	441 tonnes
Volatile organic compounds (VOCs)	0.133 g/kg	5.3 tonnes
Carbon Monoxide (CO)	2.8 g/kg	112 tonnes
Sulfur Dioxide (SO_2)	4 g/kg	160 tonnes
PM_{10}	1.4 g/kg	56 tonnes
Polychlorinated Dibenzodioxins (PCDDs)	4.3×10^{-9}	172 mg
Methane (CH_4)	0.02	0.8 tonnes

Source: UNDP, 2007

The concentrations drop to 30.3 µg/m^3 at 3 km downwind and vertical elevation of 725 m. The concentrations at 20 km downwind indicate a range of particulate concentrations between 1 µg/m^3 and 3.2 µg/m^3 (vertical elevations 260 m and 725 m respectively) (UNDP, 2007).

The report also assessed the impact of the burning of around 1,000 ha of forests in Mount Lebanon and 800 ha in South Lebanon. Emissions were estimated based on emission factors from USEPA (Table 6.3). The main pollutants released are particulate matters, carbon monoxide, total hydrocarbons or volatile organics, and nitrogen oxides.

Table 6.3 Emission factors and estimated emissions from the Airport tanks fire (UNDP, 2007)

Pollutant	*Emission Factors (kg/Mg)*	*Estimated Emissions (Mg)*
PM_{10}	8.5	88.1
CO	70	725.6
VOCs as methane	12	124.4
NOx	2	20.7

Source: UNDP, 2007

6.4 POTENTIAL HEALTH IMPACTS

While some of the values and methods reported above are invariably associated with a high degree of uncertainty, it is certain that much of the emissions are short term and has by now dissipated into the environment, particularly after the rainy season. Their impacts are difficult to quantify monetarily. It can be argued, however, that particulate matter (PM) constitutes the most significant remaining air pollutant given the continuous rehabilitation and reconstruction activities. In fact, PM is internationally recognized as the most important air pollutant in terms of human health effects. Many epidemiological studies confirmed significant associations between ambient particulate matter concentrations and adverse health impacts. Fine particulates are likely to be the most significant contributors to the observed PM health effects, due to their ability to accumulate and reach the lower regions of the respiratory system. Such particles settle slower in the atmosphere thus remaining airborne longer and tend to migrate for long distances before settling. While the effects of particulate matter vary considerably depending on its composition and size distribution, inhalation of particulate matter can have, in general, the following health effects (El-Fadel *et al.*, 2000):

- Increase in cardiac and respiratory mortality;
- Decrease in levels of pulmonary lung function in children and adults with obstructive airway disease;
- Increase in daily prevalence of respiratory symptoms in children and adults;
- Increase in functional limitations as reflected by school absenteeism or restricted activity days;
- Increase in physician and emergency visits for asthma and other respiratory conditions.

In this context, a task force formed by the *National Council for Scientific Research*, the *American University of Beirut* and the *University of Saint Joseph* is monitoring PM_{10} levels in the Southern suburbs during the reconstruction period. Generally, the recorded levels are high, exceeding national and international air quality standards. Data and trends from this monitoring program will become available towards the end of 2007.

6.5 ECONOMIC VALUATION OF HEALTH IMPACTS

The fuel and forest fires were expected to have resulted in a significant increase in ambient levels of PM over a short duration of time during the July conflict. In addition, the ongoing reconstruction activities are expected to cause a significant increase in ambient levels of PM at various locations, particularly the demolition sites, dumpsites, and along the transport routes. This is mainly due to the fact that no proper mitigation measures are being adopted, such as water dampening of stockpiles, proper unloading operations, covering of waste during transport, etc. Earlier studies of air pollution in Lebanon estimated the annual direct and indirect health cost of exposure to particulates in the Greater Beirut Area at more than US$10 million (Djoundourian *et al.*, 1998) and in all urban areas within a conservative range of US$0.41 to US$15.8 million using the cost of illness approach or US$4.53 to 173.5 million using the Willingness-to-Pay approach (El-Fadel *et al.*, 2000). Both studies based their approximations on the percent increase or decrease in morbidity and mortality reported in international literature for every increase or decrease of 10 $\mu g/m^3$ in the concentration of particulates in the air (PM_{10}). Diesel-operated motor vehicles and construction activities were assumed to be the major sources of these particulates. While recent measurements in the southern suburbs indicate a potential increase in PM_{10} levels caused by demolition waste from military aggression, the increase will likely persist for a relatively short duration. Hence, extrapolating from the economic valuation cited above becomes difficult because the latter were derived on the basis of a long term exposure.

Chapter 7. FOREST FIRES

Lebanon's forests cover is about 139,400 ha, while other wooded land occupies some 108,400 ha[109] (MOA and FAO, 2005). Forests occupy 13% of the country's surface area and other wooded land an additional 10% (FAO, 2006). About 32% of forest area is coniferous, 57% broadleaved, and the rest mixed forest. As in other southern Mediterranean countries, timber is not an important forest product in Lebanon. Forests are primarily distinguished by the non-timber forest products they provide, e.g. pine nuts, carob pods, charcoal, firewood, fodder for grazing, apiculture; and for their landscape, recreation, and biodiversity benefits.

The recent hostilities affected several parts of the country's forests, particularly in South Lebanon and Mount Lebanon. Forests suffered from:

- *direct impacts,* such as accidental fires, resulting from direct bombing (in South Lebanon) or fallen flares (in Deir Qoubil, Bsaba, Mazraat Bmrohai); and deliberate fires from burning the land to clear unexploded ordnances (UXOs) (UNDP, 2007);
- *indirect impacts,* for example the occurrence of summer forest fires raging unchecked because attention was focused on humanitarian aid; and the very limited accessibility to and utility from unburnt forest sites where UXOs had not been cleared.

In addition, hostilities halted the national reforestation program significantly and burned sites that had already been reforested.

The following sections discuss the impacts of fires on the country's forests and on the national reforestation program. No field survey of damage to forests has so far been published[110] in Lebanon (FAO, 2006). Existing information is thus incomplete and its accuracy is often not ground validated. Valuation efforts aim to arrive at the most realistic estimates of damage, to the extent available information allows. Where data are missing, conservative assumptions are used for the valuation.

7.1 IMPACTS ON FORESTS

Various sources have reported a range of estimates for burnt forest area in each province (Table 7.1). As efforts to assess the extent of forest area affected are still ongoing, available estimates unsurprisingly differ across sources. Existing figures are likely to underestimate the area affected, as some burnt areas have not yet been surveyed. For example, UNEP (2007) identified 48 fire incidents in southern Lebanon[111], a figure not able to capture fires smaller than 100 m^2. When an in-depth survey is carried out, the final estimate is likely to be higher than the provisional estimates provided in Table 7.1.

Table 7.1 Forest area affected by fires according to different sources

Location	Forest area affected (ha)		
	FAO (2006)	MOA (UNDP, 2007)	AFDC (communication 2006)
1. South Lebanon	834	800[a]	1,000[c]
2. Bekaa	536		
3. Mount Lebanon	470	1,000[b]	900[d]
4. North Lebanon	85		
Not specified	413		
Total	**2,338**	**1,800**	**1,900**

Note: [a] The area covers forests in Bent Jbeil (100 ha), Hasbaya (30 ha), Jezzine (450 ha), Sour (150 ha) and Nabatyieh (70 ha). [b] Affected forests are found in Chouf (70 ha), Aaley (900 ha) and Baabda (30 ha) (UNDP, 2007, p. 6-4). [c] It covers 700 ha of forests and 300 ha of olive trees burnt (AFDC, unpublished); [d] It covers 440 ha of *Quercus sp*., 150 ha of *Pinus sp*. and 310 ha of mixed forests (including carob) (AFDC, unpublished).

109 The data are based on a derived forest map of Lebanon, generated in 2005 by the Ministry of Agriculture (MOA) and the FAO, under the project 'National Forest and Tree Inventory and Assessment in Lebanon' (NFA) TCP/LEB/2903, in collaboration with the Directorate of Geographic Affairs of the Lebanese Army. The forest map was derived using 2002 Land Cover Land Use Map (scale 1/20 000), 1965 Forest Map of Lebanon (scale 1/50 000) and the vegetation Map of Lebanon (scale 1/200 000).

110 According to the MOE, the Association for Forests, Development and Conservation (AFDC) has conducted during February-April 2007 a participatory-based study to assess damages to forests and their associated socio-economic impacts in the South. The resulting report ('War Impact on Forest and Rangeland Resources' Assessment in Lebanon') has not yet been published.

111 Based on satellite images processed by NASA/MRRS

Among the three sources, AFDC provides the most recent information on burnt area in South Lebanon and Mount Lebanon. At the same time, FAO (2006) reports the most detailed information on the forest area burnt in the other regions of the country. Based on the above, the best currently available estimate of burnt forest area during the 34-day hostilities would be about **2,930 ha**.

According to the AFDC[112], the average forest area annually burnt in years without hostilities is about 1,200 ha[113]. Assuming that most fires occur during the three-month summer season, the area burnt during one month averages about **400 ha**.

Valuing the forest area burnt due to hostilities is based on the difference between the estimated area burnt during hostilities and the surface usually affected during one summer month in times of peace. Consequently, the area burnt due to the hostilities is estimated at about **2,530 ha**. This figure should be regarded with extreme caution due to the incomplete information so far collected.

The value of damages caused by forest fires depends on the value of the forest benefits lost. Intensive fires may provoke a complete loss of benefits in affected areas, while lighter fires may cause only partial losses. The degree of damage and the period over which the impacts of fires persist depend largely on the intensity of fires. No accurate information on these issues has been reported for Lebanon. In part, this is due to the limited information collected so far; and in part, because the long-term consequences of intense fires cannot, by definition, yet be observed. UNDP (2007) reports that the impact of fires in Lebanon was classified as severe/significant, with long-term consequences over 10–50 years[114]. This time frame is most likely to be an overestimate. In Lebanon, regeneration time for the major tree species averages 15 years[115], ranging from about 10 years for oak to 20 years for pine[116]. Therefore, the report considers that a period of 10-20 years is a more realistic time frame for this analysis.

Fires induce losses of annual flows of a variety of benefits such as firewood, non-wood forest products and other services. FAO (2006) estimates the total financial and physical loss to the forestry sector at about US$15.9 million. The analysis does not explain how the estimate was calculated, neither does it indicate what is the ratio between financial (e.g. damages to forest infrastructure for example) and environmental losses[117]. Because our report aims at assessing the environmental losses only, it does not use the FAO estimate.

Very few studies on forest valuation in Lebanon were found (Sattout *et al.*, 2005; Sattout *et al.*, 2006; AFDC, unpublished[118]). Sattout *et al.* (2005) made a first-time attempt to estimate in monetary terms the Total Economic Value (TEV) of forests in Lebanon. Valuation efforts focused on estimating the annual flows of gross benefits, including firewood, charcoal, medicinal plants, fodder for grazing and biodiversity conservation. Table 7.2 reports the valuation results adjusted to 2006 prices and the methods used for valuation.

---

[112] Based on reports of the Forestry Service at the Ministry of Agriculture.

[113] It is interesting to note that forest burnt area was about 650 ha in 2004/2005 and 346.5 ha in 2005/June 2006 (MOE Statistics, 2007). Though these figures are more recent than the AFDC estimate, we consider that the average estimate over a longer period (1,200 ha; AFDC) is a more realistic figure compared to those from specific years.

[114] UNDP (2006) reports that fires are not the natural mechanism of regeneration in Lebanon. Lebanese forests are very sensitive to fires. Forests' exposure to fires leads to severe loss of biodiversity, destruction of habitats and erosion.

[115] N. Assaf, Service of Conservation of Nature, MOE, communication, March 2007

[116] Pine and oak cover about 70% of the total forest area in Lebanon (based on Lichaa El-Khoury and Bakhos, 2003).

[117] The report states that the present value of 'lost wood resources resulting from forest fire and other damage' is about US$20,000/ha of pine forests (p.20); if the figure referred to burnt wood only, it seems extremely high, particularly in a country so poorly endowed with timber as Lebanon. Just for comparison, another valuation study estimate the annual flows of firewood and charcoal benefits at US$30/ha of Lebanese forests (Sattout et al., 2005), leading to a present value of US$400 (t =20 years, r=4%). The result is only 3% of the estimate obtained by FAO (2006). Therefore, there is good reason to believe that the FAO estimate either over-estimates the wood value, or includes a high proportion of other financial losses.

[118] For example, AFDC estimated the cost of lost firewood benefits from oak trees due to forest fires at about US$970,000.

According to Table 7.2, any hectare of forests produces benefits of at least US$465 per year[119]. This is quite a high estimate compared to that obtained in other Mediterranean countries averaging about US$148/ha of forests (Croitoru and Merlo, 2005). Such a high value can be explained by multiple reasons: (i) it represents the forests' *gross* benefit, which is higher than their net benefit; (ii) the valuation is based on the actual instead of the sustainable rate of extraction; (iii) the limited forest area in Lebanon contributes to obtaining very high averages per hectare of forests[120].

