GREEN CASUALTIES OF WAR

The need for international protection of the environment during armed conflicts and the case of the war between Israel and Lebanon in 2006

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The powerful are entitled to do as they wish,
while the weak suffer as they must.

Thucydides

Abstract

If we consider the environment as a precondition for the survival of the human system (Costanza et al. 1997 A), and recognizing the "right to life, liberty and security of person" (Universal Declaration of Human Rights, Art.3) as a fundamental right for each individual, therefore our priority should be the protection of natural resources against harmful anthropogenic actions. This need becomes even more critical in times of war which, as history has sadly thought us, "is inherently destructive of sustainable development" (Stockholm Declaration, Principle 24). Given this premise, the research questions that drive the whole dissertation aim at revealing whether the existing norms of International Humanitarian Law (IHL) are enough to protect the environment during wartime. If not, what would be the consequences of non-compliance with IHL on the ecological functions of the ecosystems, and what would be the implications for the sustainable development of the countries affected? The aim of this work is to answer these questions using the case study of the recent war between Lebanon and Israel as an illustration of the destructive potential that methods and means of warfare in use in the world's arsenals today have on the environment (Bouvier 1991).

Firstly, the overall damage occurred to the Lebanese already weak natural capital, in just 34 days of hostilities, is described in qualitative terms. The method applied is a qualitative text analysis that draws on the principal scientific reports published after the conflict. Afterwards, the analysis focuses on the damages occurred to the Lebanese marine and coastal ecosystem. An interpretative study (Mikkelsen, 2005:125) is undertaken through qualitative semi-open conversations with key informants aiming at establishing the most relevant aspects to explore. Thereafter, two complementary approaches are adopted to assess quantitatively the magnitude and the typology of harm. Using Costanza's taxonomy of ecosystem functions (Costanza et al. 1997 B, see Appendix 1), as a first step in the assessment, the principal functions provided by this specific environment are identified. After that, a biophysical evaluation of the impairments occurred is carried out. The third step is to assess the cost associated to the losses occurred, in terms of ecological services and goods impaired. A review of the quantitative methods proposed by ecological economics to measure natural capital was undertaken with the purpose of finding the best system to apply to this case. However, it resulted in an impossibility of applying the classical methods and the consequent need to configure new ways of proceeding. They will be explained in details in Chapter 5. The assessment of the ecological loss in monetary terms, equal to 0,24-1% of GDP, does not pretend to be exhaustive. Indeed the intention is to give an immediate insight of the damage occurred. That is why the qualitative description provided must be considered at the same time, in order to place this loss within the much broader harm borne by the Lebanese natural capital.

The overall methodological framework applied is a systems analysis on a case study that combines the disciplines of international law and international relations, with economics and natural science, to understand the complex concatenation of effects that can occur as a consequence of unpunished warfare acts against the environment.

What emerges from this study is that compliance to the extensive rules put forth by IHL is extremely poor. This results in enormous damages to the ecosystems, whose restoration can in the best scenario cost a lot of money or otherwise be impossible. The outcomes have not only direct economic consequences, but as the case study shows, they can indeed impair the whole process of sustainable development and the recovery of the victim country. More detailed reflections on the findings of the case study will be given in the chapter 5 and 6.

Keywords*: natural capital, ecosystem functions, International Humanitarian Law, sustainable development.*

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LIST OF ABBREVIATIONS

AUB	American University of Beirut
CNRS	National Council for Scientific Research Lebanon
Chl *a*	Chlorophyll *a*
CO	Carbon monoxide
CO2	Carbon dioxide
EPA	Environmental Protection Agency
ESCWA	United Nation Economic and Social Commission for Western Asia
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
ICRC	International Committee of the Red Cross
IDF	Israeli Defence Force
IHL	International Humanitarian Law
IMF	International Monetary Fund
IOC	International Oceanographic Commission
LP	Lebanese Pound
MAP	Mediterranean Action Plan
MEDASSET	Mediterranean Association to Save the Sae Turtles
MoA	Ministry of Agriculture of Lebanon
MoE	Ministry of Environment of Lebanon
MoT	Ministry of Tourism of Lebanon
NO_X	Nitrogen Oxide
PAH	Polycyclic Aromatic Hydrocarbons
ppm	Parts per million
ROPME	Regional Organization for the Protection of the Marine Environment
SER	Society for Ecological Restoration
SO2	Sulphur Dioxide
UN	United Nations
UNCC	United Nation Commission for Compensation
UNDP	United Nation Development Program
UNEP	United Nation Environment Program
UNESCO	United Nation Educational, Scientific and Cultural Organization
UNIFIL	United Nations Interim Force in Lebanon
UNSAID	United States Agency of International Development
USJ	Saint-Joseph University of Beirut
UXO	Unexploded Ordinance
VOC	Volatile Organic Compound
WB	World Bank
WHO	World Health Organization
WTA	Willingness to Accept
WTP	Willingness to Pay
µg/kg	Microgram per kilogram
µg/kg d.w.	Microgram per kilogram of dry weight
µg/kg w.w.	Microgram per kilogram of wet weight

CURRENCY AND EQUIVALENTS

Currency Unit used in the whole dissertation= 2006 US $
1 US $ = 1.500 Lebanese Pounds

CHAPTER 1: INTRODUCTION

In 1948 the General Assembly of the United Nations adopted the Universal Declaration of Human Rights, recognizing inherent dignity and equal and inalienable rights of all members of the human family as the foundation of freedom, justice and peace in the world (Preamble, Universal Declaration of Human Rights). At the very beginning it states:

"Everyone has the right to life, liberty and security of person." (Art.3)

But guaranteeing the right to live implies as well to ensure all the conditions needed in order to live. In fact, if we continue reading the UN document, we encounter a number of other rights which characterize the type of life ensured to all human beings. Article 22 claims the right to social security and personal realization; then we read the right to work and to a free choice of employment (Art.23); the right to rest and leisure (Art.24); the right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing and medical care (Art.25); the right to education, which shall be free and directed to the full development of the human personality (Art.26). As it becomes clear, the concept of life undergoes a wide interpretation, which implies aspects that go beyond the simple idea of surviving. Nature, to this extent, is a fundamental element to guarantee the continuity of all the dimensions of life in the future. As the Secretary General of the United Nations said in 1994, "without protection of the environment, the basis of human survival will be eroded" (quoted in Turner 2004). In fact, without clean air, fresh water, productive land, and in general without the availability of natural resources all the rights stated in this universal document are very hardly achievable. The same concept has found, later, a clear reconfirmation in the Stockholm Declaration[1], and it has also been upheld by different authors[2].

Thus, in this work the environment and the ecological functions granted by it are considered as preconditions for the surviving of the human system. The neoclassical economists perspective that technological advances could outpace the scarcity of natural resources, and in this way the implicit justification of their unsustainable exploitation, it is here rejected using the ecological economists arguments. These can be presented through four main principles which state the shift with the neoclassical paradigm (Costanza R. et al. 1997 A). They are indeed crucial, as we will see below, for my claims:

- the vision of the earth as a thermodynamically closed system, where the human system (and thereby the economic system) is a subsystem limited in its growth by the constrains posed by the global system;
- the belief in the possibility of a sustainable development (which differs from economic growth) for all citizens within the material constrains posed by the Earth;
- the recognition that in the study of certain complex and largely unknown systems, such as the ecological systems, uncertainty is wide and certain processes are irreversible. This implies taking a precautionary stance towards them;
- the claim that, given all these features, institutions and management should be proactive rather than reactive, and based on a systemic understanding of the connections between the different aspects contributing to life.

1.1 AIMS AND RESEARCH QUESTIONS

Given the theories briefly exposed, my aim is to contribute to the already existing discourse on the need for specific protection of natural resources during armed conflicts. This will be done by presenting new evidences of such a necessity obtained from a real case study.

The belief that "warfare is inherently destructive of sustainable development" (Stockholm Declaration, Principle 24) is stated in many international documents[3], and the evidences of the environment being seriously harmed in such situations belong to our historical background as citizens. Moreover, in my case this awareness has been magnified by the personal experience I had in Lebanon in July 2006, at the outbreak of the conflict with Israel. Therefore an analysis of the damages occurred to the Lebanese environment due to the Israeli attacks is carried out as the umpteenth example of the destructive potential that methods and means of warfare in use in the world's arsenals today have on the environment (Bouvier 1991). The biophysical description and the monetary evaluation of the losses occurred in just one month of hostilities

[1] Declaration of the United Nations Conference on the Human Environment (1972), Principle 1: "Both aspects of man's environment, the natural and the man-made, are essential to his well-being and to the enjoyment of basic human rights the right to life itself".
[2] See for instance Shari Collins-Chobanian 2000 and Turner 2004.
[3] For a more detailed description see Chapter 2.

will be the core proof of my argument. To comply with this aim, the idea was to take the ecological economic concept of *Natural Capital*, defined as the stock that yields a sustainable flow of valuable goods and services from the ecosystems into the future (Costanza and Daly 1992, Costanza et al. 1997 A), and apply it to calculate the losses occurred to Lebanon. However, problems have risen during the concrete implementation of the analysis in a complex reality as the Lebanese's. In fact the concept presents ambiguities, mostly concerning the division between the actual stock of capital and the rate of return generated by it, and the process of monetarization of such resources. Therefore, during the evaluation process described in Chapter 5, natural capital was measured when possible. In those cases when the concept was too complex to apply, it has been accounted instead for the loss in terms of goods and services provided. These aspects will be indeed discussed in the conclusions of the thesis.

International Humanitarian Law (IHL) is the discipline that seeks to limit the effects of armed conflicts on human beings and their assets, since during wartime sovereign States are usually involved. Though, compliance to these rules is proved to be extremely poor[4]. Against those who maintain that "the principle that States […] are under the responsibility to ensure that their activities do not cause environmental destruction or degradation on a scale that threatens fundamental human rights has satisfied all the requisites of an accepted rule of customary international law" (McCallion and Sharma 2000:353)[5], this thesis will bring evidences of the environment being seriously damaged during armed conflicts and the impunity that such wrongful warfare strategies still undergo.

Hence, the research questions that driven my work are:

1) Are IHL rules enough to limit sovereign States' actions during armed conflicts and thereby to protect a vital asset as natural capital?

2) Which are the weak points, and where is there space for action?

3) What are the consequences of a weak compliance to IHL in terms of ecological services and goods provided by the ecosystems, and which are therefore the implications for the sustainable development of the whole country?

4) What is the environmental degradation borne by Lebanon as a consequence of the war with Israel, and which could be its monetary value?

1.2 THESIS RATIONAL AND METHODOLOGICAL APPROACH

My thesis finds its rational in the actual debate on the need of reforming IHL to ensure a better and more efficient protection of the environment in warfare situations. In fact, this issue suddenly assumed new urgency during the conflict that set the Middle East ablaze in 1990-1991. In those days experts of humanitarian law and environmental conservation raised a very lively discussion on the content and scope of and on possible shortcomings in the available international laws for the protection of the environment in time of armed conflict[6].

Starting from this background, and referring to the existing literature for an in-depth review of the existing customary rules, treaty provisions and general principles of IHL (Chapter 2) which are to protect the environment in time of armed conflict, my argument is corroborated by the findings obtained from a case study, adopted as main research method. The analysis of the recent conflict between Israel and Lebanon has therefore a double meaning (Yin 2003): descriptive (to answer to the first two research questions) and exploratory (to answer the other two).

Facts and evidences of the magnitude of the damage borne by the Lebanon's already fragile environment in just 34 days of hostilities with Israel are provided in qualitative and quantitative terms. Chapter 3 aims, thought a qualitative text analysis that draws on the principal scientific reports published after the conflict, a providing the general picture of what happened to different ecosystems, as well as to the economic sub-systems of the country. Given these evidences, the focus is placed on the impairments occurred to the Lebanese marine and coastal ecosystem (Chapter 4 and 5). The damages have been mainly

[4] The International Committee of the Red Cross (ICRC) has published numerous reports denouncing such problems. See principally the Biennial Reports on the national implementation of IHL, available on www.icrc.org

[5] On the same line of reasoning see John Lee 2000.

[6] A very interesting initiative was taken in London, on 3rd of June 1991, under the auspices of the London School of Economics and the Centre for Defence Studies and Greenpeace International, to assess the need for a fifth Geneva Convention. However, the suggested solution were did not find strong backing (Gasser 1995).

caused by an oil spill of dimensions comparable to the Erika's one (12/12/1999, 80 miles off south Finistere in Brittany, France), caused by two consecutive Israeli air strikes on the 13th and 15th July. An interpretative study (Mikkelsen, 2005:125) is undertaken through qualitative semi-open conversations with key informants on different aspects of the oil spill, in order to establish the most relevant issues to explore. The approach to the whole analysis draws from a systemic theory of science (Costanza et al. 1997 A), since it is considered essential to adopt simultaneously different disciplines in order to understand the complexity of a single issue. In this case, sharing with ecological economics theory the denial of the reductionist approach to nature (Costanza et al. 1997), natural science and economics are used together to assess and describe the damage occurred to the Lebanese natural capital. International law is then the framework in which the whole discourse is placed. Thus, the concept of sustainability, as it is evident in the introductory part, is applied to motivate and to analyse the post conflict situation that came to be.

Thus, Chapter 4 presents a biophysical evaluation of the impairments occurred to the marine and coastal ecosystem as a direct consequence of the oil slick. The evaluation of the damages occurred is presented in terms of: (a) effects on primary production, (b) polycyclic aromatic hydrocarbons (PAHs) level in quantitative bio-indicators, (c) PAHs contamination in natural bio-indicators and in fish muscles, (d) sediment contamination, (e) effects on biodiversity.

In Chapter 5 then, a cost assessment of the losses occurred is carried out, and the functional approach proposed by de Groot (in Faber et al. 2002 and De Groot 1994) is applied. Therefore, as a first step the principal functions provided by this specific environment are identified. Costanza's taxonomy (Costanza et al. 1997 B, see Appendix 1) is used as main reference. Then the cost associated with the losses and the damages previously identified and described scientifically is estimated. A review of the quantitative methods proposed by ecological economics to measure natural capital was carried out with the aim of finding the most appropriate technique, but, in most of the cases they resulted too complex to be used. Therefore peculiar accounting methodologies had to be established, in order to respond to the characteristics and the needs of the Lebanese case. The result is a value that includes both ecological services and goods lost to the oil contamination and the portion of natural capital harmed that could be evaluated. This is by no means a real and comprehensive figure of the losses, but indeed it only aims at giving an immediate picture of the damage occurred, and in this way showing the urgency of the interventions proposed. In fact, the belief is that these concrete insights can be a powerful argument to support the main claim of the dissertation. Ecosystem service valuation in fact, as Munda claims (quoted in Cheen 2004), is being developed as a means of putting natural capital into the equation of economic 'development' and on the agenda of policy-making. This is also the rational behind my choice.