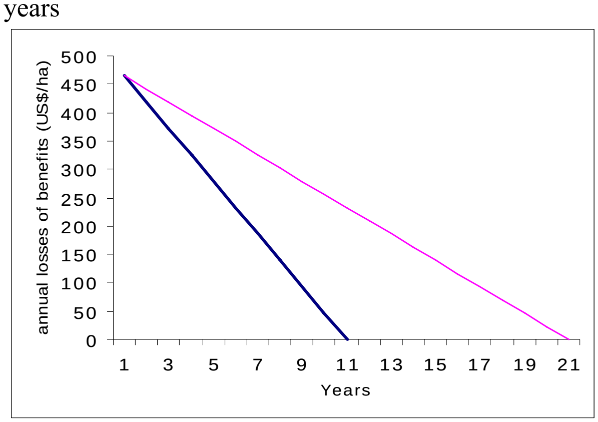
Because of high intensity of fires, we assume that forest benefits are completely lost in 2006 and will gradually recover within 10-20 years[121]. For the sake of simplicity, we consider that benefits recover linearly[122]. The losses (foregone benefits) thus decline linearly from US$465 to US$0, as illustrated in Figure 7.1. Using a discount rate of 4% the Present Value of losses on 1 hectare of burnt forest ranges between US$2,200 – 3,700. The total damage on 2,540 ha of forests ranges between US$5.6 – 9.4 million[123].

Table 7.2 Annual flows of forest benefits in Lebanon (2006 prices)

Types of values	Quantity	Value (000 $)	Value ($/ha)
Use values			
Firewood (m^3)	82,300	2,011	15
Charcoal (m.t.)	11,400	2,011	15
Honey and wax	n.s.	12,928	96
Pine nuts (t)	600	13,000	96
Medicinal and aromatic plants	n.s.	17,717	130
Fodder for grazing (mil. FU)	9.6	1,022	8
Carob (t)	2,000	625	5
Hunting (no. hunters)	600,000	12,769	95
- Legal hunting	*200,000*	*6,384*	*48*
- Illegal hunting	*400,000*	*6,384*	*48*
Recreation in reserves (no. visits)	n.s.	287	2
Non-use values			
Biodiversity conservation (ha)	n.s.	919	7
TEV		**63,300**	**465**

Source: Sattout et al. (2005) for all data except for pine nuts which are based on FAO (2006); n.s. = not specified.
Note: The study applied the market pricing to estimate firewood, charcoal, honey and wax, pine nuts, medicinal and aromatic plants; substitute goods method to value fodder for grazing; and cost-based methods to estimate hunting, recreation and biodiversity conservation.

Figure 7.1 Annual losses of forest benefits in 10 and 20 years



Aside from these losses, additional efforts of cleaning the burnt broadleaved forests need to be

[119] This is quite a high estimate compared to that obtained in other Mediterranean countries averaging about US$148/ha of forests (Croitoru and Merlo, 2005). This is in part due to the relatively small area of forests in Lebanon which contributes to a high estimate in average terms.

[120] Despite these considerations, we regard some individual benefits with caution, as the original text does not fully explain how these values are computed in all cases. For example, it tells that the estimate of medicinal and aromatic plants represents the sales value of such products, with no accurate detail on the quantities and prices used.

[121] Arguably, this is quite a strong assumption, as: (i) not all forest benefits are always lost in forest fires (some forest fires may even generate benefits, such as charcoal or soil nutrients); (ii) because of the high forest degradation due to overexploitation in Lebanon, it is likely that only a partial recovery of benefits in 10-20 years.

[122] In many cases, benefits recovery does not necessarily follow a linear function. In our case however, the available data represent only single point observations which do not allow drawing a more realistic function for benefits recovery.

[123] In addition to the annual losses of benefits reported in Table 7.2, burnt forests lose also the carbon stock which was sequestered in forests before the hostilities (~7.4tC/ha of forests, based on FAO, 2005). At a market price of about US$42/tC (World Bank, 2006b), this loss would be equivalent to about US$500,000. However, unlike other benefits, this global damage does not affect Lebanon *per se*. The value of damage to Lebanon from carbon emissions is thus equal to 0.

carried out. Available data does not separate the burnt area between broadleaved and conifers. Thus, the report assumes that the burnt area covered by broadleaves is proportional to that at national level (55%), i.e. about 1390 ha. At a cost of US$600/ha[124], the cost of cleaning operations on burnt broadleaved forests is estimated at US$0.8 million. Overall, the impact of fires on forests is estimated in the range of **US$6.4-10.2 million (a)**.

7.2 Impacts on Protected Areas

The bombings also affected inland protected areas of natural importance, e.g. the Biosphere Al Shouf Cedars Biosphere Nature Reserve and the Jabal Al Rihane potential nature reserve by threatening wildlife and habitats (UNDP, 2007). In addition, they caused significant decline in tourism activities and sales of local products in all seven nature reserves of the country. Results of the 2006 IUCN assessment indicate that Shouf Cedar Reserve suffered losses in tourism and sales of local products of about **US$150,000[125] (b).** These losses are economic costs related to the hostilities. It should be noted that they affected the conservation efforts of protected areas in the near future e.g., through the inability to pay administrative salaries. In this light, they also reflect environmental damages caused by the hostilities.

7.3 Impacts on the National Reforestation Program [126]

MOE has been running an ambitious reforestation campaign in Lebanon since 2002. The ministry currently manages 25 reforestation sites throughout the country, with reforestation activities contracted to the private sector through tendering and competitive bidding. The tender for Phase II of the program for the whole of Lebanon went to a private commercial nursery. According to the terms of the contract, the contractor would produce the saplings, mainly stone pine (*Pinus pinea*), Lebanese Cedar (*Cedrus libani*), and cypress (*Cupressus sempervirens*), prepare the sites for planting, transplant the saplings, irrigate them for up to three years (period from June through October) and weed the site to reduce competition.

The recent hostilities affected MOE's reforestation program in several ways:

- *direct impacts*: direct shelling and bombing leading to partial or total burning of the site; lack of access due to scattered UXOs (South Lebanon);
- *indirect impacts*: wilting of newly planted saplings because watering schedules were interrupted during the hottest and driest period of the year (July-August) throughout the country and particularly in the South; termination of all contracts; halting of maintenance of other areas (~ 360 ha) for 1.5 years until re-contracting, thus losing saplings and a 5-year equivalent of forest benefits; halting of Phase II of the national reforestation project; freezing of Phrase III of the national reforestation project [127]; freezing of Malaysian project; lost benefits during the additional time needed for the new saplings to be provided.

At least five reforestation sites in the cazas of the South and Nabatiyeh (in South Lebanon) were affected by the hostilities (Table 7.3). These sites were planted in the fall and winter of 2004, so the saplings were less than 2 years old.

[124] We assume that post-fire cleaning operations necessitate about 4 workers/ha for 10 days at a cost of US$15/worker (N. Assaf, Service of Conservation of Nature, MOE, communication, March 2007).

[125] H. Kilani, IUCN, communication, December 2006.

[126] Interview at the Department of Conservation of Natural Capital - Service of Conservation of Nature, MOE, communication, March 2007.

[127] For the sites already selected waiting field visits

Table 7.3 Post-conflict assessment of reforestation sites in South Lebanon

Site	**Caza**	**Area (ha)**	**Post-conflict status**
Marwanieh	South	15	Not assessed yet
Rihane	South	20	At least 60% burnt
Markaba	Nabatiyeh	15	At least 50% burnt
Khirbet Silem	Nabatiyeh	15	Not assessed yet
Zawtar el Charkieh	Nabatiyeh	15	100% burnt

Source: Department of Conservation of Natural Capital-Service of Conservation of Nature, MOE, communication, March 2007.

To estimate the environmental damage to burnt sites, the report uses the replacement cost method. It is assumed that reforestation of burnt sites makes economic sense, that is, the long-term benefits provided by forests will be higher than the costs of reforestation. Potential replacement costs include:

(i). *Damages to saplings on burnt areas*. Each reforestation site has an average density of 750 saplings/ha and an average total cost of US$6/sapling. If it is assume d that all the saplings in South Lebanon died as a result of the hostilities, this loss would be equal to US$360,000.

(ii). *Cleaning the burnt sites*. According to the MOE, burnt broadleaved forests need cleaning operations, followed by natural regeneration, while some conifer sites should be replanted. The MOE will incur the costs of cleaning broadleaved burnt sites. We assume that burnt area covered by broadleaves is proportional to that at national level (55%), i.e., about 44 ha. At a cost of US$600/ha[128], the cost of cleaning operations on burnt broadleaved forests reaches US$26,400.

(iii). *Forgone forest benefits*. If the saplings planted in 2004 had continued growing, the resulting forest would have provided benefits earlier than any new planting will be able. As the burnt stands were less than 2 years old when hostilities started, and assuming reforestation at these sites is undertaken relatively quickly (~5 years), the present value of the delayed forest benefits is probably relatively small.

According to the Kyoto Protocol, Lebanon can apply for carbon credits for the amount of carbon stored in reforested sites. As burnt stands cannot be reforested for at least 5 years, the forgone carbon credits are a potential damage to Lebanon in this period. The average carbon increment is 1.3tC/ha of broadleaved and 0.8tC/ha of conifers (MOE, 1999). About 45% of forest area is coniferous and 55% is broadleaved. Assuming the same distribution of forest types on the 80ha and a market price of US$42/tC, the annual damage due to carbon loss is about US$3,300. The present value of this loss for the next 5 years is about US$14,600.

Overall, the replacement costs of burnt forests add up to **US$401,000 (c)**. This figure is extremely conservative, as it does not include several components such as loss of access to forests because of UXOs, cost of cleaning UXOs, loss of forgone benefits during 5 years of halted reforestation, etc.

Adding up the estimates at (a), (b) and (c), the overall damage to forests and to national reforestation program ranges between **US$7.0 – 10.8 million**, with an average of **US$8.9 million.**

[128] the same estimate applied in the previous section

ANNEX 1: BIBLIOGRAPHY

Adra, M., 2006. Thesis: Preliminary assessment of the Jieh oil spill contamination and possible recovery options on the northern coastal zone of Lebanon. Coordinator: R. Masri, Facilitator: S. Saliba, Supervisor: M. Nadar. University of Balamand, Institute of the Environment, Marine Resources & Coastal Zone Management, 30 pp.

AFDC (Association for Forest Development and Conservation). Status of forest fires in Lebanon. www.afdc.org

AQUASTAT, 2002. Water resources. FAO.

Barnes, R.S.C. and Hughes, R., 1999. Introduction to marine ecology, Blackwell Publishing. P.286.

Bishop, J.T. (Ed.) 1999. Valuing Forests: a Review of Methods and Applications in Developing Countries. International Institute for Environment and Development. London.

Bolt, K., G. Ruta and M. Sarraf. 2005. Estimating the Cost of Environmental Degradation: A Training Manual in English, French and Arabic. Environment Department Paper No. 106. The World Bank, Washington, DC.

Bonnieux, F. and Rainelli, P., 2002. Évaluation des dommages des marées noires : une illustration à partir du cas de l'*Erika* et des pertes d'agrément des résidents, Economie et Statistique No. 357-358, p. 173-187.

Brown, G. Jr., 1992. Replacement costs of birds and mammals. University of Washington, Seattle, WA 98195.

BTC (Baku Tbilisi Ceyhan), 2003. Coastal Sensitivity Maps and Containment Manual, Iskenderun Gulf and Vicinity, Baku-Tbilisi-Ceyhan Crude Oil Pipeline Project, Ankara, Turkey, 100 pp.

Carr, A., 1987. Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles, Marine Pollution Bulletin, 18, 6B, 352-356.

Carson, R.T., Mitchell, R.C., Hanemann, M., Kopp, R.J., Presser, S., and Ruud, P., 2004. Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdes Oil Spill. Environmental and Resource Economics 25: 257-286.

Cedre, 2006. Report of analyses, oil pollution of the Lebanese shoreline. Report n° GC.06-21. 7 pp.

Cedre, http://www.cedre.fr/index_gb.html Nov, 2006.

Chas-Amil, M.L., Nogueira-Moure, E., Garcia-Negro, M.C. and Doldán-Garcia, X.R., 2004. Lessons to Be Learned from Past Oil Spills in Galicia (Spain). Interdisciplinary Environmental Review, Vol. 6(1): 92-106.

COFREPECHE, 1999. Mission d'Expertise du Secteur de Pěche Sud Liban, Centre Ifremer de Brest, France. 62 pp.

Cohen, M. J. 1995: Technological disaster and natural resource damage assessment: An evaluation of the Exxon Valdez oil spill. Land Economics 71:65-82.

Croitoru, L. and Merlo, M., 2005. Mediterranean Forest Values. In: Merlo, M. and Croitoru, L. (Eds.) Valuing Mediterranean Forests. Towards Total Economic Value. CABI Publishing. pp.406.

Dimirayak, F., R. Sadek, S. Hraouri-Bloquet, and M. Khalil, 2001. Marine Turtle Nesting Activity Assessment on the Lebanese Coast, Phase 1, Survey and Identify Nesting Sites and Fishery Interactions. Lebanese Ministry of Environment. 48 pp.

Djoundourian S., Nuwayhid I., and Chaaban F., 1998. *The economic and social impacts of mobile source pollution in Beirut, Lebanon: A country case study*, METAP III, Med Policies Initiatives.

DMJM+HARRIS, Inc. 2003. Beirut Suburban Mass Transit Corridor Feasibility Study. Ministry of Transportation and Public Works. Republic of Lebanon.

EC (European Commission), 2006a. Lebanon 34 DAY WAR: Fact finding mission and preliminary damage assessment. October 2006.

EC (European Commission) 2006b *Rapid preliminary damage assessment: Beirut and S. Lebanon*: An assessment undertaken jointly by the Joint Research Center and European Union Satellite Center, August 30, 2006

EIU (Economic Intelligence Unit) 2006 *Lebanon Country Report: Outlook for 2007-2008,* October 2006

El-Fadel, M and Massoud, M., 2000. Particulate matter in urban areas: Health-based economic assessment. *The Science of the Total Environment*, 257:133-146.

E-mine: Electronic Mine Information Network. March 2007. Mine Action Co-ordination Centre South Lebanon: Unexploded Ordnance Fact Sheet Online. Available: http://www.mineaction.org/overview.asp?o=540

Experts Working Group, 2006. Lebanon Marine and Coastal Oil Pollution International Assistance Action Plan. IMO, REMPEC, UNEP-MAP, UNDP, OCHA, EC MIC, ITOPF, ICRAM, Oceanography Centre University of Cyprus, CEDRE. 25pp.

Fall, J.A., Miraglia, R., Simeone, W. Utermohle, C.J. and Wolfe, R.J., 2001. Long-Term Consequences of Exxon Valdez Oil Spill for Coastal Communities of Southcentral Alaska. Technical Paper No. 264. Division of Subsistence, Alaska department of Fish and Game, Juneau, Alaska.

FAO (Food and Agriculture Organization), 2006. Damage and Early Recovery Needs. Assessment for Agriculture, Fisheries and Forestry. November 2006. TCP/LEB/3101, Special Emergency Programmes Service, Emergency Operations and Rehabilitation Division, Rome, 34 pp.

FAO (Food and Agriculture Organization), 2005. Global Forest Resources Assessment 2005. FAO. Rome.

GOL (Government of Lebanon), 2006a. *Rebuilding Lebanon Together... 100 days after*. Presented by Prime Minister Siniora on 21 November 2006.

GOL (Government of Lebanon), 2006b. *Setting the stage for long-term reconstruction: The national early recovery process,* Stockholm Conference for Lebanon's Early Recovery.

Grigalunas, T. A., R. C. Anderson, R. Congar, N. Meade, and P. Sorensen, 1986. Estimating the Cost of Oil Spills: Lessons from the Amoco Cadiz, Marine Resource Economics. 2(3): 239-262.

Guardia Costiera Italiana, 2006. 3º Nucleo Operatori Subaquei, 21 September – 14 October 2006.

Gundlach, E. R. and Hayes, M.O., 1978. In: The *Amoco Cadiz* Oil Spill, a Preliminary Scientific Report"; Hess, W. H., Ed.; NOAA/EPA Special Report: Environmental Research Laboratories: Boulder, CO, 1978; p 85-196.

IPIECA (International Petroleum Industry Environmental Conservation Association), 2002. Biological impacts of oil pollution: fisheries. F. Dipper and C. Thia-Eng., Joint IMO-IPIECA Report Series, International Petroleum Industry Environmental Conservation Association, London. www.ipieca.org, 32 pp.

IUCN (The World Conservation Union), 2006a. IUCN Red List of Threatened Species, www.iucnredlist.org

IUCN/Green Line, 2006: Lebanon Oil Spill Rapid Assessment- Response Mission, August 2006, Final Report, September 2006.

Jones, A.Q., Dewey, C.E., Dore, K., Majowicz, S.E., McEwen, S.A. and Waltner-Toews (2006) Drinking water consumption patterns of residents in a Canadian community, Journal of Water Health 04(2006): 125-138.

Khatib&Alami (2006) War Damage Assessment and Restoration Program, Submitted to the Prime Minister's Office on August 31, 2006.

Kremer X. (Rempec/Cedre), Pasche A. (Swiss aid), Kilani H. (IUCN), 2006. Palm Island survey on Saturday 7th October and Action Plan for cleanup operations.

Lichaa El-Khoury, D. and Bakhos, W., 2003. Land Cover Use Map of Lebanon (1/20000) – Technical Report. LEDO, Ministry of Environment/UNDP, Ministry of Agriculture/FAO and National Centre for Remote Sensing, Lebanon.

Longwell, A.C., 1978. Field and laboratory measurements of stress response at the chromosome and cell levels in planktonic fish eggs and the oil problem. In: In the wake of the Argo Merchant,. Kingston: University of Rhode Island. p.16-125.

Loomis, J. B. and Rosenberger, R. S. 2006. Reducing barriers in future benefit transfers: Needed improvements in primary study design and reporting. Ecological Economics 60: 343-350.

Loureiro M.L., Ribas, A., Lopez, E. and Ojea, E., 2006. Estimated costs and admissible claims linked to the Prestige oil spill. Ecological Economics 59 (2006), 48 – 63.

MACCSL (Mine Action Coordination Center South Lebanon). 2007. Casualties (civilian & demining) in South Lebanon from 14 Aug 06- to 03 April 07. Available from: http://www.maccsl.org/reports/Victims/Victims.pdf

McCay, D.F., Rowe, J.J., Whittier, N., Sankaranarayanan, S., Etkin, D.S., 2004. Estimation of potential impacts and natural resource damages of oil, Journal of Hazardous Materials 107 (2004): 11-25.

Ministry of Agriculture, 2006. Data report on chemical analyses completed by Ifremer Ifremer working with the National Center for Scientific Research – National Marine Center in Lebanon, Press Conference on 20 October.

Ministy of Agriculture and FAO, 2005. National Forest and Tree Inventory and Assessment in Lebanon (NFA) TCP/LEB/2903, in collaboration with the Directorate of Geographic Affairs of the Lebanese Army.

Ministry of Agriculture and UNEP, 1992. Etude de la Diversíte Biologique du Liban, Ministry of Agriculture and United Nations Environment Program, Projet GF/6105-92-72, approx. 250 pp.

Ministry of Agriculture and UNEP, 1996. Etude de la Diversíte Biologique du Liban, Ministry of Agriculture and United Nations Environment Program, Projet GF/6105-92-72, approx. 250 pp.

MOE (Ministry of Environment), 2007a. Oil spill update – February 2007, www.moe.gov.lb

MOE (Ministry of Environment), 2007b. State of the Lebanese Coast after the Oil Spill Caused by the July 2006 war. Press Release. 30 May 2007.

MOE (Ministry of Environment), 2006a. Lebanon's oil spill and its aftermath. Presented at the World Bank by Berj Hatjian, Director General, November 9, 2006.

MOE (Ministry of Environment), 2006b. The cost of oil spill clean-up in Lebanon. Internal document. MOE.

MOE (Ministry of Environment), 2004. Biodiversity assessment and monitoring in the protected areas/ Lebanon/95/G31, Palm Islands Nature Reserve. UNDP. Lebanese University Faculty of Science. August 2004.

MOE /LEDO, 2001. Lebanon State of the Environment Report, Prepared by ECODIT.

MOE (Ministry of Environment), 1999. Lebanon First National Communication under the United Nations Framework Convention on Climate Change (UNFCCC), Republic of Lebanon, Ministry of Environment, http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

Ministry of Public Health, 2007 Epidemiological Surveillance Unit. Webpage: http://www.public-health.gov.lb/

Ministry of Social Affairs/Central Administration for Statistics/UNDP (2004) The National Survey of Household Living Conditions 2004.

Monson, D.H., Doak, D.F., Ballachey, B.E., Johnson, A. and Bodkin, J. L., 2000. Long-term impacts of the Exxon Valdez oil spill on sea otters, assessed through age-dependent mortality patterns. In: Proceedings of the National Academy of Sciences of the United States of America, Vol. 97, No. 12, p. 6562-6567.

Murray, J. and A. Lopez. 1996. The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Harvard University Press.

National Center for Marine Science, 2006. Draft documents: Natural resource damage assessment plan, 4 pp., Fish 4 pp., Seabirds 6 pp.

Navrud, S. and Ready, R. (eds.) 2002. Valuing Cultural Heritage. Applying environmental valuation techniques to historical buildings and monuments. Edward Elgar Publishing, UK.

Nizam, A., 2006. Status of Drinking Water in South Lebanon, Solutions to Overcome the War Effects. Presentation made on 15 November 2006.

NOAA, 1997. Natural resource damage assessment guidance document: scaling compensatory restoration actions (Oil Pollution Act of 1990). National Oceanic and Atmospheric

Administration, Damage Assessment and Restoration Program, Silver Spring MD. 143 pp.

PCM (Presidency of the Council of Ministers), 2006. Lebanon: On the Road to Reconstruction and Recovery, First Issue, 15 December 2006.

PCM (Presidency of the Council of Ministers), 2007. Lebanon: On the Road to Reconstruction and Recovery, Second Issue, 4 May 2007.

Price, A. R. G. and Robinson, J. H. (eds.), 1993. The 1991 Gulf war: coastal and marine environmental consequences. *Marine Pollution Bulletin,* Special Issue Volume 27, 1993, Pergamon Press.

Ramadan-Jaradi, G. and Ramadan-Jaradi, M., 2001. The Avifauna of Palm Islands Nature Reserve in Lebanon 1893-2000. Lebanese Science Journal, Vol 2, No. 1, 2001.

Ramadan-Jaradi, G., 2006. On Palm Islands Nature Reserve. Informal report, 21 August, 12 pp.

Ramadan-Jaradi, G., 2007. Effects of Oil on Palm Islands Nature Reserve and approaches to long term impact assessment. Chair of the Government Appointed Committee of Palm Islands Nature Reserve. Ministry of Environment. February 2007.

Ready, R. and Navrud, S. 2006. International benefit transfer: Methods and validity tests. Ecological Economics 60: 429-434.

Republic of Lebanon (2000) *Informal Agricultural Sector Note on the Bekaa Valley*, Republic of Lebanon, June 2000.

Sarraf, M. 2004. Assessing the Costs of Environmental Degradation in the Middle East and North Africa Region. Environment Strategy Notes No. 9. The World Bank, Washington, DC.

Sarraf, M., B. Larsen and M. Owaygen. 2004. Cost of Environmental Degradation: The Case of Lebanon and Tunisia. Environment Department Paper No. 97, The World Bank, Washington, DC.

Sattout, E., Talhouk, S. and Caligari, P. 2006. Economic value of cedar relics in Lebanon: an application of contingent valuation method for conservation. *Ecological Economics*, in press.

Sattout, E., Talhouk, S., Kabbani, N., 2005. Lebanon. In: Merlo, M. and Croitoru, L. (Eds.) Valuing Mediterranean Forests. Towards Total Economic Value. CABI Publishing.

SDC (Swiss Agency for Development and Cooperation). 2007. Clean-up operations. Palm Islands. Coastline Enfe-Tripoli. Final Report, p. 19, 23 February 2007.

Shabman, L.A. and Batie, S. 1978. Economic value of natural coastal wetlands: a critique. Coastal Zone Management Journal 4, pp. 231-247.

UNDP (United Nations Development Program), 2007. Lebanon Rapid Environmental Assessment for Greening Recovery, Reconstruction and Reform 2006. Beirut, Lebanon.

UNDP, (United Nations Development Program), 2006. Clearance of Rubble and Debris from Beirut's Southern Suburbs, 2006. Online. Available from: http://www.undp.org/lebanon/project_rubble.shtml

UNEP (United Nations Environment Programme) 2007. Post-Conflict Environmental Assessment, UNEP. 181 pp.

Viscusi, W. K. and Aldy, J.E. (2003) The Value o a Statistical Life: A Critical Review of Market estimates Throughout the World. The Journal of Risk and Uncertainty, 27 (1) p. 5-76, Kluwer Academic Publishers.

Whitehead, J. 1992: Ex ante willingness to pay with supply and demand uncertainty: implications for valuing a sea turtle protection programme.

Whitehead, J. C. 1993. Total Economic Value for Coastal and Marine Wildlife: Specification, Validity, and Valuation Issues. Marine Resources Economics. 8: 119-132.

World Bank, 2006a. Lebanon. Economic and Social Impact Assessment from Recovery to Sustainable Growth. Volume 2. Sectoral Analysis. Social and Economic Development Group. Middle East and North Africa Region. World Bank.

World Bank, 2006b. State and Trends of the Carbon Market 2006. Washington DC. May 2006. IETA and World Bank.

Yellow Pages Tourism, 2006, Tourism. 250 pp.