Thus, the two chapters (4 and 5) must be seen in their complementariness. Scientific findings and economic estimations both strive toward the same goal, that is to demonstrate the need of international protection of the environment during armed conflicts.

To give a meaning to the numbers presented, they are often compared with other cases or with reference values. Lebanese GDP always refer to the estimations of the Ministry of Economy and Trade for 2002 (Ministry of Economy and Trade 2005).

1.3 MATERIAL AND DATA AVAILABILITY

Material and sources used in the different sections of the analysis will be described and substantiated in the relative chapter. However, it must be mentioned here that, sometimes official data was not available and therefore proxies and estimations were used instead.

Triangulation of sources (Yin 2003) has been a practice frequently used for the sake of reliability of my case study. This means that facts emerging from communication with key informants, or values estimated with the methodologies mentioned above, have been confronted with and presented to different subjects involved in the issue, in order to find corroboration for them. This process was usually reiterated until the point of saturation had been reached.

A positive aspect that should be mentioned concerning data collection is the positive and enlightening "snowball effect" obtained during the interpretative study carried on at the very beginning of the field work, before designing the case study analysis. Due probably to the peculiar social and cultural background of Lebanon, the establishment of the first contacts enabled me to easily create new significant contacts, and in

few weeks I had built a solid networks of direct sources of information that helped me during the successive steps of the research.

Concerning the description of the overall environmental damage occurred to the Lebanese natural capital, material and information come mainly from secondary sources, except when I went personally to visit the hot spots of contamination, i.e. Jbeil port, Batroun shores and sea, Jounie coast (see Fig.6). in the first case, a careful review of the numerous documents and reports published have been carried out. In fact, given the urgency of the situation faced at the end of the war, and given the scale of the impacts on the already weak Lebanese economy, many entities have initiated survey and assessments. Moreover, the Lebanese Government officially requested the assistance of UN Agencies and many research institutes to conduct damage assessments in the different sectors of the economy.

1.4 LIMITATIONS

The limitations of this case study are below divided according to the principal issues of concern.

Theory: the main limitation to this extent derives from the anthropocentric and utilitarian ethical framework which is dominant in neoclassical economic theory, and that ecological economists have adopted as well. Therefore, the process of placing a monetary value of environmental degradation, as presented in the methodology paragraph, face to the same limitations. That is, an ecological service or good has economic value only if people consider it desirable and are willing to pay for it (Chee 2004). The ecological approach to nature criticizes this stand, affirming that natural resources have also an intrinsic value which is not captured in consumers preferences. Moreover, we do not have a complete knowledge on how nature works, nor of all the services actually provided by it. Hence, any cost assessment will eventually produce an underestimation of the real value. This is also the case of the results proposed in Chapter 5. More limitations regarding the theoretical framework applied in order to put a price on natural resources regard the model of the 'rational actor', or *homo economicus* as the neoclassical economists originally defined it, which explains individual behaviours and choices, and are discussed by Chee in his article (bid.). Indeed, all of the previous drawback are acknowledged by this paper. That is why the economic loss deriving from the oil spill, as presented in conclusion of Chapter 5, it does not have a normative meaning, but only aims it to give an insight of the magnitude of what occurred to Lebanon. Finally, another limitation involves the shortcomings presented in the concept of natural capital. For this reason the ultimate assessment of the cost of environmental degradation due to the oil spill includes both the value of natural capital degradation, when possible, and the value of the services and goods impaired or lost.

Data: the impossibility of obtaining primary data for specific issues, and concerns for the reliability of certain primary sources (as for instance fisherman affected by the oil spill, or hotel and beach resorts owners) make the economic assessment only an estimation. To this extent, the main challenges faced during the data collection were: firstly the peculiar lack of background records on the state of the environment in Lebanon; secondly the difficulties to communicate with certain category of people for linguistic reasons as well as cultural and religious differences; thirdly the different value systems of the subjects interviewed has influenced the answers obtained; and, connected with the last issue, the intrinsic mistrust in the State which is typical of the Lebanese population, at all levels of the society. Because of such attitude, I felt the need of combining a biophysical assessment of the damage occurred, which has a higher reliability, with the cost assessment, which instead has more an instrumental aim.

Resources and time: Considering the scarce resources and the limited time available for this work, the choice of dealing only with the damages to marine and natural capital was obligated, in order to provide an in-depth analysis. Extending on this subject will therefore be extremely interesting in the light of bringing more reliable evidences of the need of international regulations to hinder the destruction of natural capital during armed conflicts.

CHAPTER 2: THE ENVIRONMENT AND INTERNATIONAL HUMANITARIAN LAW

2.1 MAIN PRINCIPLES PROTECTING NATURAL CAPITAL IN WARTIMES

Looking at the huge black cloud of smoke towering above the Rafik Hariri International Airport of Beirut on the 17th of July 2006, I couldn't restrain myself from thinking that fifteen years had passed from the first Gulf War in 1991 but the images in front of my eyes were still the same. The vulnerability of the natural environment during armed conflict and its submission to war strategies had not changed.

As a matter of fact, since those terrible days for the whole world natural capital, when the oil rigs in the Arabian desert were set in flame by the Iraqi militias and tons of heavy fuel contaminated the Persian Gulf, new rules have been created and international attention has risen on this issue. In this chapter I will first describe the relevant norms and principles of international law applicable during wartime to protect what we have defined as natural capital. The discussion of whether these provisions perform efficiently in preserving natural resources from harmful warfare actions will be undertaken in the second paragraph, where the reformist paradigm is presented. In the following chapters their claims will be corroborated using evidences obtained from the case study undertaken. However, the debate on whether a healthy and sound environment should be instituted as a "substantive" human right or a "procedural" one will not be addressed. These technicalities have been discussed in many articles and publications, and I will refer to them for further details[7]. To elaborate on the most effective and coherent system to define natural capital in legal terms is a task left to legislators. The aim of the chapter instead is to highlight lacunae and problems existing in the legal framework described, in order to stimulate further reflections on the need for revising it. The different approaches proposed to improve the existing legal standards, i.e. by strengthening its implementation, or introducing new enforcement mechanisms, or widening States compliance, establishing new laws, or even establishing an International Environmental Court[8], will not be part of the discussion[9].

Fig.1: A plume of smog from the kerosene fire rises from the Rafic Hariri International Airport on 17th of July 2006.
Source : UNDP 2007.

Considering the environment as a form of capital whose exploitation produces wealth for the society, had led States to apply, initially, the basic rules and principles of sovereignty to regulate its use and safeguard (Turner 2004). Hence, we can assess that concerns for the state of the environment first emerged at a national level (Bouvier 1991). In support of this claim, Rand McNally states that, by 1998, of 203 recognised nations, 81 had either rights to a healthy environment in their constitutions, or a duty to defend or protect it (Turner 2004). However, the recognition of the transboundary nature of many environmental problems, as well as the idea that the global ecosphere might set limits of expansion for the human sub-system, soon awoken the general attention of politicians and public opinion on the need to introduce international regulations as well. In response to this, a substantial and constantly growing body of international rules, known as international environmental law, has slowly been adopted. These agreements cover a wide range of issues, including the prevention of environmental damages and the promotion of international co-operation in dealing with their effects (Bouvier 1991).

But also, had history taught that armed conflicts could often encroached severely on people and on their environment (Sands 2003). This awareness is indeed ancestral, and that is why warfare has always been subjected to certain principles and customs. However, universal codification of these rules began only in the XIX century, when war techniques became yet much more sophisticated as well as harmful. International

[7] For in dept analyses and argumentations relevant to this debate see Sionadh Douglas-Scott 1996, Hayward 2000, Turner 2004, Hiskes 2005.
[8] In support of this last thesis, for example, McCallion and Sharma 2000.
[9] See Bouvier 1991, Gasser 1995, Schrijver 1997.

Humanitarian Law (IHL) began to be elaborated in those years, as a section of International Law which is the body of rules governing relations between States. Its role is to limit the effects of armed conflicts, protecting people who are not or no longer participating in the hostilities and to restrict the means and methods of warfare (ICRC 2004). The principal text in this field is the Geneva Convention of 1949 relative to the Protection of Civilian Persons in Time of War, in which the value and the validity of the human right to live and of the other basic human rights are reappointed also in wartimes. As the years went by and new barbarities of modern warfare took place, the link between the recognition of basic human rights and the preservation of natural resources became more evident. In 1968 the General Assembly of the United Nations recognized that depletion of natural resources could have a direct effect on a person's enjoyment of basic human rights. The same assertion was then made in 1972 at the United Nations Conference on the Human Environment in Stockholm, where Principle 1 states that "[m]an has the fundamental right to freedom, equality and adequate conditions of life in an environment of a quality that permits a life of dignity and well being, and he bears a solemn responsibility to protect and improve the environment for present and future generations".

But the official introduction, within the realm of IHL, of a body of laws dealing directly with environmental protection during wartime came in 1977 with the Protocol I additional to the Geneva Conventions. Gasser (Gasser 1995) and Bouvier (Bouvier 1991) present accurate analyses of its content and implications. However, it is important here to remember that the named Protocol asserts the most important general principle of humanitarian law to the extent nature is concerned (Bouvier 1991). It states that the Parties to the conflict do not have unlimited possibilities to choose methods or means of warfare. Specifically, they are prevented from using weapons or tactics "which are intended, or may be expected, to cause widespread, long-term and severe damages to the natural environment". Also, "attacks to the environment by way of reprisals are prohibited" (Art.35, para.3 and Art.55). Another basic principle established in this Protocol and applicable in wartimes is the rule of *proportionality* (Art. 35, para. 2; Art. 51, para. 5, and Art. 57, para. 2a and b). This means that it is prohibited to use weapons or methods or tactics that are not proportional to the lawful objective of the military operation, neither necessary to achieve that objective.

Other agreements that more or less directly or explicitly aim at protecting the environment during armed conflicts are the Biological Weapons Convention (1972), the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques ("ENMOD" Convention adopted by the United Nations on 10 December 1976, open for signature May 18, 1977), the Conventional Weapons Convention and its five protocols (1980) and the Chemical Weapons Convention (1993). The first one above all deserves some attention. In fact, there is agreement in the literature that this Convention is complementary to the Protocol I mentioned above, since the two prohibit different types of environmental damage. The ENMOD Convention bans the use of techniques that modify the environment "with a widespread, long-lasting or severe effect". The establishment of this principle can be seen as a response to the fears aroused by the use of methods and means of warfare that caused extensive environmental damage during the Viet Nam War. Problems indeed concern the different meaning that the two conventions give to the same concept, i.e. "widespread, long-term and severe effect" (Bouvier 1991). In fact, as it has been noticed by different authors, they can range from several months or seasons for the ENMOD Convention, while for Protocol I they can extend to several decades. Such discrepancies might hamper the implementation of the rules put forth, and also they implicitly justify "permissible destructions" below an established absolute ceiling (Reichberg and Syse 2000). Perhaps the 1959 Antarctic Treaty is the most encompassing international provision as far as the protection of nature is concerned. In fact it prohibits military activities of any kind in the region, partly motivated by the desire to preserve the fragile ecology of the Antarctic (Roberts 1999, quoted in Reichberg and Syse 2000).

As mentioned above, before 1970s the notion of "natural environment" does not appear in an instrument of humanitarian law (Gasser 1995). Indeed, we can find documents that indirectly protected the natural capital of the Parties to a war by means of protecting something else. As early as 1907 for instance, the Hague Convention respecting the Laws and Customs of War on Land stated that it is forbidden "to destroy or seize the enemy's property, unless such destruction or seizure be imperatively demanded by the necessities of war" (Art.23). This article is one of the earliest provisions for the protection of the environment in armed conflict, and it does it implicitly by protecting the useless destruction of private

property. Using the same ratio, also the Geneva Convention of 1949, prohibiting the destruction of real or personal property, provides minimum protection of the environment in case of enemy occupation. Additionally, several other treaties limiting or prohibiting the use of certain techniques of warfare and specific weapons assure a mild safeguard of natural capital. In 1925 it was adopted in Geneva the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases and of Bacteriological Methods of Warfare. In 1972 it was signed the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction and in 1980 the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects.

Much more recently, after the terrible environmental disaster occurred in the Persian Gulf during the first Gulf War in the 1990s, the Security Council of the United Nations with the Resolution 687/1991 created a Compensation Commission. Its task was to process claims and pay compensation for "any direct loss, damage, including environmental damage and the depletion of natural resources, or injury to foreign Governments, nationals and corporations, as a result of Iraq's unlawful invasion and occupation of Kuwait" (Principle 16, UN Resolution 687/1991). A special fund, which in conformity with Security Council resolution 1483/2003 received a 5% of the proceeds generated by export sales of Iraqi petroleum and petroleum products, was created to compensate the victims. To date, this remains a single experience which indeed has not reoccurred despite similar situations had occurred. Its success must be recognized to the extent it has fulfilled its initial objectives: i.e. providing compensation to the harmed States in the form of *restitutio par equivalent*. However, the effectiveness of such a solution from an environmental perspective could be questioned, since it does not foresee the main and primary form of reparation: i.e. *restitutio in integrum* (Aznar-Gomez 2001). When natural capital is involved *restitutio in integrum* appears to be, at least theoretically, the best method of redress the problem. According with Aznar-Gomez's analysis, normally reparation has been devoted to cover environmental loss using market prices, and therefore non-used resources have undergone only an economic evaluation. In this way it has not compensated for the environmental harm itself (ibid.). The argument can be ultimately traced back to the debate between neoclassical and ecological economists on the substitutability of natural capital with other forms of capital (in this case financial capital).