Yender, R., J. Michel and C. Lord. 2002, Managing seafood safety after an oil spill, U.S. National Oceanic and Atmospheric Administration, Office of Response and Restoration, Seattle, 72 pp.

<u>ANNEX 2: BACKGROUND INFORMATION ON THE OIL SPILL</u>

Annex 2 (i) List of sites impacted by the oil spill

Site N°	Name	Coordinate N	Coordinate E	Type	Open/ confined	Length (km)	Area (m2)	Volume e=0,1m (m3)	Volume e=0,5m (m3)
1	Jyeh	33°38'58.07"	35°23'59.88"	Sandy/*facilities*	Open	1.5			
2	Rmaileh	33°39'09.83"	35°24'53.17"	Sandy	Open	***1.7***			
3	Damour	33°42'01.91"	35°26'23.91"	Sandy	Open	***4.4***			
4	Ramleh Baida	33°52'14.45"	35°28'52.48"	Sandy	Open	***1.4***			
5	Movenpick	33°53'00.23"	35°28'21.19"	Rocky/*harbor facilities*	Confined		***14 000***	1 400	7 000
6	Sporting	33°53'35.02"	35°28'01.81"	Rocky	Confined		***750***	75	375
7	Raouche (fishermen)	33°53'12.85"	35°28'17.07"	Rocky	Confined		***1400***	140	700
8	Long Beach	33°53'38.47"	35°28'01.48"	Rocky	Confined		***5600***	560	2 800
9	Tabarja	34°01'06.61"	35°37'25.74"	Rocky	Open	0.5			
10	Byblos sandy beach	34°06'04.89"	35°39'02.46"	Sandy	Open	1.7			
11	Byblos port	34°07'17.96"	35°38'36.12"	Rocky/*harbour facilities*	Confined		***5500***	550	2 750
12	Byblos sur mer (marina)	34°07'21.20"	35°38'31.57"	Rocky	*Confined/ open*		***1000***	100	500
13	Byblos gravel beach	34°07'23.50"	35°38'34.90"	Gravel	Open	0.7			
14	Batroun	34°13'41.40"	35°39'19.09"	Sandy	Open	2.5			
15	Batroun bay	34°15'08.22"	35°39'25.12"	Pebbles	Confined		***22 000***	2 200	11 000
16	Heri (Rocca Marina)	34°18'26.98"	35°42'00.66"	Rocks */sea walls*	*Open/ Confined*		***10000***	1 000	5 000
17	Saint Antoine	34°18'18.82"	35°42'06.93"	Sandy/*Sea walls /rocky*	*Open /Confined*		***1000***	100	500
18	Blue Beach	34°18'22.52"	35°42'36.17"	Sandy	Open	0.7			
19	Chekka	34°18'41.34"	35°42'56.00"	Sandy	Open	***1.7***			
20	Ras El Sakhr & Mina Public Beach	34°??'47.25"	35°49'14.76"	Rocky	Open	***undefined***			
21	Ras Maska-Bahsas	34°25'10.16"	35°49'13.83"	Sandy	Open	1			
22	Al Zreira (Borders of Kfarabida)	34°14'38.68"	35°39'37.19"	Rocky+pebbles sandy	Open	0.2			
23	Sawari Beach	34°14'48.86"	35°39'31.61"	Sandy	Confined		***3500***	350	1 750
24	Saint Stephano Beach	34°14'53.30"	35°39'28.81"	Rocky	Confined		***3000***	300	1 500
25	Aqualand	34°14'55.81"	35°39'29.08"	Rocky	Confined		***500***	50	250
26	National Center Marine Sciences	34°15'04.37"	35°39'23.41"	Rocky/*sand*	Open	0.2			
27	Phoenician Wall	34°15'10.89"	35°39'21.58"	Rocky	Open	0.5			
28	Fishermen Wharf Batroun	34°15'27.68"	35°39'26.60"	Pebbles	Confined		***6000***	600	3 000
29	Al Ghalaghili Beach	34°15'53.83"	35°39'31.12"	Rocky	Open	***1***			
30	Palm Islands	34°27'43.31"	35°48'01.48"	Sandy	Open	*undefined*	*undefined*		
							Total	**7425**	**37125**

Source: MoE (from 18 July 2006 - 9 August 2006). Table completed with measurements of sites (on the basis of Google Earth maps and estimates of volumes (Cedre).

Annex 2 (ii) Oil Impact Sites, North Lebanon

Name	**North**	**East**	**Extent of Pollution (Length, Width)**	**Oil Characteristics**
S1. Mina Ras Al-Sakher	34°26.550	35°48.782	100 m x 3 m	Black rocks / thin film of oil in water.
S2. Anfeh	34°22.413	35°44.181	40 m x 15 m	Blackened rocks at upper intertidal.
S3. Anfeh	34°21.606	35°43.733	100 m x 20 m	Oil reaching up 1 m on rocky shore.
S4. Chekka/in front of	34°20.841	35°43.723	10 m x 10 m	Blackened rocks 10 m on shore.
S5. Chekka	34°19.841	35°438.520	10 m x 1 m (x 1 m high)	Minimum amount of oil on rocks.
S6. Chekka	34°19.582	35°43.345	50 m x 10 m (x 1 m high)	High concentration of oil on rocks.
S7. Antonio Beach / Heri	34°18.370	35°42.044	20 m x 3 m	(oiling not described)
S9. Kobba	34°16.153	35°39.416	80 m x 3 m (x 1 m high)	Oil reaching 1 m high in to rocks.
S10. Batroun / Sawary Beach	34°14.830	35°39.628	100 m x 1 m (x 2 m hjigh)	Oil tainted rocks where waves are
S12. Arida	34°37.594	35°58.813	1 km x 2 m (x 1 m high)	Sand and rocks contaminated.
S13. Sheikh Zineed	34°36.442	35°59.147	3 m x 2 m (x 2 m hjigh)	Contaminated rocks.

Source: Adra, 2006

Annex 2 (iii) Turtle Beaches in Lebanon (Known oiled sites are indicated by '*').

Location	**Coordinates**	**Turtle Nesting Status**	**Comment**
South **of Spill Site**			
S-1, El-Mansouri Beach	34°11'N, 35°11'E	35 loggerhead, 9 green (highly predated by dogs, hyenas and crabs)	2 km beach used for local swimming.
S-2, Sour Reserve Area	34°15'N, 35°13'E	Needs additional survey to determine.	Nature Reserve Status encroached by beach huts.
S-3 North Sour Beach	34°18'N, 35°14'E	Potential for nesting.	Presence of illegal housing.
S-4 Qaasmiye (El-Bourgheliye) Beach	34°15'N, 35°13'E	7 nests, 1 destroyed by irrigation channel.	At Litani River built walls causing beach erosion.
S-5 Yahoudiye Beach	34°21'N, 35°14'E	Observed in the past. Medium potential in the north.	Hotel destroyed dunes, extensive litter, and beach hut buffet built in area.
S-6 Mahmoudiye Beach	34°22'N, 35°15'E	3 nests predated by dogs and crabs. High nesting potential.	
S-7 Adloun Beaches	34°23'N, 35°15'E	1 possible nest, appeared predated.	Heavy beach use.
S-8 El-Aaddoussiye Beach	34°29'N, 35°19'E	No nesting potential.	Heavy sand extraction. Hotel developed to south.
S-9 Saida Beaches	S side: 34°34'N, 35°22'E; N side: 34°35'N, 35°23'E	Nesting reported by fishermen. Medium potential.	Developed area with road along the coastal area, plus municipal coastal landfill.
S-10 Er Rmaile	33°37'N, 35°24'E	None observed, low nesting potential.	Heavy beach use.
North of Spill Site			
*S-11 Jiyeh Beach	33°39'N, 35°25'E	Nesting reported previous year by fishermen. Low potential.	Highly developed backshore and public / private use, plus sand extraction.
*S-12 Damour Beach	33°42'N, 35°26'E	None observed. Medium potential.	Developed tourist facilities areas.
North Lebanon			
N-13 El-Aaquibe Beach	El Mina area.	None observed. Reported in the past. Low potential.	Highly utilized tourist beach.
*N-14 Jbail (Byblos) Beaches	34°07'N, 35°38'E	Loggerhead nests observed. Fishermen report loggerhead and green commonly seen at sea.	Developed tourist area.
N-15 El-Heri	34°18'N, 35°42'E	None observed. Medium potential.	Highly developed, seawalls present.
N-16 El-Minie	34°29'N, 35°55'E	None observed. Medium potential.	Tourist facilities and litter problem.
*N-17 Palm Islands (Nature Reserve)	34°30'N, 35°46'E	Year 1999 and 2000=36 nests, 1998=8 nests, 1997=3 nests.	Dimensions of beach change with bad weather and water currents.
N-18 El-Aabdé	South: 34°31'N, 35°59'E 34°30'N, 35°46'E	Some nesting reported by locals and fishermen. Low to medium potential.	Highly littered beach. Some beach erosion.

Source: Dimirayak et al., 2001

Annex 2 (iv) Principal fish species captured in Lebanon

Family	**French / English**	**Lebanese**
Demersal		
Belonidae	Aiguillette /	Arifida
Sphyraenidae Sphyraena spp.	Barracuda / Barracuda	Sfirni mafia (juv.)
Serranidae	Mérou blanc / White grouper	Loukouz ramli debe
	Mérou sombre / Dusky grouper	Ahfesh
Mugilidae Mullidae	Mulets / Mullet	Bouri
Mullus barbatus barbatus	Rouget barbet / Red mullet	Sultan Ibrahim ramli
Mullus surmuletus	Rouget de roche / Striped red mullet	Sultan Ibrahim sakhri
Spicara smaris	Picarel / Picarel	Asfour
Sparidae (Seabream)		
Boops boops	Bogue / Bogue	Goubous
Sarpa alpa	Saupe / Salema	Salban
Centex canariensis	Denté / Canary dentex	Samaket reyess
Dentex macro-phthalmus	Denté gros yeux / Large eye dentex	Bouhlok
Lithognathus mormyrus	Marbré / Striped seabream	
Oblada malanura	Oblade / Saddled seabream	Mannouri
Pagrus pagrus	Pagre commun / Southern common seabream	Gerbidi mkahal
Sparus aurata	Daurade / Gilthead seabream	‘iggag jarbeedeh
Scorpaenidae (Scorpion Fish)		
Scorpaena porcus	Rascasse brune / Black sorpionfish	Esctroub
Scorpaena scrofa	Rascasse rouge / Large scaled scorpionfish	Estreb
Small Pelagic		
Elasmobranchii	Requins divers	
Carangidae	Chinchard / Horse Mackerel	Assaifar (also Sardin)
Scombroidei (maq.)	Magereau / Mackerel	Scombro
Large Pelagic		
Clubeiodei	Sardine / Sardine	Sardin
Scombroidei (tunas)	Thonine de Atlantique / Atlantic Bonita Bonite à dos rayé / Plain Bonita	Balamida Ghazel

Source: COFREPECHE, 1999.

Annex 2 (v) Seasonality of fish captures in Lebanon
(Fish capture coincided with oil slicks from mid-June to September 2006).

Species	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Aiguille (or Barracuda)	X	X			X	X	X					
Rouget barbet / Red mullet	X	X	X	X							X	X
Daurade / Gilthead seabream	X	X										
Pagre / Southern common seabream										X	X	
Denté / Canary dentex										X	X	
Marbré / Striped Sea Bream					X	X						
Olbade / Saddled seabream					X	X						
Saupe / Salema						X	X	X	X			
Bogue / Bogue						X	X	X	X			
Picarel / Picerel							X	X				
Mulet / Mullet								X	X		X	X
Sardine / Sardine							X	X	X			
Maquereau / Mackerel		X	X	X	X	X					X	X
Bonite à dos rayé / Plain Bonita	X	X									X	X
Tonine de l’Atlantique / Atlantic Bonita	X	X									X	X
Rascasse rouge / Large scaled scorpion fish	X			X	X	X	X	X	X			
Denté gros yeux / Large eye dentex	X	X										X
Mérous / Grouper		X	X	X	X	X	X	X	X	X		

Source: COFREPECHE, 1999

Annex 2 (vi) Potential effects of oil spills on fish and fisheries.

Spill Characteristics / Reference	**Reported Effect**
1969: well blowout, Santa Barbara, California; 4,500–10,500 tons crude oil. Squire (1992)	Short-term negative effects on abundance of bonito and jack mackerel. No long-term effects on abundance of any pelagic fish species studied.
1976: *Argo Merchant*, Massachusetts, USA; 25,000 tons No. 6 fuel oil. Kühnhold (1978), Longwell (1978)	Fish eggs moribund; fish larval densities reduced. Fish stocks studied 1975–77 showed no major impacts. Spill did not occur during peak spawning season.
1977: *Tsesis,* Baltic, Sweden; 1,000 tons medium fuel oil. Kineman et al. (1980), summarized in Linden et al. (1979) Johannessen, (1980)	Herring moved normally through oiled areas during the month after the spill. Contamination not detected in their tissues. Some effects on spawning were recorded the following spring but these may have resulted from causes other than the spill.
1977: Ekofisk 'Bravo' blowout, North Sea; 9,000–13,000 tons crude oil. Law (1978)	Bottom-trawled fish analyzed for petroleum hydrocarbons. No evidence that fish had taken up oil during two weeks following the blowout.
1978: *Amoco Cadiz*, N. Brittany, France; 221,000 tons light Middle Eastern crude oil. CNEXO (1981); Haensley et al. (1982)	Several tons rockfish (e.g. wrasse) and sand eels killed. One-year-old class of plaice and sole disappeared in worst affected areas. Reproduction and growth of bottom-living fish in abers and bays disturbed and histopathological abnormalities still evident in plaice two years later. Little tainting of fin-fish.
1979: *Betelgeuse*, Bantry Bay, Ireland; Arabian light crude oil—explosion then leakage for 18 months. Grainger et al. (1980), summarized in Myers (undated)	Whiting and sprat spawned normally in spring. No serious adverse effects on eggs and larvae of commercial species detected. No apparent reduction in spatfall of scallops in 1979.
1980: oil spill, Bahrain; estimated 3,300 tons arrived at coast. Linden (1984)	Initially, numbers of dead groupers, jacks, and 'sardines'; no massive mortality.
1983: *Castillo de Bellver,* South Africa; 160,000–190,000 tons crude oil. Moldan et al. (1985)	Spill remained offshore. Dispersant used on landward edge of spill. Little apparent impact on fish grounds or stocks. Occurrence and abundance of eggs and larvae normal. Spill occurred prior to main fish spawning season.
1989: Exxon Valdez, Alaska; 35,360 tons crude oil. Wells et al. (1995)	Herring: No adult herring mortalities were observed at the time of the spill. The herring spawned shortly after the spill, thus exposing the most vulnerable life stages to the oil. Fortunately much of the heaviest spawning was in areas unaffected by the oil. The herring harvest in 1990 was very good. The herring fishing ban in 1989 may have compensated for losses due to the oil spill. However, herring returns for 1993–95 have been poor, resulting in a ban on seine fishing. Salmon: It remains unclear whether the oil killed significant numbers of newly-hatched young in intertidal spawning areas or fry in shallow water. If it did, then other factors must have allowed greater than normal numbers of the remaining fry to survive. Pink salmon returns in 1992–93 were lower than forecast whilst 1994 gave the third highest yield ever.
1991: Gulf War oil spill; 800,000–1,000,000 tons crude oil. Price and Robinson (eds.) (1993); Price et al. (1994)	In 1991–92, Saudi Arabian prawn stocks showed a decline in total biomass to 25 per cent of pre-war levels. Exact causes not ascertained.
1993: *Braer*, Shetland; 84,700 tons oil. Ecological Steering Group (1994)	No major mortality of commercial fishery species, nor were significant changes recorded in the abundance or distribution of these species or other important food chain species (e.g. sand eels). However, fisheries were directly affected through contamination of equipment and tainting of fish. Elevated mortalities at some fish farms were accepted as oil-related. In wild fish the contamination was only light, and fairly low numbers of tainted individuals were found.

Modified from: IPIECA, 2000. (References cited available from www.IPIECA.org).

ANNEX 3: BACKGROUND INFORMATION ON WASTE

Annex 3 (i) number of destroyed units in South Lebanon per Caza

(Obtained from original record of heads of municipalities and signed by the Mohafez)

Tyre Caza	**Number**	**Marjeyoun Caza**	**Number**	**Bint Jbeil Caza**	**Number**	**Nabatiyeh Caza**	**Number**	**Hasbaya Caza**	**Number**
Tyre	10	Jdeidet Marjeyoun	50	Yater	188	Nabatiyeh Tahta	150	Kfarchouba	80
Arzoun	13	Kabrikha	85	Hadatha	85	Nabatiyeh Fawka	12	Rachaya El Fakhar	4
Al Boustan	20	Debbin	88	Chakra W Doubieh	60	Ansar	34	Al Dlafeh	1
Al Jebin	7	Al Khyam	1000	Kafra	111	Jbaa Ain Boswar	12		
Jabal Al Batm	98	Mays El Jabal	50	Kfardounin	20	Jebchit	28		
Al Hallousiyeh	14	Deir Mimas	4	Haris	30	Harouf	52		
Al Henniyeh	5	Kfarkela	10	Deir Antar	11	Hbouch	5		
Al Rmadiyeh	1	Odaysa	17	Baraachit	150	Houmin el Fawka	2		
Al Chaitiyeh	500	Hola	35	Safad el Batikh	60	Al Douwayr	7		
Al Mansouri	51	Al Taybeh	135	Aita El Chaeb	650	Zebdin	30		
Batoulieh	14	Markaba	60	Ain Ebel	15	Zefta	2		
Barich	7	Al Kantara	20	Kharbet Selm	45	Zawtar el Gharbiyeh	30		
Al Bazourieh	15	Al Souwana	32	Al Soultaniyeh	110	Zawtar el Charkiyeh	4		
Baflieh	16	Adchit	12	Bent Jbeil	750	Aarabsalim	5		
Borj Chamaly	15	Talousa	17	Yaroun	30	Kakiiyet el Jisr	12		
Borj Rahal	15	Deir Seryan	150	Ainata	140	Al Ksaibeh	14		
Joya	15	Blat	8	Aitaroun	130	Kfartebnite	26		
Hennawiyeh	57	Bani Hiyan	1	Bayt Lif	150	Kfarreman	2		
Debaal	6	Rab Thalathin	7	Kounin	80	Kfarsir	23		
Derdeghya	17	Majdel Selem	100	Maroun El Ras	600	Al Kfour	8		
Deir Aames	5	Mjaibit	25	Al Kozah	4	Maifadoun	16		
Deir Kanoun El Nahr	35	Toulin	25	Bayt Yahoun	80	Al Nmayriyeh	8		
Deir Kanoun Ras El Ein	30			Froun	84	Braikee	2		
Rachknaniyeh	7			Borj Klawi	17	Aadchit	30		
Zebkin	160			Klawiya	26	Yahmor	25		
Selaa	28			Aita El Jabal	28	Chawkin	8		
Chahour	14			Hanin	16	Toul	10		
Chamee	25			Rchaf	60				
Al Chahbieh	38			Sarbin	20				
Chihin	35			Jmayjmeh	48				
Siddikin	230			Al Ghandourieh	80				
Srifa	220								
Toura	28								
Tayr Deba	18								
Tayr Fliseh	2								
Al Aabasiyeh	60								
Aaitit	10								
Ain Baal	39								
Al Koulayleh	200								
Al Majadel	14								
Majd El Zoun	60								
Marwahin	80								
Mazraet Mechref	6								
Maaraka	1								
Maaroub	50								
Al Nakoura	20								
Yarin	25								
Al Samaieh	4								
Sub -Total	**2,340**		**1,931**		**3,878**		**557**		**85**
Total									**8,791**

Annex 3 (ii) Estimated quantity of demolition waste based on field visits conducted during the preparation of this report (Oct – Nov 2006

Description	*Quantity*	*Remarks*
Surface area per apartment	150-200 m^2	
Total walls (inner, outer, pillars)[a]	45-90 m^3	10-15 % of surface area
Unit slab[a]	45-60 m^3	0.3 m as average thickness
Furniture and personal belongings[a]	18.75-50 m^3	25-50 % occupancy of surface area
Total per housing unit	109-200 m^3	
BEIRUT Southern Suburbs		
Number of units destroyed[b]	9,000	300 buildings; 10 stories; 3 apartments per story
Number of units partially blasted[c]	840	30% of the housing unit damaged
Number of units damaged[c]	2,100	5% of the housing unit damaged
Total demolition waste 1,020,000 – 1,871,000 m^3		
District of the SOUTH		
Number of units destroyed[d]	8,791	Refer to Appendix A for details
Total demolition waste 956,000 - 1,758,000 m^3		
BAALBEK-EL HERMEL area		
Number of units destroyed[e]	375	
Number of units badly damaged[e]	400	30% of the housing unit damaged
Total demolition waste 54,000 - 99,000 m^3		
TOTAL 2,030,000 – 3,728,000m^3		

[a] Expert opinion/ Field visits. [b] GOL, 2006b. [c] Personal Communication: Dr. M. Fawaz, Department of Architecture and Graphic Design, AUB, November 2006. [d] Municipalities of South Lebanon. [e] Personal Communication: Mr. M. El Jammal, Head of Baalbek Municipality, October 18, 2006

Annex 3 (iii) Assessment of Loss due to Limited Access to Agricultural Lands by UXO

Assumptions:

- Area values used are based on the agricultural census of the Ministry of Agriculture (MoA) in 1999. published on the MoA official website: www.agriculture.gov.lb
- Production rate and the value per ton are deduced from the MoA 2004 production statistics also published on the MoA official website
  - Production rate is calculated by of dividing the total production for each category of crops by its cultivated area for the year 2004 (table below).
  - The value per ton of each crop category is estimated as the average value between its import and export values (table below):
    - The value per ton of import is calculated by dividing the import total value of each crop category by its volume for the production year 2004
    - The value per ton of export is calculated by dividing the export total value of each crop category by its volume for the production year 2004
- 1 du: dunum = 1000 sq.m

Estimation of forgone agricultural production in the South and Nabatiyeh per year

Crop type	*Cultivated area (du)* [a]			*Production rate* [b]	*Total production*	*Value* [b]	*Total value*
	South	*Nabatiye*	*Total*	*(Tonne/du)*	*(Tonnes)*	*(USD/tonne)*	*(USD)*
Cereals	37,638	59,525	97,163	0.28	26,781	297	7,965,069
Legumes	2,096	5,869	7,966	0.54	4,270	565	2,413,839
Fruit trees	123,304	20,768	144,073	1.26	181,973	746	135,786,268
Olives	89,340	116,124	205,464	0.29	58,759	1,268	74,525,973
Oleaginous trees	5,806	3,836	9,642	0.10	931	2,083	1,939,556
Vegetables	20,753	12,141	32,894	3.19	104,871	251	26,276,441
Raw tobacco	14,625	40,026	54,652	0.12	6,395	2,988	19,110,223
Total							**268,017,000**

Land cover map of the South of Lebanon

Prepared by D. Lichaa Khoury

The adopted scenarios assume that a percentage of the South and Nabatiyeh agricultural lands will be inaccessible due to UXOs. This will invoke a loss of the production that might have taken place in these lands, therefore a loss of the gross income value that these lands would have generated under normal conditions, based on the year 2004 statistics (table below).

Estimation of the incurred damage cost per scenario per year

Scenario	*Damage cost*
1. 25% of the agricultural area (evenly distributed among crop categories in the 2 Mohafazas) will not be accessible for a whole year	67 million US$ per year
2. 10% of the agricultural area (evenly distributed among crop categories in the 2 Mohafazas) will not be accessible for a whole year	27 million US$ per year
3. 5% of the agricultural area (evenly distributed among crop categories in the 2 Mohafazas) will not be accessible for a whole year	13 million US$ per year

Annex 4 Oil Spill Estimates

(1) HOTELS AND FURNISHED APARTMENTS

Hotels	Value (min)	Value (max)	Units	Notes	Source
Number of rooms in 54 coastal hotels	3,500	3,500	rooms	The Syndicate of Hotel Owners lists about 337 hotels, of which 54 are located on the coast and count about 3,500 rooms.	Syndicate of Hotel Owners
Number of apartments in 97 coastal furnished appartment establishments	2,800	2,800	rooms		Ministry of Tourism
Average price/day in hotel rooms	150	150	US$/day	Room rates range from US$40/night to US$300/night, averaging to US$100/night. Additional miscellaneous revenue is about US$50/day from phone, laundry and meals.	Syndicate of Hotel Owners
Average price/day in furnished apartments	220	220	US$/day	The daily price during low season of one-bedroom appartment is between $55 (Savoy Suites in Raouche, Beirut) and $175 (Lahoya Homes in Manara, Beirut), while two-bedroom appartments cost between $200 and $450 (in Lahoya Homes).	Interviews at furnished apartments in Lahoya Homes (Manara Beirut), Savoy Suites (Raouche, Beirut), Royal Bay Suites (Ghazir, near Jounieh).
Expected income per day in coastal hotels and furnished apartments	1.1	1.1	million US$		
Expected* income in 2006 (Sept-Dec, 122 days)	87.0	87.0	million US$	Expected* occupancy is estimated at 75% in Sept-Oct and 50% in Nov-Dec for both coastal hotels and furnished appartments	
Expected* income in 2007 (Jan-Dec, 365 days)	313.2	313.2	million US$	Expected* occupancy is estimated at 50% in Jan-Feb, 75% in Mar-Apr, 100% in Jun-Aug, 75% in Sep-Oct, 50% in Nov-Dec	
Expected* income in 2008 (Jan-Dec, 365 days)	313.2	313.2	million US$	Expected* occupancy is estimated at 50% in Jan-Feb, 75% in Mar-Apr, 100% in Jun-Aug, 75% in Sep-Oct, 50% in Nov-Dec	
Forgone hotel income due to oil spill (2006)	8.7	17.4	million US$	10-20% loss to oil spill	
Forgone hotel income due to oil spill (2007)	15.7	31.3	million US$	5-10% loss to oil spill	
Forgone hotel income due to oil spill (2008)	0.0	15.7	million US$	0-5% loss to oil spill	
PV of forgone income to oil spill	**22.8**	**59.6**	million US$		