2.2 DISCREPANCIES, LACK AND ISSUES THAT PREVENT THE PROTECTION OF NATURAL CAPITAL

As described in the previous paragraph, formally there is a body of laws which deals, internationally, with warfare acts against the environment. However its limited effectiveness is widely recognized[10] by the authors that we have categorized here, for simplicity, as the reformist paradigm. Even though they propose different solutions, some issues are recurrent in all the arguments.

Firstly, as mentioned above, an incongruence can be found in the formulation and in the ratio of the different laws. Vague terms and different interpretations that courts have given throughout the years do not facilitate a broad application of these norms. Moreover, as highlighted in numerous documents issued by ICRC, this situation has not helped the transmissions of the IHL rules to the armed forces, which are often the ones that soil their hands with unlawful crimes.

Secondly, the issue of limited applicability of the framework is reinforced as well by the fact that many States have not yet ratified the named conventions. In the case of the conflict between Lebanon and Israel for instance, although forests have been set in fire, sea and costal areas have been seriously polluted, land and cultivations have been destroyed and turned into unfertile soil, no international actions have been taken. The most obvious reason is that Israel is not part of the Geneva Convention of 1949, and therefore it can not be punished for having acted against its prescriptions.

This brings us to the third point: the enforcement mechanisms actually in place in IHL to safeguard natural capital are evidently weak, and this results in a very low State's compliance, as often denounced by ICRC in their annual reports. According to Sands: "most environmental treaties are silent on the issue of their applicability following the outbreak of military hostilities" (Sands 2003:309). This consciousness, sadly reaffirmed in recent conflicts (Persian Gulf, Balkans, Darfur, Lebanon), has promoted many appeals to States

[10] Among others, see ICRC (www.icrc.org) , Gasser 1995, Bouvier 1991.

to become parties of the relevant international conventions. An important one was included by the Secretary-General of the UN in the report to the General Assembly for its forty-seven session (1991). This was the spark for the adoption of Resolution 47/37 (Protection of the Environment in Times of Armed Conflict), which urges States to become party to the international conventions relevant for the protection of the environment, and exhorts them to take all measures to ensure compliance with those obligations. Closely related with the third point is the lack of mechanisms to deal with situations of non-compliance. New laws need to be enacted to seriously punish the violators of these conventions, and appropriate international fora should be made available to discuss and deal with situation of non compliance (Sands 2003). The 1977 Convention on the Prohibition of Military or Any Hostile Use of Environmental Modification Techniques (ENMOD) seems to be the only text of IHL to present such a feature (Kiss and Shelton 2001), providing the creation of a Consultative Committee of Experts in charged of making appropriate findings of fact and offering expert views relevant to the achievement of the objectives or the application of the Convention (Art.5 and Annex). Other conventions have only established the right of compensation for the damages caused by one party to the natural capital of the other party in a conflict. To date however, compensation claims related to environmental impacts from war have only been settled either by diplomatic means (Vietnam War) or by political means (1st Gulf War), as we described above. Yet, they have never been claimed before an international judicial authority (UNDP 2007).

2.3 CONCLUSIONS

The way to go appears to be long before an international solution to protect the environment during armed conflicts will be found and widely accepted. Apparently a body of international laws dealing with these concerns has been codified, but its inadequacy finds confirmation both in the academic debate presented above, and in the images that come to us from the actually on-going conflicts. Ecosystems services are interrupted and natural capital is depleted hindering the recovery of the population trapped in the hostilities and the sustainability of their future. Also, the transboundary implications of many environmental problems, due to the fact that ecosystem functions work on a global level to ensure welfare to the whole world population, must be regarded as another argument for the need of revising the actual IHL system as regards to environmental protection.

CHAPTER 3: THE LEGACY OF ONE MONTH OF WAR[11]

3.1 LEBANESE SOCIO-ECONOMIC BACKGROUND

Lebanon is a small country, with a surface of 10.452 km2. With a GDP per capita of $4.360 it is considered a upper-middle-income country. However, large geographical disparities in poverty rates have been often highlighted (WB 2005). Poverty is concentrated in the suburbs of the large urban poles and in remote rural areas. Zones of conflict during the long lasting civil war also appear to constitute, still, major pockets of poverty. The most deprived regions are Bint-Jbeil (67% in poverty) town in the very south of the country, followed by the Cazas[12] of Hermel (66%), Marjayoun (60%), Baalbeck in the Bekaa Valley (49%) and Tyre (45%) principal urban pole on the southern coast. In fact, these areas have also again been the theatre of the strongest offensives during the recent conflict with Israel which is analyzed in this paper. This resulted, of course, in a widening of the disparities among the different strata of the Lebanese population.

The level of urbanization is pretty high. 88% of its inhabitants, estimated at 4-4,6 million, live in urban areas. This fact creates important environmental and health problems associated to the high level of smog, the depletion of natural resources to meet the quick rising demand of a urbanized and not environmentally aware community, the phenomenon of “cementification”. The average family size is 4.8 individuals, with significant regional and social disparity. 11% of the families has more than eight members. Population size is increasing at the rate of 1.65% yearly (CAS Bulletin/No.1, 2000). Average life expectancy is 71,3 years (MoE, 2001). The rate is, as expectable, lower in the North (68,5 years) where socio-economic conditions are

[11] References have sometimes been omitted for the sake of the readability of the chapter. However, all the data presented have been gathered reviewing and comparing WB 2005, FAO 2006, UNEP 2007 and UNDP 2007.

[12] Lebanon is divided into six regional administrative districts, in Arabic Mouhafazat (singular: Mouhafazah). The six Mouhafazat are further subdivided into counties, in Arabic Caza.

lower, and higher in Beirut (74,5 years). About one-third of the population is concentrated in the capital and its suburb. The rest of the population is distributed in the five other Mouhafazat (governorates or districts).
Before the recent war, Lebanon was still struggling to recover from about two decades of devastating civil war (1975-1990) and Israeli occupation (1977-2000) (FAO 2006). As a result of the 15-year civil war, the country's infrastructure and the physical assets of all principal sectors were destroyed or severely damaged; the administration and public institutions were severely affected; the religious differences among the population were stigmatized and made much more visible; the income level in 1991 was one-third of what it was in 1975 and a quarter of the population was displaced (ibid. 2006).
The Lebanese economy is based principally on the service industries, with a weak, and often marginalized, agriculture sector. The Lebanese labour force is estimated to be 1,36 million people (34% of the population). Between 1994 and 2004, the service sector witnessed the highest growth, increasing its contribution to GDP from 61 to 72%. Tourism, trade and financial services constitute the principal sources of both income and foreign earnings. The industry and manufacturing sector accounts for 21% of the GDP. The great majority of the industrial enterprises are of small and medium size and, according to a 1998 industrial survey reported in the FAO Report, the food industry is the most important component accounting for the 23% of the industrial enterprises, and almost 26% of the total industrial output. In 2005, Lebanon's principal exports were machinery, jewellery, metals, foodstuffs and chemicals (UNEP 2007). As mentioned above, agriculture plays a minor role in the economy. Nevertheless its importance lies in the fact that this sector sustains and give jobs to the poorest groups of the society. In 2002, it contributed less than 6% of the GDP (Lebanese Ministry of Economy and Trade 2005). The most important crops produced in the country are: cereals, fruit, olives, industrial crops (such as tobacco and sugar beets) and vegetables. Agricultural activities are concentrated principally in the Beqaa Valley, which accounts for 42% of the total cultivated land (MoE 2001).
Another important and unique feature of the Lebanese economy is highly dependence on remittances from Lebanese people emigrated abroad. Since these remittances are frequently made through private channels, no reliable figure exists of their actual size. However, estimates present figures around $ 5 to 8 billion that expatriates send to Lebanon each year (FAO 2006), a significant amount if compared with an annual GDP of $22,5 billion (projection as in September 2005, WB 2005). According to International Monetary Fund (IMF) estimates, from 1970 to 1998, the diaspora remittances represented, on average, the 35% of the GDP and caused the majority of exports of goods and non-factor services. Furthermore, another important role of the diaspora is found in the tourist sector, them constituting in fact the backbone of the tourists entering the country every year. Also, Lebanese bank deposits, which equal to 150-200% of Lebanon's GDP, are largely made by expatriate investment.
The socio-demographic context is marked by important and interconnected phenomena:
- rapid urbanization. Lebanon shows the sharpest decrease in rural population in the Mediterranean and Middle East countries (FAO 2006). The massive rural exodus has been from disadvantaged regions in the Bekaa and the south, and it is related to poverty and war. The lack of intervention and awareness from the centre has led to the growth of urban slums in the southern suburb of Beirut;
- mass emigration to foreign countries all over the world, from both urban and rural areas, motivated mainly by the security conditions during the civil war (1975-1991) and the Israeli occupation (1977-2000), high unemployment rates and poor socio-economic conditions. Since 1975, up to 1,3 million people have left the country. 1,5 to 2% of the active population had been emigrating every year between 1996 and 2001 (WB 2005);
- a large number of immigrant workers, mainly Syrian labourers and female Asian and East-Asian domestic workers who live in precarious conditions, estimated at more than one million people. They constitute a class of emarginated people, living at the border of the society, often exploited without the recognition of any form of right or protection;
- the presence of 405.000 unofficially registered Palestinian refugees who live in 12 refugee camps throughout the country and whose socio-political condition limits extremely their possibility of integrating and working in the country.

Lebanon is considered to have relatively poor health and education indicators, especially in the public sector. In addition, there are important regional disparities in access to services. At the socio-economic level, as

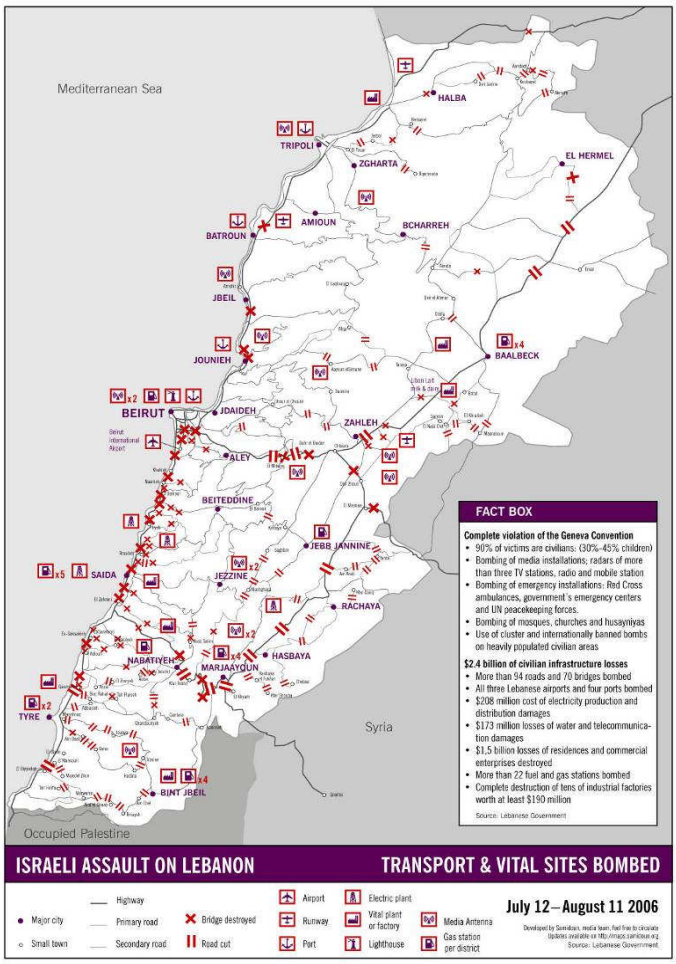

Fig.2: Transport and vital sites bombed by IDF.
Source: Lebanese Government.

mentioned above, the situation is increasingly marked by inequality among the population living in different areas of the country and the erosion of the purchasing power, in particular of the middle class.

3.2 JULY 2006: THE CONFLICT WITH ISRAEL

Between 12 July and 14 August 2006 large scale hostilities broke out between Lebanon and Israel, ending with a ceasefire under UN Security Council Resolution 1701. Even though the period was relatively short, lasting 34 days, the impact on Lebanon's civilian population and natural capital was significant (UNDP 2007). The Lebanese environment was targeted systematically by the enemy forces, as the description below will prove, resulting in evident ecological losses. In the following part of the chapter I will try to give an overview of the damages occurred to the country as a result of the Israeli military attacks. The focus is indeed concentrated on the direct harms inflicted to the Lebanese environment. This will ultimately corroborate the argument of the need of a better form of protection for natural resources during wartimes.

1.191 people were reported as killed and 4.405 injured (UNEP 2007), one-third of them believed to be children (FAO 2006). In addition, the violence led to the displacement of almost one forth of the Lebanese population, 974.184 people (ibid.), creating four times more refugees than the NATO bombardments in Kosovo did (data retrieved from www.icrc.org on 10 May 2007), even though the length of the hostilities were similar (slightly longer the latter). Severe damages were caused to infrastructure, with 130.000 dwelling units destroyed; 900 factories and commercial buildings shattered; 107 bridges and overpasses, approximately 445.000 m2 of road network and 27 fuel stations bombed. Although the offensive targeted various types of infrastructure across Lebanon, the areas most directly impacted due to heavy shelling include the Dahieh region, a southern suburb of the capital Beirut, as well as the municipalities of Aita ech Chaab, Khiam, Bint Jbeil in South Lebanon and Nabatiyeh, and Baalbek in the Bekaa plain .

The hostilities have generated a very high level of demolition waste, which disposition will pose new environmental threats to Lebanon. In fact UNDP classifies this type of damage as "severe" and estimates a its outcome to have a medium to long term duration, that is between 1 and 50 years (UNDP 2007). The total volume of generated rubble is in fact estimated to be up to 3,5 million m3 (ibid.), almost the volume of the biggest pyramid in the world, the Chulula Pyramid (data retrieved from www.wikipedia.org on 14 May 2007), or more than three Empire State Buildings (data retrieved from www.esbnyc.com on 14 May 2007).