Expected* (occupancy or income) reflect the situation if the hostilities had not occurred

(2) MARINAS SPORTS ACTIVITIES

Losses to public	Value (min)	Value (max)	Units	Notes
Number of large marinas	4	4	marinas	
Number of small marinas	30	30	marinas	
Expected annual income of large marinas' sports activities	600,000	600,000	US$/year	Based on the annual income of Movenpick Hotel Marina in Beirut, consisting of boat rental (100,000) and water jet rental (50,000)
Expected annual income of small marinas' sports activities	400,000	400,000	US$/year	
Total expected annual income	1,000,000	1,000,000	US$/year	
Expected income in 2006 (since Sept)	250,000	250,000	hotel-days	
Expected income in 2007 (all season)	1,000,000	1,000,000	hotel-days	
Expected income in 2008 (all season)	1,000,000	1,000,000	hotel-days	
Forgone marinas' income due to oil spill (2006)	187,500	250,000	US$	75-100% loss to oil spill
Forgone marinas' income due to oil spill (2007)	50,000	100,000	US$	5 - 10% loss to oil spill
Forgone marinas' income due to oil spill (2008)	0	50,000	US$	0 - 5% loss to oil spill
Total forgone income to oil spill (2006-2008)	**226,516**	**377,290**	**US$**	

Losses to private owners of leisure boats

(3) BEACH RESORTS, CHALETS AND PUBLIC BEACHES

Beach resorts	Value (min)	Value (max)	Units	Notes	Source
Number of beach resorts	68	68	beach resorts		Syndicate of Hotel Owners (interview)
Expected number of visitors per beach/day (peak season, 47 days)	500	500	visitors/beach/day	The peak season extends between July 15 - Aug 31 (47 days)	
Expected number of visitors per beach/day (rest of the season, 61 days)	300	300	visitors/beach/day	Th rest of the season covers May 15 - July 15 and all month of September (61 days)	
Visitor entrance fee and other spending/day	20	20	US$/visitor/day	Average between a minimum of $7 and a maximum of $30	
Expected income in 2006 (Sept, 30 days)	11,930,000	11,930,000	visitors		Ministry of Tourism
Expected income in 2007 (May 15-Sept 30)	55,430,000	55,430,000	visitors		
Expected income in 2008 (May 15 -Sept 30)	55,430,000	55,430,000	visitors		
Forgone income due to oil spill (2006)	2,980,000	5,970,000	US$	25-50% loss to oil spill	
Forgone income due to oil spill (2007)	2,770,000	5,540,000	US$	5-10% loss to oil spill	
Forgone income due to oil spill (2008)	0	2,770,000	US$	0-5% loss to oil spill	
PV of forgone income due to oil spill	**5,426,405**	**13,324,946**	**US$**		

Chalets	Value (min)	Value (max)	Units	Notes	Source
Number of chalet establishments	25	25	chalet establ.		Syndicate of Hotel Owners (interview)
Number of chalet units/establishment	200	200	chalet units/establ.		
Number of chalet units	5,000	5,000	chalet units		Ministry of Tourism
Rent/chalet/month	1,000	1,000	US$/day	Chalet rental is $1000/month or $6000 for the whole season	
Forgone income due to oil spill (2006, Sept-Oct)	2,500,000	5,000,000	US$	25-50% loss to oil spill	
Forgone income due to oil spill (2007, May-Oct)	1,500,000	3,000,000	US$	5-10% loss to oil spill	
Forgone income due to oil spill (2008, May-Oct)	0	1,500,000	US$	0-5% loss to oil spill	
PV of forgone income to chalets due to oil spill	**3,790,680**	**8,914,855**	**US$**		

Public beaches	Value (min)	Value (max)	Units	Notes
Number of public beaches affected by the oil spill	9	9	number of beaches	
Average number of visitors/day (all beaches)	8,400	8,400	visitors/day	
Average benefit/visitor/day	10	10	$/day	
Expected visitors in 2006 (Sept)	252,000	252,000	visitors	30 beach-days during Sep
Expected visitors in 2007 (July - Sep)	772,800	772,800	visitors	92 beach-days during July-Sep
Expected visitors in 2008 (July-Sep)	772,800	772,800	visitors	92 beach-days during July-Sep
Forgone income due to oil spill (2006)	614,250	1,228,500	US$	25-50% loss to oil spill
Forgone income due to oil spill (2007)	122,850	245,700	US$	5-10% loss to oil spill
Forgone income due to oil spill (2008)	0	122,850	US$	0-5% loss to oil spill
PV of forgone income to public beaches due to oil spill	**704,207**	**1,517,627**	**US$**	

Events	Value (min)	Value (max)	Units	Notes
Number of beach resorts organizing events	93	93	beach resorts	
Number of events/beach resort	64	72	events/beach resort	The chalets organize about 3 events/week for about 24 weeks, while the beach resorts without accomodation organize around 3 events/week for about 24 weeks.
Total annual number of events	5,952	6,696	events	
Total number of events during Sept-Oct	3,720	3,720		
Average number of participants/event	300	300	participants/event	
Cost per participant/event	40	40	US$/participant/event	
Expected annual income from organizing events	71,424,000	80,352,000	US$	
Forgone income from events due to oil spill (2006, Sept-Oct)	0	0	US$	0% from the income during Sep-Oct 2006 is loss due to oil spill
Forgone income due to oil spill (2007, May-Oct)	3,571,200	8,035,200	US$	5-10% from the income during May-Oct 2007 is loss due to oil spill
Forgone income due to oil spill (2008, May-Oct)	0	4,017,600		0-5% from the income during May-Oct 2007 is loss due to oil spill
PV of forgone income from events due to oil spill	**3,301,775**	**11,000,626**	**US$**	

LOSS TO BEACH RESORTS, CHALETS, EVENTS (million US$)	**13.2**	**34.8**

(4) PALM ISLAND NATURE RESERVE

Tourism-recreation	Value (min)	Value (max)	Units	Notes
Expected visitors in 2006, of which:	22,500	22,500	visitors	The number of visitors varies between 20,000 and 25,000 (MOE statistics). 20% come by their own boat. The rest of 80% use PINR facilities: either in groups or individual visitors.
- expected number of individual visitors coming by own boats	*4,500*	*4,500*	visitors	About 20% of visitors come by own boats (Jaradi, President of GAC, communication).
- expected number of individual visitors coming by PINR boats	*10,500*	*10,500*		The number of individual visitors is the difference between 80% of the total number of visitors and the number of those coming in groups.
- expected number of groups	*500*	*500*		The average size of a group is 15 (Jaradi, President of GAC, communication)
Actual number of visitors in 2006	1,740	1,740	visitors	
- actual number of individual visitors coming by PINR boats	*812*	*812*		The same proportion of individual visitors/total visitors as in the 'expected' case was applied.
- actual number of groups	*62*	*62*		
Forgone number of visitors in 2006, of which:	20,760	20,760	visitors	
- forgone number of individual visitors coming by PINR boats	*9,688*	*9,688*		
- forgone number of groups	*438*	*738*		
Forgone annual income from tourism in 2006	72,363	91,113	US$	The average fee is US$62.5 per group, US$4 for individual transportation and US$6 for renting chairs and umbrellas. Only 5% of the total visitors usually rent chairs and umbrellas.
Forgone income due to oil spill (2006, Sept)	12,524	15,770	US$	75-100% loss to oil spill
Forgone income due to oil spill (2007, July-Sept)	3,618	9,111	US$	5-10% loss to oil spill
Forgone income due to oil spill (2008, July-Sept)	0	4,556	US$	0-5% loss to oil spill
Forgone income due to oil spill (2006-2008)	**15,388**	**27,637**	**US$**	
Loss of biodiversity	**97,200**	**324,000**		
Cost of impact assessment and monitoring	**600,000**	**850,000**		
TOTAL LOSS TO PALM ISLANDS (million US$)	**0.7**	**1.2**		

(5) BYBLOS

Tourism-recreation	Value (min)	Value (max)	Notes
Expected annual income	144,000	144,000	
Forgone income due to the oil spill			% of expected income
- in 2006	9,000	24,000	25-50% loss to oil spill
- in 2007	7,200	14,400	5-10% loss to oil spill
- in 2008	0	7,200	0-5% loss to oil spill
PV of forgone income due to oil spill (2006-2008)	**15,311**	**42,791**	

Historical-cultural value	Value (min)	Value (max)
Losses in historical-cultural value	100,000	100,000
TOTAL LOSS TO BYBLOS (mill. $)	**0.1**	**0.1**

(6) RESTAURANTS

Restaurants	Min	Max	Unit	Notes
Number of fish restaurants (on the coast and inland)	170	170		
Average turnover/restaurant/year	400,000	400,000	US$	
Average turnover/restaurant/month	33,333	33,333	US$	
Forgone benefits due to the oil spill in 2006	17,000,000	22,666,667	US$	75-100% of the expected income in 2006
Forgone benefits due to the oil spill in 2007	3,400,000	6,800,000	US$	5-10% of the expected income in 2007
Forgone benefits due to the oil spill in 2008	0	3,400,000	US$	0-5% of the expected income in 2008
PV of forgone benefits to restaurants due to oil spill	19,500,000	31,100,000		
TOTAL LOSS TO RESTAURANTS (million US$)	**19.5**	**31.1**		

(7) COMMERCIAL FISHERY

% sales in revenues before and after the war (survey Marine resources and coastal zone management program)

Monthly income (US$/fisherman) (A)	Average monthly income (US$/fisherman) (B)	Number fishermen		Average monthly income (US$)	
		Before hostilities (C)	After hostilities (D)	Before hostilities (E)	After hostilities (F)
Less than 200	100	100	163	10,000	16,300
200 - 400	300	74	30	22,200	9,000
401 - 666	500	16	4	8,000	2,000
667 - 2,000	1,300	5	0	6,500	0
More than 2,001	2,500	3	1	7,500	2,500
Average income				**54,200**	**29,800**
Loss in income due to hostilities and oil spill					**45%**

Sources: Data in (A), (C) and (D) are provided by University of Balamand, the Marine Resources and Coastal Zone Management Program, Interview with Dr. Manal Nader, April 2007. Data in (B) are average estimates based on (A). Own calculations: (E) = (B) * (C), (F) = (B)*(D).

Expected fish income	Share of total catch (%)	Seasonal income (million US$)	Monthly income (million US$)
- in Spring	30	9.1	3.0
- in Summer	42	12.9	4.3
- in Autumn	22	6.7	2.2
- in Winter	8	2.3	0.8
Total income	**100**	**31.0**	**10.3**

Commercial fishery	Value (min)	Value (max)	Notes
Expected annual income	31.0	31.0	
Forgone income due to the oil spill			% of expected income
- in 2006 (Sept-Dec)	1.7	1.7	50% of total forgone loss (ie 45% of total income during Sept Dec) is due to the oil spill
- in 2007	1.6	3.1	5-10% loss to oil spill
- in 2008	0.0	1.6	0-5% loss to oil spill
PV of forgone income due to oil spill (2006-2008)	**3.0**	**5.9**	

(8) SHORE-SIDE FISHERY

Number of anglers affected by oil spill	2600
Average catch (kg/angler/day)	2
Average price of fish ($/kg)	4
Number of days of angling (days/angler/year)	50
Consumption value of angled fish ($/year) (A)	1,040,000
Recreational value of angled fish ($/day)	10
Recreational value of angled fish ($/year) (B)	1,300,000
Total annual value of shore-side fishing ($/year) (A+B)	**2,340,000**

Expected fish income	**Share of total catch** (%)	**Seasonal income** (million US$)	**Monthly income** (million US$)
- in Spring	30	0.7	0.2
- in Summer	42	1.0	0.3
- in Autumn	22	0.5	0.2
- in Winter	8	0.2	0.1
Total income	**100**	**2.3**	**0.8**

Commercial fishery	**Min**	**Max**	**Notes**
Expected annual income (000 US$)	2,340.0	2,340.0	
Forgone income due to the oil spill			% of expected income
- in 2006 (Sept-Dec) (000 US$)	157.5	157.5	50% of total forgone loss (ie 45% of the income during Sept-Dec) is due to the oil spill
- in 2007 (000 US$)	117.0	234.0	5-10% of total income
- in 2008 (000 US$)	0.0	117.0	0-5% of total income
PV of forgone income due to oil spill (2006-2008)	**259.6**	**471.8**	
LOSSES TO SHORE-SIDE FISHING DUE TO OIL SPILL (million US$)	**0.3**	**0.5**	

(9) OIL SPILL CLEANUP

	Val (mil. $)
Expenses already made	14.9
Treatment of oiled waste	47.1
Monitoring expenses	1.5
Total cleanup cost	**63.5**

(9) SUMMARY OF DAMAGE AND CLEANUP COSTS (million US$)

	Min	**Max**	**Mean**
DAMAGE COSTS			
Hotels	22.8	59.6	41.2
Beach resorts, chalets, public beaches	13.2	34.8	24.0
Marinas sports activities	4.0	4.2	4.1
Palm Island Nature Reserve	0.7	1.2	1.0
Byblos	0.1	0.1	0.1
Restaurants	19.5	31.1	25.3
Commercial fishing	3.0	5.9	4.4
Sea-shore fishing	0.3	0.5	0.4
Cost of oil fuel burnt	39.1	39.1	39.1
TOTAL DAMAGE COSTS	**102.8**	**176.4**	**139.6**
OIL SPILL CLEANUP			
Expenses already made	14.9	14.9	14.9
Treatment of oiled waste	47.1	47.1	47.1
Future expenses	1.5	1.5	1.5
TOTAL CLEANUP COSTS	**63.5**	**63.5**	**63.5**
TOTAL COSTS DUE TO OIL SPILL	**166.3**	**239.9**	**203.1**

Annex 4 Demolion Waste Estimates

(1) Quantities of demolition waste generated in each region	
Beirut	1,430,000
South	3,320,000
Baalback-El Hermel	1,000,000
Total	**5,750,000**

Source: PMC, 2007

(2) Estimated cost of hauling and transport of C&D waste (in US$)

Description	*Rate*
Waste Hauling [a]	
Dozer charging rate [b] ($/day)	400
Filling capacity of 3 dozers [c] (Truck/day)	30
Daily volume of C&D waste loaded (m^3/day)	540
Cost of Loading each Truck per m^3 of DW ($/$m^3$)	**0.07**
Waste Transport	
Truck charging rate [b] ($/day)	250
Daily number of round trips	6
Loading capacity per truck (m^3)	18
Daily Volume of DW Transported per Truck (m^3/day)	108
Cost of Transport per m^3 of DW ($/$m^3$)	**2.31**
Total Unit Cost ($/$m^3$)	**2.38**
Cost in Beirut Southern Suburbs	3,409,000
Cost in the South	7,915,000
Cost in Baalbek El Hermel	2,384,000
Total Cost (US$)	**13,708,000**

[a] *Based on field surveys and expert opinion*
[b] *Including wage of driver*
[c] *Average number of dozers per site, based on field surveys and expert opinion*

(3) Estimated cost of road maintenance in Beirut

Description	*Rate*	
	Min	*Max*
Average road length (km)[a]	2	3
Average road width (m)[a]	6	8
Average road area (m^2)	12,000	24,000
Cost of road refurbishment (USD/ m^2)[a] 40 cm of compacted gravel 10 cm of asphalt	20	30
Total cost of road maintenance ($)	**240,000**	**720,000**

[a] *Based on field surveys, expert opinion, and GIS analysis*
[b] *Range accounts for degree of intervention and thickness damaged*

(4) Number of commuters and vehicles at the Southerm Entrance to Beirut

	Private passenger cars	*Private buses*	*Public buses*	*Taxis*	*Total*
Fraction of fleet	0.69	0.15	0.035	0.125	-
Number of vehicles	41,400	9,000	2,100	7,500	60,000
Vehicle occupancy	1.58	9.01	21.47	2.37	-
Number of passengers	65,412	81,090	45,087	17,775	209,364
Number of passengers going to work [a]					**115,150**

[a] *Around 55% of the trips are work-related*

(5) Estimated cost of traffic delays

Description	*Rate* Min	*Rate* Max
Average extra time spent in traffic (hr/day)[a]	2	2
Average hourly wage (USD/hr)[b]	2.5	2.5
Number of working days per month[c]	22	22
Fraction of lost productive time[a]	0.5	0.5
Duration of waste removal (months)	6	8
Lost wages (USD/ person)	330	440
Average daily number of affected commuters[d]	115,150	115,150
Total lost wages (USD)	38,000,000	51,000,000
Fuel consumption per hour spent in traffic (L/hr)[a]	1	1
Unit cost of fuel (USD/L)[a]	0.8	0.8
Cost of fuel spent per person per month (US$/month)	35.2	35.2
Number of affected vehicles[d]	60,000	60,000
Cost of gasoline spent per person per 6-8 months (USD/person)	211.2	281.6
Total cost of gasoline spent per 6-8 months (USD)	13,000,000	17,000,000
Total cost of traffic delay (USD)	**51,000,000**	**68,000,000**

[a] *Based on field surveys and expert opinion*
[b] *Based on a GDP of 5,300 USD/capita*
[c] *Peak travel delays are assumed to occur 22 days/month rather than 26 days/month*
[d] *Based on DMJM+HARRIS, 2003-Refer to Appendix B*

(6) Estimated cost of land for C&D waste disposal

Area	*Waste volume* (m^3)	*Landfill height* *(m)*	*Area of waste* (m^2)	*Landfill area* [a] (m^2)	*Unit cost of land* (USD/m^2)	*Cost of land* *(USD)*
Beirut	1,430,000	25	57,200	74,360	1,000	74,360,000
South	3,320,000	25	132,800	172,640	10	1,726,000
Baalbek	1,000,000	25	40,000	52,000	15	780,000

[a] *Based on a 30 percent buffer zone*

(7) Estimated total damage cost of C&D waste

Parameter	Damage cost (million $US) Beirut		South	Baalbek	Total	
Waste hauling and transport	3.4		7.9	2.4	13.7	
Road maintenance	0.2	0.72	-	-	0.2	0.72
Traffic delays	51.0	68	-	-	51.0	68
Land for disposal	74.4		1.7	0.8	76.9	
Land depreciation	-		-	-	-	
Total	129.0	146.5	9.6	3.2	**142**	**159**

Annex 4 Unexploded Ordnances Estimates

(1) Estimation of projected number of casualties

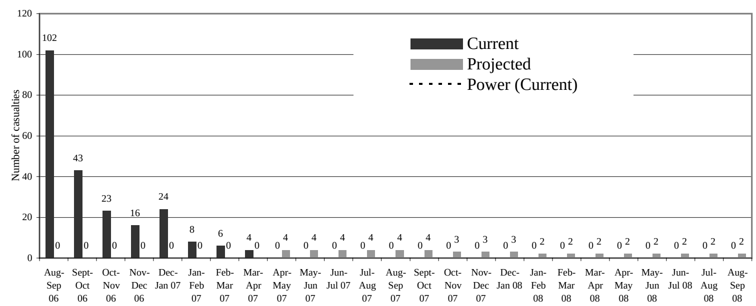
Month	*Number of casualties*	
	Actual	*Projected*
Aug-Sep 06	102	
Sept-Oct 06	43	
Oct-Nov 06	23	
Nov-Dec 06	16	
Dec-Jan 07	24	
Jan-Feb 07	8	
Feb-Mar 07	6	
Mar-Apr 07	4	
Apr-May 07		4
May-Jun 07		4
Jun-Jul 07		4
Jul-Aug 07		4
Aug-Sep 07		4
Sept-Oct 07		4
Oct-Nov 07		3
Nov-Dec 07		3
Dec-Jan 08		3
Jan-Feb 08		2
Feb-Mar 08		2
Mar-Apr 08		2
Apr-May 08		2
May-Jun 08		2
Jun-Jul 08		2
Jul-Aug 08		2
Aug-Sep 08		2
Subtotal	**224**	**51**
Total		**275**

(2) Distribution of projected casualties by age & type

Age group	*Current nb of casualties*	*Ratio of distribution by age*	*Projected nb*
	MORTALITY		
0-12	2	0.009	2
13-18	4	0.018	5
19+	23	0.103	28
SubTotal	**29**	**0.129**	**36**
	MORBIDITY		
0-12	24	0.107	29
13-18	39	0.174	48
19+	132	0.589	162
SubTotal	**195**	**0.871**	**239**
Total	**224**	**1**	**275**

[a] Based on the assumption

distribution as the current numbers



(3) Estimated damage costs of UXOs

Age group	*Current number of*	*Current and projected*	*DALYs/ per case* [b]	*DALY* [c] *($ VSL)* *Min*	*Max*	*Current & projected economic loss* **(million** *$/ age* *Min*	*Max*
			MORTALITY				
0-12	2	2.5	33	5,300	42,000	0.43	3.40
13-18	4	4.9	36	5,300	42,000	0.94	7.43
19+	23	28.2	20	5,300	42,000	2.99	23.72
SubTotal	**29**	**35.6**				**4.36**	**34.55**
			MORBIDITY				
0-12	24	29.5	9.9	5,300	42,000	1.55	12.25
13-18	39	47.9	10.8	5,300	42,000	2.74	21.72
19+	132	162.1	6.0	5,300	42,000	5.15	40.84
SubTotal	**195**	**239.4**				**9.44**	**74.81**
Total	**224**	**275.0**				**13.80**	**109.35**

[a] *MACCL, 2007b* [b] *Murray and Lopez, 1996* [c] *Lebanon economic data 2004/2005*

(4) Estimation of forgone agricultural production in the South and Nabatiyeh per year

Crop type	*Cultivated area (du)* [a] *South*	*Nabatiye*	*Total*	*'roduction rate (Tonne/du)*	*Total production (Tonnes)*	*Value* [b] *(USD/tonne)*	*Total value (USD)*
Cereals	37,638	59,525	97,163	0.28	26,781	297	7,965,069
Legumes	2,096	5,869	7,966	0.54	4,270	565	2,413,839
Fruit trees	123,304	20,768	144,073	1.26	181,973	746	135,786,268
Olives	89,340	116,124	205,464	0.29	58,759	1,268	74,525,973
Oleaginous tre	5,806	3,836	9,642	0.10	931	2,083	1,939,556
Vegetables	20,753	12,141	32,894	3.19	104,871	251	26,276,441
Raw tobacco	14,625	40,026	54,652	0.12	6,395	2,988	19,110,223
Total							**268,017,000**

Scenario 1:	Percentage of the agricultural area that will not be accessible for a year =	**0.05**	**13,401,000**
Scenario 2:	Percentage of the agricultural area that will not be accessible for a year =	**0.10**	**26,802,000**
Scenario 3:	Percentage of the agricultural area that will not be accessible for a year =	**0.25**	**67,004,000**

	Min	*Max*
Total agricultural loss during the first year (10-25%) in million	**27**	**67**
Total agricultural loss during the second year (5-10%) in million	**13**	**27**
Total agricultural loss over a period of two years (in US$ million)	**40**	**94**

[a] *Based on the agricultural census of the Ministry of Agriculture (MoA) in 1999*

[b] *Deduced from the MoA Production Statistics for the year 2004*

(5) Total Estimated Damage Cost by UXOs

Parameter	*Damage cost (million US$)* *Min*	*Max*
Casualties	13.8	109.4
Agriculture	40.2	93.8
Demining	11.0	11.0
Total	**65.0**	**214.2**

Annex 4 Medical Waste and Total Waste Estimates

Estimated cost of Medical Waste Sterilization and Landfilling

Description	*Unit*	*Rate*	
		Min	*Max*
Generated infectious waste quantities	tonnes	200	250
Unit cost of sterilization	US$/tonne	60	60
Total cost of sterilization	US$	**12,000**	**15,000**
Unit cost of landfilling	US$/tonne	15	120
Total cost of landfilling	US$	**3,000**	**30,000**
Total cost of medical waste management		**15,000**	**45,000**

Total Estimated Damage Costs

Parameter	*Damage cost (million US$)*	
	Min	*Max*
Construction and Demolition Waste	141.8	159.3
Military Waste (UXO)	65.0	214.2
Medical Waste	0.02	0.05
Total	**207**	**373**

Annex 4 Water Estimtates

(1) Additional costs of getting water during Sept-Dec (82,900 people gradually served during 4 months)	Sept	Oct	Nov	Dec	TOTAL
Population affected by shortage of water	83,000	62,000	41,000	21,000	…
Cost of bottled water ($/liter)	0.7	0.7	0.7	0.7	…
Cost of water from water tanks ($/liter)	0.06	0.06	0.06	0.06	…
Number of days of reliance on other water alternatives (days)	30	31	30	31	…
Total cost of drinking water*	193,000	149,000	95,000	50,000	487,000
Total cost of water for other household uses*	11,300,000	8,700,000	5,600,000	3,000,000	28,600,000
Total cost of water if hostilities had not occurred*	120,000	92,000	59,000	31,000	302,000
Additional cost of water due to hostilities	**11,400,000**	**8,800,000**	**5,600,000**	**3,000,000**	**28,800,000**

* it captures only 50% of daily water consumption, e.g. 0.5 liter/day of drinking water and 79.5 liters/day for other household uses