3.3 THE ENERGY SECTOR

Key infrastructures of the energy sector damaged by IDF include the Jiyeh power plant, the Beirut Rafic Hariri International Airport, and various petrol stations. As we will see in more details in the following chapters (see Chapter 4 and 5), the Jiyeh power plant's fuel storage tanks were targeted by Israel the 13th and 15th of July, in two successive air strikes. Two fuel storage tanks containing 15.000 tons of fuel each were hit. Both tanks caught fire. The fire spread to the remaining tanks and kept burning for 12 days. Plant personnel estimated that between 55.000 and 60.000t of fuel oil may have burned. About 15.000-20.000t is assumed to have spilled to the sea, causing one of the major environmental disaster experienced by Lebanon

(UNDP 2007). The airport fuel storage tanks were also damaged by a direct Israeli air strike on the 13th of July. Estimations talk about a volume of 5.000 m3 of kerosene released from the fuel tanks. The relative proportions of kerosene burnt and leaked into the ground it is very difficult to assess, since no one could reach the area in flames during those days of heavy bombings. However, a huge black cloud of smoke could be seen for days towering above the Rafic Hariri International Airport (see Fig.1). The environmental damages caused by these two events are ascribable to three main types. First of all the atmospheric pollution deriving from the potentially toxic cocktail of pollutants contained in the smoke released by the burning fuel. This would have most probably included soot, particulate matter, carbon monoxide, methane and a range of hydrocarbons, the combination of which can be expected to remain in the air for long time causing respiratory problems for local residents or falling again to the ground in the form of acid rain or snow. The second harm to the environment concerns mostly the area surrounding the Airport. Ground contamination is likely to have occurred due to the fuel leakages which has potentially led to groundwater contamination as well. In fact kerosene contains a large amount of benzene, toluene, ethylbenzene and xylenes, compounds which are highly toxic and highly mobile. UNEP recognized a high risk of water contamination since hydrocarbon plumes in the groundwater can reach several hundred metres in length (UNEP 2007). The risk of harms for the population is even more evident when considering the peculiar location of the airport: only 200 m far from residential housing, industrial complexes and agricultural land, and very close to the Ghadir stream. This means that most likely wells will be located in the proximity of the site, and this implies a high potential for contamination. The third environmental loss, that will be examined in the following two chapters, occurred in terms of damages to the marine and coastal ecosystems caused by the huge amount of heavy oil that spilled in the sea after the tanks of the power station have been hit.

Several petrol stations were also directly hit by the IDF during the war. Official reports by the Higher Relief Council indicate that a total of 22 stations were either completely or partially damaged: these include 4 in Bint Jbeil, 2 in Tyre, 4 in Marjaayoun, 1 in Nabatiyeh, 5 in Saida, 1 in Jebb Jannine, 1 in Beirut, and 4 in Baalbeck. This number could however be much higher. In fact local authorities have reported a total of 47 petrol stations damaged only in the area of Bint Jbeil, Marjayoun and Tyre (UNDP 2007). A total amount of about 360.000 l of gasoline and 140.000 l of diesel were reported to be present in the storage tanks, and hence they have either burned or leaked into the aquifer. Pollution of the upper aquifer is therefore an issue and its grade of harm should be urgently assessed for designing the needed interventions. The potential losses to natural capital are of the same typology highlighted above, in the case of the Beirut airport.

Concluding, there are as well indirect environmental damages that will be faced in the medium term, and they depend mainly on the elevated amount of hazardous and solid waste and rubble that will need to be disposed when the dismantling phase will be over. Other types of waste include agriculture wastes from the spoiled harvests, animal carcasses that could be drivers of diseases if not appropriately disposed, hazardous and special wastes, pharmaceutical wastes, and domestic solid wastes.

3.4 THE INDUSTRY SECTOR

Several industrial facilities were also hit and severely damaged during the war, causing damages also beyond the direct economical loss, implying in fact serious environmental harms. The extent of these damages is indeed variable.

In total, 31 industrial facilities in South Lebanon, Beqaa and Beirut Suburbs were reported to have been completely or partially destroyed (UNDP 2007). The environmental concerns are mainly related to soil and groundwater contamination. In fact the concrete base present in the factories has been proved to have cracked extensively (UNEP 2007), probably from the impact of the bomb, creating potential pollution pathways which can constitute a matter of concern, particularly during the rainy season. Depending on the core production of the factories, potential risks of surface water contamination arose as well. In the case of the Al Arz Lilnasiej textile factory, for instance, located in the Beqaa Valley (Zahleh area) and surrounded by agricultural land, primarily olive trees and vineyards, forms of water contamination are highly foreseen. In this episode in fact machine oil and textile industry special fluids and dyes spilled some 100 m2 of the actual site. The karstic nature of this area, and of a wide part of the Lebanese hydrogeology, could have led to relatively rapid migration of on site pollution towards the underlying aquifer (UNEP 2007).

Circumstances as the one presented in this paragraph can be considered as indirect damages to the Lebanese environment nevertheless, since the link between the attack and the effect on the natural capital

was not so evident and straightforward. Also the raison d'être of the attack can in some cases be different from the intentional impairment of the environment, as for example in the case of the Jiyeh power plant, which was located directly on the beach, few meters away from the sea. Therefore such events, even though turned down by the author of this work, will not be used in support of the main argument of the thesis. They are mentioned here just to give a big picture of what happened on the Lebanese ground in July 2006.

3.5 THE AGRICULTURE SECTOR

The agricultural sector also suffered a very hard impact from the IDF attacks on the Lebanese territory. Direct damages to natural capital and implications for the ecosystem services and goods provided can be summarized as follows:

(a) unexploded ordinances (UXOs) that were dropped on the agricultural fields. Israeli rocket units fired a total of 1.800 rockets containing cluster bombs in the last days of the conflict. Each rocket fired contained 644 cluster component bombs, adding up to a total of 1.159.200 individual bombs that were dispersed over southern Lebanon. About 90% of these were dropped in the last 72 hours of the war, when the ceasefire had already been set. Many agricultural fields and pastures were rendered useless because inaccessible until unexploded bombs could be removed or exploded. Also water resources have been severely targeted by the IDF. In fact UXOs have been often located very close to water sources(see Fig.3), which as a consequence have been made inaccessible for the community. These represent additional stress factors for the rural population, which relies of agriculture for almost 70% of the total household income (FAO 2006). In the long term there is also a risk for an over-use of remaining accessible resources in an attempt to recover some losses. The result was the adoption of unhealthy practices like drainage of wetlands for more aggressive irrigation or extensive use of pesticides with associated detrimental impacts on the natural resources namely water and birdlife. Moreover the presence of UXOs poses a major hindrance to MoE reforestation plan. It is expected that thousands of hectares of scrubland may be lost to fires. Faunal assets, particularly large mammals, are also probably being lost or variably injured as a consequence of UXOs in the wild. Water resources might have also been contaminated as the streambeds and banks are littered with cluster bombs. Complete clearing, according with the experts engaged in the clearing activities (the Mine Coordination Centre of South Lebanon and its contractors, UNIFIL troops and the Lebanese Armed Forces) of the south could take up to 10 years. With approximately 85% of southern Lebanon being assessed for cluster bombs strikes (data elaborated by the UN Mine Coordination Centre, November 2006), clearing the land will be essential to enable the reconstruction of the agriculture-based livelihoods that prevails in large areas of southern Lebanon.

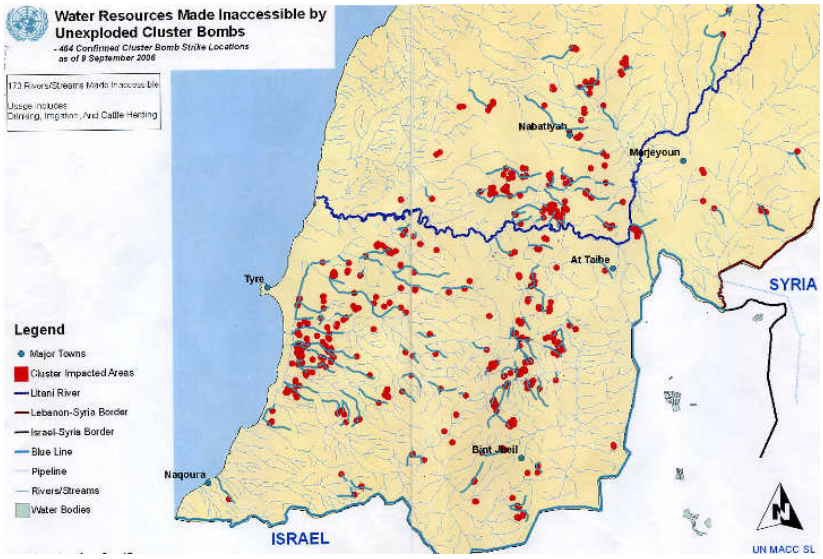

Fig.3: The map shows where UXOs are located in south Lebanon in relation to water sources. They make water inaccessible for local people.
Source: UNMACC

(b) direct bombing, artillery fire, lighting bombs or clearing vegetation for military operations;

(c) losses to forest ecosystems. These occurred as a consequence of the fires systematically lighted by the Israeli soldiers while advancing toward the north. A precise data of the losses occurred to the forest ecosystem is not available, but the MoA has estimated a total area of 1800 ha of forest and other wooded land in the South and Mount Lebanon Governorates to have been affected directly by fire or indirectly during the war. From a literature review of the functions generally performed by forests and given the principal economical uses of these resources made in Lebanon (Merlo and Croitoru 2005), we can assess that the main

impacts caused by the Israeli attacks are loss of wood products, loss of non-wood forest products, biodiversity loss, loss in regeneration dynamics, soil erosion and decrease in water infiltration into the soil. The estimated damage (physical and financial) presented by FAO is roughly around $16 Million (FAO 2006), but this is a minimum estimate, since it applies a direct market evaluation of the hectares that have been damaged. That is only the ecological goods and services that are exchanged in the market are accounted for, while and all the environmental aspect highlighted above are not included;

(d) damages to fish stocks and to the water resources. In the case of freshwater fish, losses occurred particularly in the Assi River known for its rich biodiversity, due to the heavy bombardments. Sea and coastal biomes, on the other hand, have been affected as a consequence of the Jiyeh oil spill briefly described above and explained deeper in the next chapters;

(e) soil compaction due to the movement of military vehicles in the highly affected areas in the South. This could lead to loss of soil fertility and increased soil erosion if excessive.

Even though the agricultural sector, as presented above, contributes only for a minor part to the Lebanese GDP, in a perspective of sustainable development has a meaningful role. This for at least three reasons. First of all, the first sector usually employs the poorest layers of the population, which do not have other forms of income on which to rely. According with FAO (FAO 2006) half the working population in the south of Lebanon earns its living entirely from agriculture, which constitutes, generally, almost 70% of the total yearly household income. Second, it can potentially assure to the country a form of sustainable and independent development, and also, given the large macro-economic imbalances of the Lebanese economy and a public debt of 171% of the GDP (estimation as in September 2005, WB 2005), a diversified agriculture production could contribute to keep national financial resources within the country.

Concerning the indirect damages, on the other hand, they are mainly caused, according with the FAO survey (FAO 2006), by the impossibility of accessing the fields during the 33 days of bombing, as farmers fled their villages and left their crops and animals unattended, and the impossibility of irrigating and taking care them afterwards as well, due to the lack of electricity and fuel supply that unable the farmers to use agriculture machineries. Moreover, most of the agricultural workforce, including foreign labourers, fled the governorates of South Lebanon and Nabatiyeh. The interruption in the care of crops and animals was responsible for a large portion of the income/production losses. In fact, the war took place at the peak time for the harvest of crops (mainly stone fruits and potatoes) destined for export, and much of the year's harvest perished on the ground, or was spoiled since transport to market became impossible. However these category of damages are not particularly relevant for the overall aim of my thesis. They only help the reader to have a big picture of the post war situation faced by the country.

The total financial losses calculated by the FAO experts only for the two governorates of southern Lebanon (the hardest hit), amount to approximately $ 95 Million, of which about 76% relates to tree crops and the rest to field crops. Overall, the assessed damage and losses to the agriculture, fisheries and forestry sub-sectors totals around $ 280 Million13. That is, the 29% of the annual contribution of the sector to the GDP. These figures indeed can be considered as one time losses, in terms of revenues potentially provided by natural resources, and in this way it is evidently an underestimation of the real damage. Also, they do not account for the other ecological functions carried on and that do not show up in the market. However, unfortunately no estimates of the damages using this criteria were available at the time of writing.

The heavy losses supported by the rural households, mainly living in a condition of subsistence economy, have established a downward spiral of debt and poverty that risks to have negative long term outcomes. In fact, farmers usually repay their debts with the revenues collected during the harvest period (May-October). In such a way they secure credit for the following planting/production season. This year however, their ability to repay these debts has been reduced to the minimum, making it impossible to start the new cropping cycle. Many households will remain burdened by asset/harvest/income losses over the medium term and may also suffer from the loss of other sources of income. There is a big concern that this situation will be difficult to interrupt if the government won't intervene in support of these families.

[13] These, as the losses to forests, refer simply to the physical damages occurred (tree crops and field crops). So they consider the use-value of natural resources, whereas the monetary figure does not say anything on the environmental value of these resources. For further details on the methodology adopted see FAO 2006.

Therefore, as a priority, assistance should target the lack of working capital, which poses a greatest threat to the recovery of the agricultural sector.

Surface water streams pollution from bombing of bridges	Water pollution from PCB leakage from damaged transformers			
Water pollution from fuel leakage from damaged petrol stations in Baalbeck	**Littoral pollution from oil spill**	**Marine sediment impact from sunken oil**		
Water pollution from hit factories	Water pollution from pesticides and fertilizers from damaged storage houses	**Impact on seawater quality from oil spill**	**Impact on marine biodiversity from oil spill from Jiyeh power plant**	
Assi river impact from fisheries bombing	Water quality deterioration from disposal of Debris and Rubble	Impact on natural resources from quarrying	Loss of flora, fauna and degradation of ecosystems due to fires	
Water pollution from fuel leakage from damaged petrol stations	Water pollution from bombed storage facilities	Degradation of floral base and ecosystems from demolition waste disposal	Impact on ecosystems, habitats, flora and fauna from military activities	
Soil impact at Jiyeh Site	Soil erosion from forest fires	Soil pollution from Fine Tissue Factory	Dust and PM release from construction works	Air pollution from airport fuel storage tanks fire
Soil pollution from fuel leakage from damaged petrol stations	Soil pollution from deposited contaminants of fuel burning at Jiyeh and airport	Soil pollution from pesticides and fertilizers released by damaged storage houses	Air pollution from Jiyeh power plant fire	Air pollution from forest fires
	Soil pollution from PCB leakage from damaged transformers		Air pollution from fuel tanks burning in petrol stations	

Fig.4: Visual representation of the overall environmental damages occurred to Lebanon, divided into categories according with the natural resource effected. Light blue indicates causes of water contamination, pink soil contamination, dark blue relates to air, green to biodiversity, yellow to general environmental harms which are hardly classifiable into one category. The four cells bordered in red are the aspects analyzed in depth and quantified in this thesis.
This illustration aims at representing the order of magnitude of what I measured in relation to the overall harm to the environment.
Source: UNDP 2007. Personal elaboration.