(2) Additional costs of getting water during Sept-Dec 2006 (62,100 people short of water) and Jan-Dec 2007 (62,100 gradually served)	Sep-Dec	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec	TOTAL
Population affected by shortage of water	62,100	62,100	46,575	31,050	15,525	
Cost of bottled water ($/liter)	0.7	0.7	0.7	0.7	0.7	
Cost of water from water tanks ($/liter)	0.06	0.1	0.1	0.1	0.1	
Number of days of reliance on other water alternatives (days)	122	89	92	92	92	
Total cost of drinking water*	585,893	427,414	331,366	220,910	0	
Total cost of water for other household uses*	34,417,594	25,107,917	19,465,689	12,977,126	6,488,563	
Total cost of water if hostilities had not occurred*	363,658	265,291	205,675	137,117	68,558	
Additional cost of water due to hostilities	**34,600,000**	**25,300,000**	**19,600,000**	**13,100,000**	**6,400,000**	**64,400,000**

* it captures only 50% of daily water consumption, e.g. 0.5 liter/day of drinking water and 79.5 liters/day for other household uses

(3) Additional costs of getting water during Sept 2006-May 2007 (5,000 people short of water) and Jun 2007 (5000 people served)	Sept-May
Population affected by shortage of water	5000
Cost of bottled water ($/liter)	0.7
Cost of water from water tanks ($/liter)	0.06
Number of days of reliance on other water alternatives (days)	273
Total cost of drinking water*	105,560
Total cost of water for other household uses*	6,201,000
Total cost of water if hostilities had not occurred*	65,520
Additional cost of water due to hostilities	**6,200,000**

water and 79.5 liters/day for other household uses

(4) Cost of repairing water infrastructure	**32,000,000**

TOTAL COST CAUSED BY WATER SHORTAGE (mil	**131**

Annex 4 Quarry Estimates

(1) Real Estate Prices per Mohafazah (US$/m2) in 2006

MT Lebanon	land ($/m2)	Apts ($/m2)
Baabda	532	740
Haret Sett	148	429
Jamhour	445	593
Loueize	256	525
Sibney	109	474
Abadie	90	638
Aley	190	829
Araya	62	593
Baalechmay	119	708
Besseine	21	385
Bhamdoun El Da	72	575
Bhamdoun El Ml	165	725
Bkhechtay	24	513
Btater	25	363
Chanai	57	513
Kahale	77	618
Mansourieh Ain	30	413
Aanout	27	325
Ain Zehalta	25	325
Al Jmaileh	41	350
Al Mghaireh	37	325
Baakline	224	450
Barja	72	400
Batloun	14	313
Beiteddine	27	350
Brih	13	300
Chhim	46	365
Damour	29	350
Deir Dourit	85	450
Deir El Qamar	225	450
El- Barouk	29	375
Fraidis	14	313
Hasrout	23	338
Jiyeh	178	383
Ketermaya	48	365
Kfarhim	111	500
Kfar Nabrakh	18	313
Kfar Qatra	303	450
Maaser Beiteddir	122	475
Mazboud	46	365
Mechref	121	613
Naameh	211	430
Saadiyat	202	425
Sibline	57	375
Amchit	169	705
Blat	53	396
Halat	227	775
Jbeil	251	822
Mastita	43	392
Ashkout	79	500
Faraya	83	725
Feytroun	62	488
Ghadir	392	503
Hrajel	86	
Kfarhbab (Ghazi	299	617
Mazraat Kfardeb	141	500
Reyfoun	142	563
Sahel Alma	368	675
Sarba	525	842
Zouk Mikael	485	710
Zouk Mosbeh	375	478
Ain Saadé	219	602
Aintoura	77	450
Al Ayroun	82	433

MT Lebanon	land ($/m2)	Apts ($/m2)
Amaret Chalhoul	1,238	656
Antelias	1,406	653
Baushrieh	787	569
Bikfaya	181	525
Bois de Boulogn	135	450
Dbayeh	100	508
Dekwaneh	1,320	640
Dora	750	592
Dhour Shoueir	1,033	574
Fanar	133	467
Furn El Shebbak	212	636
Jal-El-Dib	671	693
Jdeideh	1,387	603
Mansourieh	1,125	
Mkalles	497	575
Mrouj	119	433
Tarshish	60	413
Zalka	1,440	623
AVERAGE	**139**	**496**

THE BEKAA	land ($/m2)	Apts ($/m2)
Ain Bourday	9	312
Baalbek	70	402
Bednayel	7	267
Brital	4	233
Chmestar	8	292
Douris	8	305
Iaat	6	267
Makne	7	200
Nahle	5	238
Al Mraijat	67	325
Jalala	113	333
Jdita	110	300
Makseh	67	308
Shtaura	176	346
Taanayel	102	315
AVERAGE	**51**	**296**

THE SOUTH	land ($/m2)	Apts ($/m2)
Abra	210	419
Bramieh	190	373
Dakermane	187	373
Helalieh	286	443
Madinet Saida	449	507
Wastani	220	364
Abbassieh Road	607	876
Mina area	361	707
Rachidiyeh road	118	501
AVERAGE	292	507
AVERAGE	**292**	**507**

THE NORTH	land ($/m2)	Apts ($/m2)
Beit El Haj	10	
Bquerzla	12	
Cheikh Tabba	16	288
Halba	34	342
Miniara	16	
Sheikh Mohamac	10	
Sheikh Taba	11	
Aabrine	40	383
Bejdarfel	57	800
Hamate	60	667
Ijdabra	27	350
Kfaraabida	101	1,133
Rashana	44	635
Thoum	39	613
Bazoun	15	
Bkerkacha	14	
Bsharri	45	530
Diman	20	
Hadchit	21	
Hasroun	34	480
Amioun	100	519
Bechmezzine	69	467
Bziza	49	425
Kfarhazire	66	467
Kousba	101	550
Abou Samra	248	530
Azmi	1,157	712
Beddawi Road	473	535
Fouad Chehab	950	637
Kalaa	185	530
Kobbe	90	500
Maarad	1,183	792
Mina	735	617
Nouri	68	550
Tell	1,020	675
Aitou	20	300
Ehden	77	488
Ejbaa	24	313
Kfardlaqous	25	325
Rachaaine	37	363
Zghorta	59	388
AVERAGE	**179**	**528**

Reference: http://www.opportunities.com.lb/Lebanon/RealEstate/RealEstateRef_OUTSIDE.asp

Annex 4 Quarry Estimates

(2) Impact of (a) quarry operation and (b) the non rehabilitation of quarries on land and apartment value

Quarry 1 Nahr Ibrahim (Impact during operation)		*Reference*
Estimated quarry area (m^2)	96,830	*MOE, 2007*
Estimated excavated volume (m^3)*	4,115,000	
Land area affected by the quarry (m^2)	2,000,000	*Sarraf et al, 2004*
Decline in Land price (US$/m2) in 2002	7.0	*Sarraf et al, 2004*
Decline in Land price (US$/m2) in 2006	8.2	*Consumer Price Inflation (EIU, 2006)*
Total decline in land price 2006	16,400,557	
*Decline in **land** price $/ m3*	**4.0**	
Quarry 2 Shnanaayer (Impact after closure)		
Estimated quarry area (m^2) in 2 locations[a]	48,370	*MOE, 2007*
Estimated excavated volume (m^3)*	2,056,000	
Land Area affected by the quarry (m2)	600,000	
Decline in Land price (US$/m2) in 2002	125	
Decline in Land price (US$/m2) in 2006	146	*Consumer Price Inflation (EIU, 2006)*
Total decline in land price 2006	87,860,125	
*Decline in **land** price $ / m3*	**43**	
Apartments affected by quarry (m2)	36,000	
Decline in apartment price (US$/m2) in 2002	225	
Decline in apartment price (US$/m2) in 2006	264	*Consumer Price Inflation (EIU, 2006)*
Total decline in apartment value 2006	9,488,894	
*Decline in **apartment** value $/m3*	**5**	
Quarry 3 Abu Mizan (Impact after closure)		
Estimated quarry area (m^2) in 3 location	276,930	*MOE, 2007*
Estimated excavated volume (m^3)*	11,769,525	
Land Area affected by the quarry (m2)	175,000	
Decline in Land price (US$/m2) in 2002	8	
Decline in Land price (US$/m2) in 2006	9	*Consumer Price Inflation (EIU, 2006)*
Total decline in land price 2006	1,537,552	
*Decline in **land** prince $/m3*	**0.13**	
Quarry 4 Antelias (Impact after closure)		
Estimated quarry area (m^2) in 1 location	51,577	*MOE, 2007*
Estimated excavated volume (m^3)*	2,192,000	
Land Area affected by the quarry (m2)	100,000	
Decline in Land price (US$/m2) in 2002	50	
Decline in Land price (US$/m2) in 2006	59	*Consumer Price Inflation (EIU, 2006)*
Total decline in land price 2006	5,857,342	
*Decline in **land** prince /m3*	**3**	
Apartments affected by quarry (m2)	7,500	
Decline in apartment price (US$/m2) in 2002	100	
Decline in apartment price (US$/m2) in 2006	117	*Consumer Price Inflation (EIU, 2006)*
Total decline in apartment value 2006	878,601	
*Decline in **apartment** value /m3*		**0.40**

** This estimate is based on a approximate height of exaction (face cut) of about 100m multiplied by the approximate quarry area and devided by 2 (to account for mountain slope)*

Annex 4 Quarry Estimates

(3) Estimate of Aggregate and Sand (in m^3)

				Reference
Beirut				***Reference***
Demolition waste generated		1,430,000		Council of Ministers, 2007
Off wich **aggregate** and sand (35 - 50%)	501,000		715,000	UNDP, 2007
Off wich concrete (35 - 50%)	501,000		715,000	UNDP, 2007
Equivalent in **aggregate** (1m^3 of concrete contains 0.71 m^3 aggregate)	356,000		508,000	UNDP, 2007
sub total aggregate and sand	*857,000*		*1,223,000*	
South and Bekaa				
Demolition waste generated		4,320,000		*Reference*
Off wich **aggregate** and sand (30 - 40%)	1,296,000		1,728,000	Council of Ministers, 2007
Off wich concrete (40 - 60%)	1,728,000		2,592,000	UNDP, 2007
Equivalent in **aggregate** (1m^3 of concrete contains 0.71 m^3 aggregate)	1,227,000		1,840,000	UNDP, 2007
sub total aggregate and sand	*2,523,000*		*3,568,000*	UNDP, 2007
sub total aggregate and sand from demolition waste		4,086,000		
total demand in aggregate and sand from quarry (knowing that there is about 15% los of raw material at the quarry)		**4,700,000**		El Fadel, 2007

(4) Estimated distribution of quarry operation after the war

Mohafazah	Percentage*	Estimated distribution of needed Aggregate
South & Nabatieh	32%	1,494,000
North & Akkar	24%	1,105,000
Bekaa & Baalbak Hermel	31%	1,447,000
Mount Lebanon	14%	654,000
	100%	**4,700,000**

**This distribution is based on the actual distribution of quarry permits (or administrative extention) issued between January and May 2007 (Ref MOE, 2007)*

(5) Relative price of land and real estate per Mohafazah in 2006

Mohafazah	Relative price of **Land** (compared to Mt Lebanon)*	Relative price of **Apts** (compared to Mt Lebanon)
South & Nabatieh	2.09	1.02
North& Akkar	1.29	1.06
Bekaa & Baalback Hermel	0.36	0.60
Mount Lebanon	1.00	1.00

** data for 2006 (Lebanon Opportunities www.opportunities.com.lb) see detailed table below*

(6) Estimated Impact of Quarrying Activity per Mohafazah in 2006

South & Nabatieh	min	max	average
Needed aggregate (million m^3)			1.5
Impact during quarrying operation on land price (million US$)			12.5
Impact of non rehabilitating quarries on land price (million US$)	0.4	133.7	67.0
Impact of non rehabilitating quarries on apts price (million US$)	0.6	7.0	3.8
Sub Total			***83.3***
North & Akkar			
Needed aggregate (m^3)			1.1
Impact during quarrying operation on land price (million US$)			5.7
Impact of non rehabilitating quarries on land price (million US$)	0.2	60.8	30.5
Impact of non rehabilitating quarries on apts price (million US$)	0.5	5.4	2.9
Sub Total			***39.1***
Bekaa & Baalback Hermel			
Needed aggregate (m^3)			1.4
Impact during quarrying operation on land price (million US$)			2.1
Impact of non rehabilitating quarries on land price (million US$)	0.1	22.4	11.2
Impact of non rehabilitating quarries on apts price (million US$)	0.3	4.0	2.2
Sub Total			***15.5***
Mount Lebanon			
Needed aggregate (m3)			0.7
Impact during quarrying operation on land price (million US$)			2.6
Impact of non rehabilitating quarries on land price (million US$)	0.1	27.9	14.0
Impact of non rehabilitating quarries on apts price (million US$)	0.3	3.0	1.6
Sub Total			***18.3***
TOTAL (million US$)	**25**	**287**	**156.2**