3.6 OTHER ENVIRONMENTAL IMPACTS

The quality of the air in Lebanon has also been compromised. The most important direct impacts of the war were indeed identified in the pollution generated by the burning fuel oil and kerosene at the Jiyeh power plant and Beirut airport respectively (UNDP 2007). Main pollutants of concern include SO2, NOx, Carbon Monoxide (CO), particulate matter, Polycyclic Aromatic Hydrocarbons (PAHs), and dioxins and furans. Also forest fires and burning of fuel at the petrol stations hit by the Israeli rockets will contribute to the deterioration of the atmosphere, but due to their localized and temporary nature they are not considered as priority impacts (ibid.). Indirect impacts, on the other hand, are the increase in particulate matter that is likely to occur in the vicinity of reconstruction sites, the increased traffic at damaged roadway sections and bridge sections.

The most important impacts on fresh water resources are considered to be the damage to surface water streams from destroyed bridges and infrastructures, potential groundwater pollution from PCB leakage or leakage of gasoline and diesel from damaged petrol stations, potential surface and groundwater pollution occurred, as mentioned above, in the proximity of the industries and facilities destroyed. Impact in these cases however depends on level of pollution at the sites and to the local hydro-geological conditions. Concerning surface water ecosystems, they were affected directly by bombings and indirectly by damaged infrastructure, especially near destroyed bridges, or dead carcass decomposition as in the case of Assi River.

Impacts on soil are closely related to impacts on water. In fact, soil often acts as a conduit to water receptors. The most severe impact on soil and land is the one on coastal sandy and rocky stretches that were severely damaged by the oil spill, as it will be explained in details later.

Biodiversity was affected both directly and indirectly by the war. Protected areas and fragile ecosystems, wetlands and a biosphere reserve were damaged during the conflict, leading to the destruction of wildlife and habitat. Use of heavy machinery by the Israeli army (tanks and bulldozers) to clear roads during the invasion resulted in disturbance and fragmentation of ecosystems and floral and faunal populations as well as eradication of marginal habitats by the sides of roads. These troops in fact entered natural areas with heavy machinery and vehicles to settle and carry out frequent patrols.

At sea, the Mediterranean basin has also suffered significantly during the war and after. The issues risen by the oil spill have already been discussed briefly. Also, it is important to remember that the sea is, in general, the ultimate receptor of most sources of in-land pollution caused by the war (UNDP 2007). Conservationists have reported waste dumping by foreign troops coming in from the sea. The waste was seen shored on turtle nesting beaches used by the endangered Loggerhead and Green Turtles.

3.7 CONCLUSIONS

In this chapter I tried to give an overview of the damages occurred to Lebanon during the war with Israel in July 2006. Special attention has been reserved to the demarcation between direct environmental damages, i.e. those outcomes that can be directly traced back to means of warfare; and indirect damages, where the environment is not hit or harmed directly, but it is damaged as a consequences of other war related activities (for instance the increase in domestic quarrying activity to satisfy the war-related demand of reconstruction). The importance of making this division lies in the fact that the firsts acts are banned by all the international conventions and by IHL and international environmental law, as we have presented in Chapter 2.

As we have seen qualitatively from the description provided, environmental losses are strictly related to losses in the people's quality of life, and in this way they have social, political and economical corollaries. Some of them will be discussed in depth in the following chapters, where the analysis will concentrate specifically on the damages to the Lebanese marine and coastal ecosystem. Fig.4 aims at giving a visual and immediate understanding of the overall situation in terms of natural resources affected (soil, water, air, biodiversity and other environmental harms are represented in different colours). The red bordered cells represent the section that will be analyzed in details and quantified monetarily in the remaining chapters. We will refer back to this image at the end of the thesis, when the total cost of degradation will be presented for the marine and coastal ecosystem. It will be useful for understanding the order of magnitude of the damage suffered by the whole Lebanese environment.

CHAPTER 4: ENVIRONMENTAL IMPACTS TO THE MARINE AND COASTAL ECOSYSTEMS CAUSED DIRECTLY BY THE ISRAELI OFFENSIVE

4.1 OVERVIEW OF LEBANON'S COASTAL AND MARINE ECOSYSTEM

Lebanon's coastline is characterized as Mediterranean with sub-tropical components: regular and open coast, hilly and uneven, overall absence of islands (UNDP 2007). The littoral is 238 km long (Sanlaville 1977) and it presents several types of marine biotopes, the principal being sandy beach, for around 140 km, and rock or gravel, 90 km (ibid.). Unusual coastal habitat types include rocky terraces covered with the mollusk Vermetes and calcareous algae (Vermetid terraces), coastal springs, and coastal dunes. The Vermetid terraces/coralline reefs are an important and unique feature of the eastern Mediterranean. These wave-resistant terraces host a diverse ecosystem consisting of brown algae, calcareous algae, encrusting sponges, barnacles, scleractinian corals, bryozoans, bristle worms, nudibranchs, anemones, sea urchins, sea cucumbers, crabs, cuttlefish, various fish species, and sea turtles (Steiner 2006). The source of sand and gravel are the sea cliffs, detrital materials from local watersheds, and calcium caronate from shells (ECODIT 1997). However, in the last thirty years there has been a massive alteration due to anthropogenic factors, with more than 50 percent of the population now being concentrated along the coast (ECODIT, 1997). The seabed substrate is a mixture of bare rock, boulders, gravel and sand. A soft sediment bed is found only in a few areas protected from currents. Sea surface temperature varies between 16 C in winter and 30 C in summer. Tidal range is slight, averaging from 15 cm to 30 cm, with a maximum up to 50 cm (UNDP 2007). The currents experienced outside the Lebanese coast are influenced by the large scale counter-clockwise movement of water of the eastern Mediterranean sea, and consequently they move north,

up the coast (UNEP 2007). This is a feature to bare in mind to understand the typical behaviour presented by the oil once it spilled in the southern part of the country.

Although Lebanon's marine ecosystem is not particularly well studied, it is reported to be nutrient-poor mainly because of the summer wind patterns which inhibit nutrient replenishment through upwelling (MoA and UNEP 1996). This situation makes it not particularly productive relative to other coastal seas in terms of chlorophyll concentration. However, Lebanese sea is known to be rich in biodiversity and exhibits high endemism. It hosts approximately 1,685 species of marine fauna, of which at least 50 species are commercially important. The National Centre for Marine Sciences has inventoried 218 marine fish species from 140 genera. Fish diversity is highly correlated with rocky bottom substrate and habitats with greater substrate complexity. Much of the marine biodiversity – 1,250 species - is found in the plankton community. Zooplankton account for the largest share with more than 747 species recorded (Khalaf 2006). Micro-zooplanktons are at the base of the marine food pyramid and are hence essential for maintaining the ecological equilibrium.

Other families of marine organisms include the cephalopods (octopuses, cuttlefish and squids), reptiles (Loggerhead turtle and Green Sea turtle) and mammals (dolphins and porpoises and, less common in local waters, whales and seals) (MoE 2001). The two sea turtle species – Loggerhead (Caretta caretta) and Green – are known to nest in Lebanon. Surveys based around the entire coast found that the nesting activities are sparse along part of the northern coast, which is scattered on several developed beaches, but they are concentrated on the southern part of the country, where nesting sites were found to be more important and relevant nationally and regionally. Hatching season extends from July to September.

Concerning birds, Lebanon lies on the great migration routes of three continents. Thus it constitutes a bridge where most migrating birds tend to concentrate (Khairallah 1985, quoted in WB 2001). However it is not an area of high nesting abundance, due at least in part to over hunting and habitat degradation. But lying along a north-south migration corridor, some 250 bird species are known to migrate through the coastal zone (UNDP 2007).

4.2 THE OIL SPILL

The damages suffered by the Lebanese marine and coastal ecosystems during the July war can be imputed to the physical advance of Israeli warships (and the associated release of their waste which has been reported by different sources[14]), the direct bombing, and the massive oil spill which occurred as a consequence of the air strikes held by Israel against the power plant of Jiyeh, 30 km south of Beirut. However this chapter will only deal with the third event. In fact, in the first two cases the impacts are extremely complex to evaluate both in scientific and economic terms, due to a lack of studies carried on to this concern. Also the scale of the damage is much smaller as regards to the oil spill occurred after the intentional bombing of the Jiyeh power station. Moreover, this action has also a higher meaning within the theoretical framework established at the beginning of this thesis, firstly because of the magnitude of the environmental outcomes, and secondly because of the potential condemnation of the Israeli action according with the existing

Fig.5: Jiyeh Thermal Power Plant and its Fuel Storage Tanks. Source: UNDP 2007.

[14] Fishermen, Ngos, UNDP, MoE.

norms of IHL (see Chapter 2). Therefore when evaluating the losses for Lebanese marine and coastal ecosystems, in this chapter we will focus only on this last event.

Expecting a very intensive tourist season, all the 5 tanks housed on site had been filled up just few weeks before. Their total capacity was of 75.000 tons, including 2 tanks of 10.000t each; 2 of 15.000t each and 1 holding 25.000t. The oil was heavy oil – number 6 fuel, which has the following key properties:

- high viscosity, or resistance to flow, resulting in low mobility of the oil;
- high specific gravity (0.95-103);
- tendency to break up into tar balls and sink to the bottom when released into water;
- low volatility, leading to low fuel evaporation.

The oil has a density similar to the one of seawater (UNEP 2007).

The 13th of July one of the 15.000t tank was hit in the first Israeli air strike[15]. Some of the oil burned and some slowly started to lick into the sea because the containing wall has been aslo destroyed during the attack. Data concerning the quantities could not be obtained exactly, since no one could access the site in the critical early days because of the very intensive bombing. The figure presented above therefore is only an estimate. Adopting a very optimistic view, the Ministry of the Environment calculated that 40% of the oil contained in this tank licked. In the next days the fire spread also to the other 2 tanks of 10.000t. The fire is reported to have burned for a total amount of 27 days. The 15th of July, also the 2nd tank of 15.000t was hit and caught fire. The extremely high temperature developed in the area melted the valve of the biggest tank which was not bombed by Israel, causing a slow linkage of the oil in the see.

Due to the intensive air strikes occurring in the area around Jiyeh power plant, no one could access the site to arrest the enormous environmental damage before the 25th of July. Then, it was already too late because the oil still remaining inside the last big tank had reached the flash point (94°C) and started to burn from inside, making impossible any attempt of extinguish it.

Reassuming, the estimations given by the Lebanese MoE are the following:

- Oil burned: 55.000-60.000 t
- Oil spilled: 15.000-20.000 t
- TOT. oil in the 5 tanks: 75.000 t

The consequences of this attack are considered to be among the major environmental disasters that Lebanon and the eastern basin of the Mediterranean Sea were ever subject to (UNDP 2007).

Regarding the oil that spilled in the sea in front of Jiyeh, a great part of it precipitated to the seabed bottom because of its high density and because flowing over the land it had collected sand particles which made it heavier. Witnesses have also reported to have seen the sea surface burning for few days after the attack. This fact would explain the extremely high density found in part of the oil lying on the sea bottom next to the power station (see Fig.7). This circumstance resulted in a thick layer of oil covering the seabed over an area of few hundred meters (UNEP 2007).

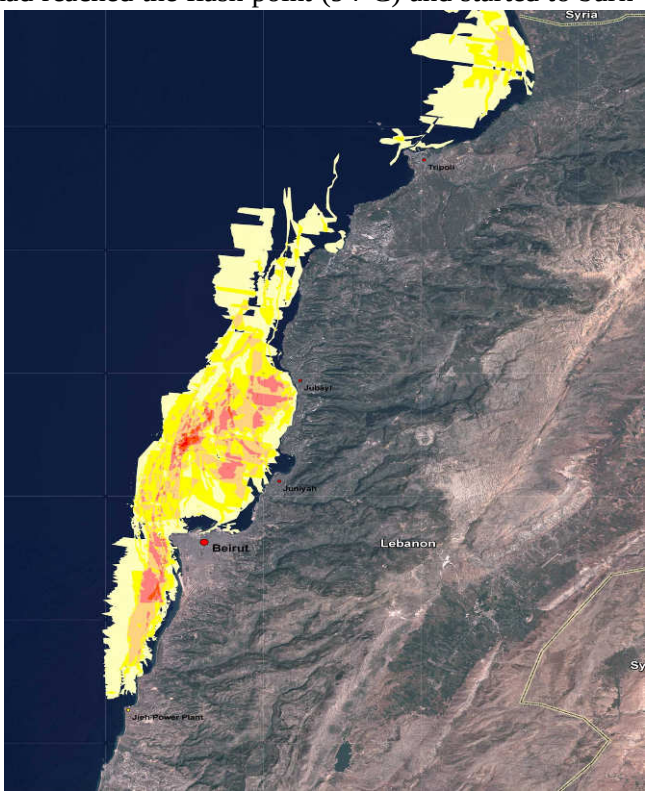

Fig.6: Oil spill extent between July 21st and August 10th 2006. Different colours indicate the number of satellite observations made.
Source: DLR Center for Crisis Based Satellite Imagery.

[15] The description of the facts which occurred in relation to the oil spill is based on the information gathered directly during the numerous interviews with the staff at the Lebanese Ministry of Environment and with personnel at the Jiyeh power plant, and indirectly from the reports issued by UNEP and UNDP (respectively UNEP 2007 and UNDP 2007).

Under the action of winds and general currents running from SW to N-NE, oil slicks drifted towards the north, up to 150 km from the source. On the 2nd of August, some oil reached the Syrian coastline (REMPEC et al. 2006). The fuel got trapped in the cracks of the rocks, in the typical Levantine terraces, or pooled up on the beach because combining with sand had increased its viscosity. Photos provided by the Ngo Bahr Loubnan, the principal Lebanese Ngo involved in the cleaning up process, show that oil penetrated up to 50-60 m inland on beaches and shores, with an average of 30 m. Also ports and marinas were damaged since the oil tended to get trapped destroying fisherman boats and equipments (Kalaf et al. 2006). The lighter part was indeed caught in the northbound current characteristic of this part of the Mediterranean, which took it up the Lebanese coasts, all the way to Al Abdeh in the North, reaching also Tartous in Syria. Therefore the worst effects were reported on the coastline facing west and southwest.

Fig.7: Oil which probably burned before, has deposited with a thick layer on the bottom of the sea.
Source: Bahr Lounan Ngo.

4.3 SCIENTIFIC FINDINGS[16]

Fuel and other petroleum products are complex solutions of up to several hundreds different chemical compounds. All the petroleum-derived fuels have the similar feature of being predominantly hydrocarbons, that is a class of chemical compounds that contain only the elements of hydrogen and carbon (Cole 1994). Their impact on the environment is determined by their chemical and physical properties.

In our case, what we need to look at is the concentration and types of short-chain polycyclic aromatic hydrocarbons (PAH), such as benzene and toluene, and heavy metals as Nickel, Cadmium, Mercury and Lead, found in the Lebanese marine biota. PAH are usually crystalline solid materials having high melting point, low vapour pressure and low water solubility. Their hydrophobicity is the driving force for partitioning of PAH between aqueous and lipid phases, which makes them bioaccumulative. The bioconcentration factor varies between 100 and 10.000 times their level in water, depending on the compound (Afghan and Chau 1989). Studies with petroleum indicate that naphthalenes and phenolic compounds are mainly responsible for the acute toxicity of oils (ibid.). Beside toxicity to aquatic organisms, the greater concern about PAH is their carcinogenic potential, which apply also to human beings. This, together with their possibility to increase in concentration as they move up the food chain, makes oil spillages a potential hazard for the people living in the affected areas. For this reason the American EPA and the WHO both have issued a standard for maximum levels PAH admissible in food, accounting for a number of compounds considered the most toxic and dangerous for human beings. In the case of the US Agency 16 of them are included, while the United Nation Agency set limits accounting for 6 of them. These limits have been used as standards to compare the concentration found in fishes and mussels collected along the Lebanese coast (see Tab.2). On the other hand, the physical properties of oil which are meaningful to understand the potential harms for the environment and the human health are volatility, solubility in water, specific gravity and kinematic viscosity (Cole 1994). These features for the heavy IFP number 6 fuel contained in the Jiyeh tanks have been reported above (see paragraph 4.2). A high kinematic viscosity as in the Lebanon case, has a direct impact on the marine biota since it implies a tendency of the fuel to stick to objects. This causes deaths among marine organisms because their movements are inhibited, which results in animals loosing temperature or drowning; or because they suffocate; or again, because they loose their permeability.

[16] The data presented in this chapter are partly taken from an article published by the centre presenting the preliminary results of the study (Khalaf et al 2006), but mostly from personal interviews with experts and visits to the CNRS centre, as well as personal participation in the scientific activities of samples collection.

Immediately after the second air strike that hit Jiyeh on the13th of July the National Council for Scientific Research (CNRS), in coordination with Ifremer-France, began an assessment plan to evaluate the direct impact of pollution by hydrocarbons on the whole marine ecosystem and monitor its evolution on a long term base. In fact, their strategy is divided in three phases: a short term phase (2006), a mid-term phases (2007) and a long term phase (2008-2010). Being them in charge of monitoring the state of the Lebanese sea for more than 10 years, they have been able to compiled a large database which is used here as a comparison between pre-spill baseline figures and test results. At the time of writing the first phase was completed, and the results are presented below. Nevertheless I had the opportunity to take part in some of the on-going activities and get some direct insights of the evolution of the post oil-spill situation. Samples are collected and analyzed each 15 days and new material is continuously published. The analyses done by the team revealed that the fuel composition in Jiyeh was relatively similar to the one involved in the Erika (outside the coast of France 1999) and Prestige (Spain and France 2002) spills, except for the absence of volatile organic compounds (VOC) which was observed in Lebanon. However this last finding is coherent with the literature[17] which claims that light VOCs and medium molecular weight soluble tend to volatize or dissolve with time, and samples were collected on the 28th of August, 15 days after the spill (UNDP 2007, Khalaf et al. 2006).

The evaluation of the damages occurred to the marine and coastal natural capital of Lebanon is presented here in terms of: (a) effects on primary production; (b) PAHs levels in quantitative bio-indicators; (c) PAHs contamination in natural bio-indicators and in fish muscles; (d) sediment contamination; (e) effects on biodiversity.

The choice of these variables as main indicators of the damages connected with a oil contamination of marine and coastal ecosystems has been made on the basis of the recommendations made by the Intergovernmental Oceanographic Commission of UNESCO to the ROPME Sea Area (IOC 1991, Annex VI) in order to deal with the environmental damages occurred to foreign nations during the first Gulf War as a result of the "deliberate torching of an estimate of 700 Kuwaiti oil wells, and the deliberated release of tens of millions of barrels of oil from storage tanks" (Becker 1997). Concerning heavy metals concentration, evidences have been raised (UNDP 2007 and UNEP 2007) that their hazard for the environment is higher in terms of air pollution and not much for marine ecosystems. Moreover the results presented by CNRS did not show any evidence of contamination of fish by mercury, cadmium or lead (findings presented on the 22nd of August to the MoE).

Primary production. Primary production is the production of energy (typically molecules such as glucose or other sugars) and oxygen from atmospheric or aquatic carbon dioxide, principally through the process of photosynthesis. It represents an extremely important service provided by marine ecosystems to human beings, namely the absorption of anthropogenic CO2. Hence oceans work as *carbon sinks*, playing a role in the global carbon cycle and climate regulation (Chisholm et al. 2001). The organisms responsible for primary production in the oceans belong to the family of phytoplankton, and although they account for less than 1% of the of the photosynthetic biomass, they are responsible for around half of the carbon fixation on Earth (ibid.). Furthermore, their importance derives from the fact that they form the base of the marine food chain, and hence they are essential for the resilience of the whole ecosystem itself.

In the light of this considerations, the effects of oil on primary production were calculated by measuring the levels of *Chlorophyll a* and counting nano and microphytoplankton population in samples taken in different spots of the Lebanese coast. Comparing the results with the data of the same period in 2005 (see Tab.1), a net decrease in the concentration of chlorophyll a was noted, which implies a great reduction in primary production activities. In fact, the layer of oil which extended on the water surface by occluding light has most probably caused the drop in photosynthesis by phytoplankton. This however was only temporary, and in October (last column in Tab.1) the concentration of Chl *a* was higher that the one in 2005, indicating a recovery situation in the water column.

[17] Scientific evidence of this phenomenon for PAH with a low molecular weight can be found in the literature. See Afghan and Chau 1989.

	Concentration of Chl *a* (mg/m^{-3})						
Sites	**August**		**September**			**October**	
	2005	**2006**	**2005**	**5/9/2006**	**25/9/2006**	**2005**	**2006**
n.1	0,31	0,22	0,36	0,08	0,11	0,01	0,09
n.2	0,73	0,37	0,70	0,37	0,17	0,20	0,11
n.3	0,36	0,28	0,30	0,20	0,17	0,13	0,08
n.4	0,23	0,12	0,15	0,06	0,14	0,03	0,14
n.5	0,12	0,20	0,31	0,45	0,08	0,06	0,30
n.6	0,99	0,20	1,02	0,13	0,52	0,13	0,28
n.7	0,55		0,52		0,14	0,18	0,37
n.8	0,35		0,20		0,15	0,09	0,13
n.9	0,43		0,23		0,13	0,06	0,13
n.10	0,74	0,19	0,50	0,21	0,67	0,06	0,30
n.11	5,89	2,18	1,54	0,61	2,67	0,33	2,47
n.12	0,33		0,30		0,07	0,10	0,17
n.13	1,61		0,50	1,23	1,51	0,45	1,74

Tab.1: Comparison of concentration of Chl *a* (mg/m^{-3}) in the 3 months after the oil spill and the same period in 2005. Source: Source: Khalaf et al 2006.

Concerning phytoplanktonic populations, the quantitative studies have not shown a general decrease in the number of organisms, but an impact instead has been recorded in the specific diversity and at the level of the cells. To this extent, cells have been found distorted and many were empty and without chloroplasts. The little impact found on these organisms is justified according to the CNRS experts because of their really short life and the fact that they reproduce very quickly. This favours a continuous replacement of the individuals, which therefore hinder pollutants accumulation.

PAHs in mussels. Mussels are considered particularly good bio-indicators of petroleum hydrocarbon contamination for several reasons. Firstly, molluscs have no enzyme system to metabolize petroleum hydrocarbons (unlike crustaceans, echinoderms and most other marine organisms); they consequently bioconcentrate fat soluble substances. Secondly, as they are filtrating organisms, they are exposed to any dissolved or particulate substance present in the water. The analyses were performed on the wet tissue of mussels collected in October along the Lebanese coast. The results are presented in the following table, and they use the standards set by the American EPA and WHO for evaluating PAH concentration. Benzo(a)pyrene, one type of PAH, is here presented alone since it has been recognized by the EU Scientific Committee on Food as a marker for the occurrence and effect of carcinogenic PAH in food (Commission Regulation EC No 208/2005).

	Mussel Sample 1	**Mussel Sample 2**	**Mussel Sample 3**	**Limitations (µg/kg d.w)**
EPA-PAH[18] method (µg/kg d.w)	15,93	2242,4	375,88	EPA maximum concentration 500
WHO-PAH[19] method (µg/kg d.w)	4,51	1442,6	197,81	WHO maximum concentration 200
Benzo(a)pyrene (µg/kg)	0,58	26,3	9,51	EU maximum concentration 10[20]

Tab.2: PAH concentration in the tissues of three mussel samples collected along the Lebanese coast, measured with two principal methods put forth by the US EPA and WHO. Next to the results there are the EPA, WHO and EU limitations, which work as a means of comparison. Sample number 1 was collected from an area outside the influence of the oil spill and can therefore be used as reference sample. Source: Khalaf et al 2006.

[18] The American EPA has set limitation for the concentration of PAHs in food using the 16 considered most toxic and carcinogenic.
[19] WHO has instead selected 6 of them and set the limits in relation to their concentration.
[20] Limitation on the concentrations of Benzo(a)pyrene in bivalve molluscs imposed by the EU through the Commission Regulation EC No 208/2005.

The results show that mussels have been contaminated by the oil spill. This has been confirmed also by UNEP in the analyses performed by its team. This circumstance poses a direct risk on human health in case molluscs are eaten by people, but also indirectly since they are part of the marine food chain, and therefore they can be in the long run drivers for bioaccumulation. Moreover these organisms constitute the primary prey that support commercial and non-commercial fish and are expected to lead to an acute reduction in fish larvae and adults. Fishing activities in Lebanon are still part of a sector in which subsistence economy predominates, fisheries are artisanal and traditional, and fishermen and their families survive by eating what they haven't sold in the market. This means that the risk of contamination is higher, as well as the environmental losses in monetary terms, because the ecosystem is first of all a "life-supporting" system (Jansson et al. ed. 1994).

PAHs in fish tissues. Fishes have been caught in nets in October 2006 and the dissection of fish muscles has been carried out in the CNRS laboratories. The aim was to assess whether contamination occurred in the form of direct pollution or bioaccumulation. None of the sample analyzed showed PAHs levels exceeding the "advisory/admissible" level imposed. Furthermore, UNEP analyses revealed that the concentrations are identical for fish from different areas and in species from different trophic levels (UNEP 2007), meaning that no bioaccumulation has occurred yet. The explanation given by the CNRS experts is based on the fact that the ability of fish to metabolize PAHs makes them of considerably less concern as a dietary source of PAHs if compared, for instance, to mollusc bivalves. However this result does not indicate absence of ecological/physiological/biochemical pressure for the marine ecosystems. Indeed, it has been reported that persistent ecological impacts have often taken time to manifest and have sub-lethal but chronic and large-scale effects. For instance, in the Exxon Valdez Oil Spill in Alaska, some fish population collapses did not occur until 3 years after the initial spill (Steiner 2006, quoted in UNEP 2007). This evidence invalidates the meaningfulness of the results obtained so far. The actual effects can indeed still be hidden by the initial resilience of the ecosystem analyzed.

What has been observed instead was a massive presence of fish and crab carcasses on different beaches, and a decrease in the abundance of fish in the sea. Anecdotic evidences collected by talking directly with the fishermen in the port of Batroun (10th February 2007) show that often in the months following the war the nets for fishing have been found empty, or with only one fish. These episodes seems to find a justification not really in the effect of the pollution per se, but in the fact that fish can smell the odour of oil, and this has most likely made them escape form the area.

Sediment contamination. Benthic meiofauna have frequently been used as a potential bio-indicator of pollution of the sediments by oil spill (Khalaf et al. 2006). In fact these are specific species living in the soft bottom and the intertidal zone of the sandy beaches and therefore they are directly effected as soon as the oil deposits.

Meiofauna taxa	**0 m Depth**		**10 m Depth**	
	29 August '02 (ind./10 cm2)	**24 August '06 (ind./10 cm2)**	**29 August '02 (ind./10 cm2)**	**24 August '06 (ind./10 cm2)**
Nematodes	1221	53	2314	2554
Oligochaetes	381	0	3	1
Polychaetes	1	0	24	152
Harpacticoides	1	0	179	14
Nauplii	4	0	22	0
Cyclopoides	3	0	1	0
Bivallves larvae	1	0	7	0
Total	**1611**	**53**	**2550**	**2721**

Tab.3: Summary of the mean Meiofaunal density (individuals/10 cm2) at 0m and 10m depth, before and after the oil spill.
Source: Khalaf et al. 2006.

The results indicate that oil hasn't had the time to affect sediments at 10 m depth. Meiofaunal response to pollution occurred only at the wave-washing zone.

Effects on biodiversity. The UNDP report published in February 2007 classifies the impact on marine biodiversity from oil spill from Jiyeh power plant as a long term (10-50 years) severe damage (the highest grade of the scale). Protected areas and fragile ecosystems, as the Palm Islands Nature Reserve, were directly harmed by the fuel released. The direct effects are degradation of ecosystems, deterioration of vegetation, disturbance to wildlife, and destruction of delicate habitats. In general it is likely that slow moving and benthic species have been the highest affected fauna in the places where the oil sunk in the seabed.

Effects on marine turtles (Caretta caretta and Chelonya mydas or Green Turtle) are still highly unknown, and the long term outcomes have not been displayed yet. In fact the hatching seasons for these creatures is between July and September, but due to the war before and the sea blockade imposed by Israel after, it was hard to reach the three main nesting location and control the state of the new born. From my conversations with key informants (Bahr Loubnan Ngo director, Ministry of Environment, CNRS staff, Prof. Khalaf) it was difficult to infer a common version of what has really happened. Only one turtle has been found dead because of the oil spill. However it is reasonable to believe that all the eggs deposited in 2006 on the beaches north of Jiyeh were hardly harmed by the oil which lied unclean on the shores for weeks, before any intervention could take place. Whereas eggs entered in contact with the oil they die. This means that between 2.000 and 5.000 eggs have been contaminated and spoiled as a direct consequence of the oil spill. In fact exposure to residual oil on beaches as well as offshore waters may result in sub-lethal effects including carcinogenesis, physiological and reproductive impairment (Steiner 2006 quoted in UNDP 2007).

Concerning marine birds, they are affected by oil spills, either by being oiled, or through acute poisoning, decrease in reproduction, or damage to the food source. In the short term no cases of dead animals have been reported, only some oiled birds were observed in the Palm Island Natural Reserve (UNDP 2007). It is expected that others could have been exposed, yet went unnoticed as they might have stopped in unmonitored areas along the shoreline. However the effects, as for fish, are likely to show up in the future since it takes time for the pollutants to scale up the trophic levels.

4.4 DISCUSSION

Even though the results of the analyses presented above are only preliminary, some conclusions can be indeed drawn. The marine and coastal ecosystem has been affected mostly at the lower level of the trophic chain, with the primary production activities being halted because of the impossibility for the light to filtrate through the water when the layer of oil was covering the surface and because of the high mortality of nano- and microphytoplankton. The actual state of the water appears, at the time of writing, clear and clean (personal observation along the coast), and the function of gas regulation recovered to normal levels. In fact, high temperatures, water salinity, oxygen and bacteria dissolved in the water, together with tides and waves are important factors that allow an auto-depuration of the water. Observations conveyed that photodegradation have occurred in the Levantine terraces of the Lebanese coast and on the sides of rocks and cliffs exposed to the sun. However, if we look at previous experiences of oil contamination, we notice that to a great extent the rate of biodegradability of fuel is attributable to its chemical composition (Oudot 2000). The richer in biodegradation-resistant or refractory compounds, such as resins, asphaltenes and polycyclic saturated and aromatic compounds, the slower and less efficient the process of biodegradation is. In an experiment done with the Erika oil spill which, as assessed in paragraph 2.3, is quite similar to the Jiyeh heavy oil, over an 80-day period the total fuel was only 11 % degraded, while an Arabian light crude oil for example was 65% degraded under similar conditions and a gas oil over 85 % degraded (ibid.). Therefore, we can expect a long term persistence of the oil in the marine environment.

At the moment, the risk of contamination remains high for sediments. As shown above, at the time of measuring oil hadn't had the time for affecting meiofaunal population, but with time submerged oil becomes covered with sediment and frequently goes undetected. Winter storms and wave action can normally return the oil to the water column where tends to re-pollute coastlines that were cleaned. The magnitude of this problem is very complex to evaluate. Estimations on the quantity of oil that has already been cleaned are very hard to obtain, due to the fact that many different subjects were involved in the cleaning activities. Furthermore I don't posses the means for calculating the limitation of the global damage by bio- and photo-degradation. This is in fact another factor to take into consideration. The problem of deposition of oil on the seabed however has to be considered since it can pose a relevant environmental harm, mainly to turtles coming to nest on the Lebanese sandy beaches.

Concerning fish community, evidences of PAHs contamination were not found. However, if we are to make forecasts on the long term damages suffered by marine biota, this result is not very reliable. Also, concerns have been raised because whenever an ecosystem is known to have a high degree of endemism as well as high species diversity, both characteristics found in the Lebanese coastal ecosystem, this gives rise to concern that the relative impacts on individual populations or species may be higher than normal (UNDP 2007).

Concluding, another indirect but relevant environmental issue is the substantial amounts of hazardous waste generated by the clean up activities and which disposition displays an environmental cost for Lebanon. In fact, oil collected from the surface of the sea contains debris such as seaweed, wood, plastic materials of various types, oily sand, gravel, pebbles, rocks, sorbent materials, gloves and other materials used during the clean-up process. This issue will be examined in the next chapter in terms of costs associated to the treatment and disposal activities.

CHAPTER 5: ENVIRONMENTAL COST ASSESSMENT OF THE DAMAGES CAUSED BY THE OIL SPILL

5.1 INTRODUCTION

The cost of environmental degradation can be understood as a measure of the lost welfare of Lebanon due to this form of harm (WB 2004). This process requires to place a monetary value on the consequences of such degradation. In fact, ecosystems hold different functions which are defined as the capacity of providing goods and services that satisfy human needs (de Groot 1992). In this sense, using the neoclassical economic discourse, they have an economical value. Over the years a number of methodologies have been developed as a vehicle to integrate ecological understanding and economic considerations concerning these services[21]. They have often been based on the differentiation between a *use value* and a *non-use value* of natural resources. The first case occurs when a change in the resource affects market behaviours. In this case the cost to society is very straightforward to calculate, since it is revealed directly in market prices (Direct Market Evaluation). It does not matter whether the change in the resource is real or it is only a common belief, rather it is important that it causes a direct impact on the market, mirrored by a shift in the demand or in the supply. For instance the popular fear for a contamination of the fish as a consequence of the oil spill turned into a net decrease in the demand of fish. On the other hand a resource is said to have a *non-use value* when a change in it is not reflected in market behaviours. This usually occurs when the resources is not marketable, there is not property for it, or its utility is not well acknowledged by the population yet. This last aspect is relevant when we consider the environment. In fact a current non-use value may turn into a use value in the future, when more knowledge are available on how ecosystems function. However, in all these cases the price is not set by the classical encounter between supply and demand, and it can therefore be more complex to establish. It is also said that the resource has a shadow price. Alternatives methods have therefore been proposed by scholars. Table 4 reports a brief overview of the principal one.

Methods	**Description**
Indirect Market Evaluation (or Behavioural Methods)	When goods or services are not exchanged in the market, then we must resort to more indirect means of assessing values. Willingness To Pay (WTP) or Willingness To Accept compensation (WTA) for the availability or loss of these services are therefore used as proxies for consumer's preferences. These can be calculated through desk studies, observations, role games etc. which attempt, observing the reaction of people in response to changes in public goods (either in real settings or with role play), to reveal the shadow price associated with different natural resources.

[21] Daily 1997 and Garrod and Willis 1999 provide a detailed compendium on describing, measuring and valuing ecosystem services.

Methods	Description
Contingent Evaluation	This methodology is indeed similar to the one presented above, but it require an active participation of the consumers. Researchers pose contingent or hypothetical questions to respondents, face them with scenarios that involve the description of alternatives, thus inducing responses that trade off improvements (or maintenance) in public goods or services for money. For example, a survey questionnaire might ask respondents to express their willingness to pay (i.e. their stated preference as opposed to revealed preference, see above) to keep the park existing in the neighborhood they live in.
Group Evaluation	Another approach to ecosystem service valuation that has gained increasing attention recently involves group deliberation[22]. Derived from social and political theory, this valuation approach is based on principles of deliberative democracy and the assumption that decisions of public goods should result, not from the aggregation of separately measured individual preferences, but from open public debate.
Avoided Cost Method	This method is usually adopted in those cases when a loss can occur as a result of a damaging action, and it is not easy to estimate the loss itself. In these circumstance "the value of the services that allow society to avoid costs that would have otherwise incurred in the absence of those services" (Farber:388) is instead calculated. However, it is only a proxy of the value of the asset on stake. It is the case, for instance, of the cost of waste treatment to avoid health costs.

Tab. 4: Brief overview of the different accounting methods to reveal shadow prices of natural resources.
Sources: Farber et al. 2002, Garrod and Kenneth , 1999

Debates have arisen on the scientific accuracy and soundness of the techniques presented above. For instance the choice of adopting such an utilitarian view of nature (which is the standard approach used in economic theory) could be argued on the basis that it might lead to biased results since only useful and known ecosystem services can have a monetary value. Conversely, when the utility of a specie is unknown its value would equal zero. Moreover, as the field work in Lebanon has demonstrated, the applicability of such methods to complex realities is often very hard and requires resources, time, a certain level of education of the respondents or alternatively extensive databases on consumers behaviours etc. My field study evidently was not characterized by these features. Lebanon is a complex country, with at least six major religious groups (CIA 1983, retrieved from www.reliefweb.int on 5th May 2007), that has experienced 25 years of civil war and many years of foreign occupations. Background data are therefore not available on many issues, the actual political instability made it hard to gather many people together or to undertake extensive surveys, and furthermore my time was pretty limited.

Given all these features, I tried to find alternative and more handy methods of cost assessment, which find their rational in the existing literature on ecosystems functions, goods and services (Jansson et al. 1994) and on the neoclassical theories of value. They will be explained and backed up in details in the relative sections. However it is here important to describe the steps followed. Firstly, since the main focus is on the oil spill, the ecosystem functions carried on by the Lebanese sea and coastal areas have been assessed. To do so the list provided in Costanza's article on the value of the world ecosystem services (Costanza 1997 B) has been used as a checklist[23]. Once these functions have been identified, their impairment has been assessed on the basis of the data provided in Chapter 4. Whereas this was not feasible, for different reasons that will be described in the relative sections, the loss to the goods or services provided was instead measured. In fact, using Costanza, "we use the term value to mean the contribution of an action or object to user-specified goals, objectives or conditions (Costanza 2000)".

The value obtained from these calculations does not have a normative purpose, but it must be considered instead for its instrumental value (Goulder et al. 1997). Following from the aims of this thesis, the final figure helps in getting an immediate picture of the magnitude of the damage occurred to the Lebanese marine and coastal ecosystem, and by no means wants to be exhaustive or exact. It is instead operational in supporting the main argument of the need of international intervention to protect the environment during armed conflicts.

[22] See Wilson and Howarth, 2002; Jacobs, 1997; Sagoff, 1998.
[23] See Appendix 1 for references.

The relevant damages caused by the oil spill occurred, according with this paper, to the following ecosystem services:

- gas regulation and climate regulation;
- food production;
- amenity services.

5.2 LOSS TO GAS REGULATION AND CLIMATE REGULATION SERVICES

Atmospheric Co2 is absorbed by oceans in two main processes. On one hand it exchanges constantly with the Co2 contained in the oceans surface, and this leads to an equilibrium between the atmosphere and the surface of water. Co2 dissolves in water, forming a weak acid that reacts with carbonate anions coming from the slow weathering of rocks and water to form bicarbonate (Falkowski et al. 2000). This has been called the "solubility pump". On the other hand there is the "biological pump" that also contributes to the absorption of atmospheric Co2 by the ocean. This occurs through a process of photosynthesis carried on by phytoplankton communities and that has been described in the previous chapter. Around half of the carbon dioxide fixed on Earth occurs through the oceans. These processes keep atmospheric concentration of Co2 150 to 200 ppmv (part per million) lower than it would be if phytoplankton have to die (ibid.). Hence oceans, through this service, play a critical role in regulating Earth temperature.

In Chapter 4 the impact of the slick of fuel on primary production activities, which are commonly carried out by ocean ecosystems, has been described. As we have seen there, the effects seem to have been so far limited due to a series of causes, i.e. the prompt and effective emergency response of the Lebanese authorities, civil society organizations and international community; the ecosystem resilience and its ability to auto-recover from such damages through features such as biodegradation of pollutants. All these variables make the evaluation of the potential damage that could have occurred as a consequence of the deliberate Israeli air strike very hard to undertake. Moreover there is a recognized lack of knowledge to predict the ecological impacts of disturbances to these complex systems, since "it is difficult to determine the causal relationships between human actions and ecosystem functions and processes" (Bingham et al. 1995). Also, ecosystem services can be appraised only after those services are well understood, yet predicting how ecosystem service flows will change as a result of human intervention is often difficult or impossible. In economic terms the lack of scientific knowledge on ecosystem dynamics and interdependence implies that their real utility will be underestimated, and consequently the occurrence of the phenomenon known as market failure. The price/cost is inaccurate and too low, therefore the exchanges do not satisfy the condition of Pareto efficiency.

Here, I have decided to present the potential damages to gas and climate regulation services in terms of expenditures needed to avoid long term damages and restore the environmental conditions in place before the war. This method refers, in its general terms, to the Avoided Cost Method (AC) put forth by ecological economics (Farber et al. 2002) and described above. International law justifies as well the methodological choice made here, since it prescribes that a directly injured State might choose between *restitutio* and compensation. But when the damage has been caused to the environment and it goes beyond national sovereignty or control, as in the case of the Jiyeh oil spill, "*restitutio in integrum* appears to be, at least theoretically, the best method of redress" (Aznar-Gómez M. 2001). This methodological choice leads of course to an underestimation of the real value that could have been lost, that in some aspects it is not even foreseeable. However, looking at the jurisprudence on similar cases (for instance Puerto Rico *v.* SS Zoe Colocotroni case, example quoted in Aznar-Gómez M. 2001) and bearing in mind the core concepts of sustainability, the one provided is considered the most verisimilar figure.

The limitations to this choice will be discussed at the end of the paragraph nevertheless.

METHODOLOGY

Ecological Restoration has been chosen to evaluate the avoided costs of damage. This concept, according to the Society for Ecological Restoration (SER 2004:2), implies the ''process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed''. It includes therefore any action that endeavours to restore to the prior conditions (or to the condition that would have existed before the pollution incident has occurred) any population injured or lost as a result of the spill, or that replaces for the injured resources, or that provides another positive environmental offset to the damage suffered (Steiner 2006). Another definition claims the importance of "establish[ing] a functional

ecosystem of a designated type that contains sufficient biodiversity to continue its maturation by natural processes and to evolve over longer time spans in response to changing environmental conditions'' (Clewell et al., 2000). Recovery or restoration of an ecosystem is achieved when ''it contains sufficient biotic and abiotic resources to continue its development without further assistance or subsidy'' (SER 2004:3). In case of an anthropogenic and localized damage as an oil spill, an ecosystem can be considered recovered when the distribution and number of the population of the organisms is at least equal to the average previous the spill. Steiner in the post conflict assessment on Lebanon suggests also another characteristic, which is that "people [should] have the same opportunities for the use and enjoyment of natural resources as they would have had if the spill [did] not occur" (Steiner 2006).

The concept used here implies, for several reasons, a much narrower range of activities. First of all, according with the data on the damages available so far and presented in the previous chapter, impacts on the fish stock have not been recorded, with fish catches being even higher than the same periods before the war (FAO 2006), and the marine flora is recovering quite quickly. This implies that no replacement is needed in terms of marine biome. Moreover, there are not statistics on the pre-war marine and coastal situation which could be use in comparison to evaluate the changes and consequently the amount of work needed to restore the antecedent conditions. Thus, the cost of restoration includes here the amount of money that will be spent by the Lebanese Authorities[24] for carrying on two main activities: all the operations related to firstly the clean up of the fuel from shores and sediments; and secondly the treatment of the hazardous waste generated by the firsts.

The rational behind the choice to operate such a division is that the fist part of the process has been mainly ensured by international organizations which have selected and directly paid contractors to undertake the operations. On the other hand, the responsibility for dealing with the very high amount of solid and liquid waste produced is entirely up to the Lebanese MoE, which at the moment of writing is collecting and storing them in two facilities in south and north Lebanon. Once all operations will be finished, they will have the authority to decide the better way to treat them as well bearing the costs of it. Therefore the assessment of the total cost to restore the pre-war conditions of the marine and coastal ecosystem has to be split in these two entries: the total cost of cleaning the estimated 15-20000t of oil which contaminated around 150 km of coast, and the cost to dispose the waste. The calculation will evidently makes use of assumptions and estimations, since the clean up activities are still under process and no compiled data are available.

$$\text{Share of ecosystem value threaten by the oil spill} \approx \text{Cost of restoration} \approx \text{Total expenditures for clean up activities} + \text{Liquid and solid hazardous waste disposal}$$

ESTIMATION

1. Total expenditures for cleaning up activities

Monthly the Lebanese MoE updates a progress report where the status of the polluted sites is reported together with the subject undertaking the activities. Being still in the "Phase I"[25] part of the remediation strategy makes impossible to have a real figure of the total amount of money that will be spent to recover the marine and coastal ecosystem. Hence, an estimation is needed, based on the extrapolation of the average cost of cleaning per unit of work (1 km of beach). However, some issues made this attempt fairly complex. First of all, the number and nationality of the organizations involved in the post-emergency activities is very high and this made very challenging the attempt to contact all of them, some having already left the country, and get their financial data. According with the MoE 80 Ngos, 30 private companies, 10 international organizations and 31 countries participated in the activities (data revealed by MoE in a conference at the University USJ the 26th February 2007). On the other hand, the legal structure of these organizations has been observed to impact considerably on the order of magnitude of the expenditures per unit of work. This of course occurs for a number of reasons, as the presence of foreign experts, the equipment used, the living standards assured to the employees etc. As it can be easily expected, for instance,

[24] These information have been obtained either directly at the Lebanese MoE, or in their official website (www.moe.gov.lb).

[25] Priorities has been decided in the International Assistance Action Plan published the 15th August 2006. The document is available on www.moe.gov.lb. Phase I includes clean up of the most polluted sites and of those presenting the highest environmental concerns.

Ngos have primarily worked with volunteers, cooperative of fishermen and other types of civil society organizations, environmental activists as well as residents, who have often offered their time and work for free. Therefore by looking at the break down of the budgets obtained from a sample of organizations (one Ngo, one American company hired by USAID and the Greek company that won the bid put up by UNDP), an enormous difference emerges in the expenses supported.

Finally, some specific factors also hamper the clean-up operation, causing a consequent variation in the costs. Amongst them:

- the geological nature of the rocky shore (porous limestone);
- the presence of copious floating debris; and
- the strength of the waves action to which beaches were exposed (difficult for recovery in water) (REMPEC 2006).

However, since the cost of restoration was chosen as a proxy (underestimation) of the potential loss of natural capital that would have otherwise occurred to Lebanon, a unique measurement for the costs of the cleaning activities must have been found. In fact the value of sea ecosystem is likely to be similar worldwide. Thus, to satisfy this norm, market prices of labour are used for all categories of workers. In this way we imply the existence of a single cost-opportunity for working hour, that is the salary obtained to work somewhere else instead of Lebanon. The costs presented by private companies hired by International Organizations is adopted as the standard market price. In fact, if no volunteers would have been available, or if the slick would have occurred in another country where the cost of life were different from Lebanon, those prices would have been the same.

The 150 km of coast affected has been cleared and the total cost is presented in the table below. Concerning submerged oil, only one Ngo have carried out the cleanings. From the conversation with the President of the organization, which provided me with the data, it was not possible to establish the number of people taking part in the activities or the details on the material used. This is why market prices could not have applied in this circumstance.

Sites of clean up	Average cost per km	Total Cost per type of area
Contaminated shores	173.000 $/km	25.950.000 $
Submerged oil		250.000 $
TOTAL		**26.200.000 $**

Tab.5: Average cost per km of the areas cleaned. The costs associated to coastal activities are at market prices, whereas for the sediments the total costs do not account for externalities.

Judgment on the work done by the single entity was not undertaken, because of the difficulty on accessing reliable information. In fact as stated in the Action Plan (RAMPEC 2006) “standard of clean-up to be achieved will be decided by the group in the course of action”. With these premises, the cost of cleaning per km of beach is the only unit on measurement of the cost of restoration, and evaluations of efficacy or effectiveness do not enter the equation.

The figure obtained has to be considered an underestimation of the real value of the natural capital rescued. As specified above, the labour put in cleaning the submerged oil has been highly underestimated, since the cost presented mirrors the bill of the Ngo that carried out the activities. It is thus evident that the labour cost of an Ngo does not equal the market price. Beside the voluntary work that do not show up in the final expenditures, they also had free access to most of the equipment and materials, as boats, diving equipment, bulldozer, etc. (personal communication with the President of the Ngo).

The budget foreseen by the MoE at the beginning of the clean up activities, and presented in the Donor Conference in Paris held in February 2007, was in the range of $ 12 and 20 Million. The reason why these estimations are lower than the one calculated above lies in the fact that the latter do not included externalities, such as the free contribution of Ngos and environmental activists.

2. Liquid and solid hazardous waste disposal

The clean up activities generates a high quantity of waste in different forms, which are considered as hazardous waste due to the toxicity of the fuel. So far, this has been collected in waterproof barrels and bags,

and in some cases in large containers. Evidences (UNDP 2007 and personal experience) have shown that these storage boxes have often been left near the boarder coast line with the risk that water currents would re-locate them.

Once the "Phase I" will be completed it will be transported to two secure storage sites in Lebanon which belong to the Ministry of Energy and Water, until the management and final treatment plan will be decided. This is a very delicate phase, because inadequate storage, handling and disposal of recovered oil waste could easily result in transporting the pollution inland with high possibility of secondary contamination of water resources, soil and air. There are a number of different possibilities to ultimately treat, recycle or dispose the hazardous waste, the objective of course being to reach the highest level of efficiency and an outcome which is as environmentally friendly as possible. The disposal option chosen will depend upon the amount and type of oil and contaminated debris, the location of the spill, environmental and legal considerations and it is likely to involve very different costs (UNDP 2007). To what concerns the total quantity of waste, in this early moment it is extremely hard to estimate. Historical data shows that oil spill impacting the shoreline can, in extreme cases, produce up to 30 times more waste than the volume of oil originally spilt (IFPMA, 2006).

Based on literature review, UNDP has provided a review of the typical treatment and disposal options with regard to different categories of collected oil-spill waste (UNDP 2007). To this extent it must be said that Lebanon generally lacks the necessary infrastructure for waste management, and this aspect reduces the range of possibilities to handle this situation. Particularly lacking are hazardous waste landfills and industrial incinerators, which are options typically used in developed countries to treat and dispose of hazardous or special wastes (ibid.). The aim here is not to undertake a cost-benefit analysis of the alternative options, but only to give to the reader an idea of the order of magnitude of the expenses that the Lebanese Government is facing. To do so the two extreme alternatives (the cheapest and the most expensive) are described and compared in table 6. For liquid oil waste one is the alternative that is more likely, and would be more logical, to undertake. Whereas for solid waste two alternatives are presented. The total cost, therefore, will be found summing "technique 1" to one of the two alternatives for processing solid waste. This will give the final range of costs.

Techniques for disposition	**Cost**	**Quantity**	**Total cost of treatment**
Liquid/oil waste			
Technique 1: Re-use directly as fuel source	- 40 $/ton for liquid oil processing; - 20 $ - 60 $/trip at 10m3/trip for transport.	1.236 m3	**51.440 $ - 55.000 $**
Solid Waste[26]			
Alternative 1 Technique 2: Re-use as raw material in cement industry	- 20 $ - 60 $/trip for low contaminated sand; - $200/ton for co-processing the heavy contaminated parts in kilns.	3.800 m3 low contaminated sand or debris + 3.800 m3 highly contaminated	**910.000 $** **- 1.216.000 $**
Alternative 2 Technique 3: Export under Basel Convention	10.000 $/ton	7.600 m3	**76.000.000 $**

Tab. 6: Different alternatives for the Lebanese Government to dispose the hazardous waste deriving from the process of clean up. They are differs according with the two principal typologies of wastes: liquid and solid. In the first case only one alternative is presented, while for the latter the choice can be made between Alternative 1 and 2. Therefore, the total market cost that Lebanon will face is the sum of Technique 1 plus either Alternative 1 or 2.

[26] This entry includes: Semi-solid waste, Polluted Sand, Polluted Pebbles, Polluted debris and Polluted equipment.

For the sake of the evaluation the total waste produced is divided into "liquid/oil waste" and "solid waste". These are very broad and general categories used by the Ministry of Environment in compiling its Progress Report and applied here with the aim of calculating the cost of treatment alternatives. In fact the two types have to be handle in completely different ways. The quantities are estimated on the base of the last Progress Report available[27], and should therefore be considered very conservative estimations.

Fig.8: Containers to collect by the Ngo Bahr Loubnan during the cleaning of rocky beaches

Re-use directly as fuel source. Liquid oil collected from the sea can be reprocessed in local refineries or private companies in order to improve its quality level. A de-emulsification (solid to liquid) and decanting (separate oil/water) process are necessary. In fact in its raw state the level of salinity increases the chance of equipment corrosion (UNDP 2007). The recovered oil is mixed with heavy fuel oil and finally used as a fuel source for heavy energy consuming industries. Cement, glass and smelting industries are available in the country and could be used for such a purpose. This method will provide immediate and permanent disposal of liquid oil, even though environmental concerns are present. The main issues related to this choice are that in this way traditional and not environmentally sound methods to produce energy are encouraged, and local air quality will undergo a degradation due to industrial furnaces not equipped with air pollution control units.

The estimation of the costs associated to the different alternatives have been calculated using data provided in the UNDP Report (UNDP 2007) for rubble removal in Beirut southern suburb and for incineration. The total cost ranges between $51.440 and $55.000.

Re-use as raw material in cement industry. In this case we need to make a difference between the lightly polluted solid waste and heavy polluted one. In fact the first category can be used directly as solid fuel for cement industry (UNDP 2007, GTZ-Holcim 2006) and therefore the only cost to account for is the transportation expenses, while the latter would need before a co-processing in cement kilns. Woods, plastic, and other macro-waste can be processed in such a way, and the experience in Holcim France for the Erika oil spill case in 1999 is an example.

For the sake of the calculation, in this paper we assumed half of the solid waste collected to be low contaminated sand or debris and the other half heavy contaminated. Estimated cost for treatment in cement kilns could reach up to 200 $ per ton, which includes pre-processing costs and additional monitoring requirements to abide by the Stockholm Convention. This process provides an immediate and permanent disposal option of waste. In case the Lebanese Government will decide to undertake this way the costs faced would range between 910.000 $ and 1.216.000 $. This solution is alternative to the third one, i.e. to export the solid waste under the rules of the Basel Convention. Therefore the costs presented just above need to be summed with the first technique option.

Export under Basel Convention. Basel Convention on transboundary movements of hazardous wastes was ratified by act of law 387/1994.

This last choice satisfies the need of handling hazardous waste as the country does not possess the adequate disposal facilities within its borders. The Convention in fact provides that "Parties co-operate with each other in order to improve and achieve environmentally sound management of hazardous wastes and other wastes" (Art.10). This means that a State can ask to export the waste to another State party of the convention, with the aim of allowing a more environmentally sound treatment. However this process can result very expensive. A study made by the American University of Beirut (AUB) have shown that one ton

[27] MoE, List of polluted sites update, March 2007.

of chemical waste disposal could cost up to $ 10.000. This amount of money covers the charge of disposal per consignment, transport and contingency fee. Whether this was the choice of the Lebanese Government the estimated costs would rise to $ 76 Million.

Alternative 1 for the Lebanese Government would be, strictly economically speaking, the cheapest alternative. It implies the choice of re-using the liquid waste recovered after the cleaning process directly as fuel in heavy energy consuming industries, and the transfer of the solid waste to cement factories, where it could be employed in their production process. The amount of money spent in this case would be in the range of $ 961 thousand to $ 1,26 Million.

Alternative 2 instead uses again the same technique for the disposal of the liquid waste, but adopts the indications established in the Basel Convention for the international transfer of hazardous solid waste generated during the clean up activities. This alternative is extremely expensive due, as explained above, to the high costs of exporting toxic waste. The amount of money Lebanon could be asked to pay rises to $ 76-77 Million.

LIMITATIONS

The main limitation to the methodology applied is that the assessment doesn't account for the quality and effectiveness of the process of clean up undertaken by the Lebanese Authorities.

Secondly, other activities to restore a healthy ecosystem life might be needed once this preliminary process of cleaning is finished and other scientific results will e available. Those are not estimated here. Therefore, the result proposed must be considered an underestimation of the real damage.

Concluding, the negative environmental outcomes of the different choices are not accounted in terms of their economic cost, even though their existence is recognized by the author and they are mentioned in the qualitative description of the treatment methods. Coming mainly from the contamination of public goods (air pollution in case of fuel burning, soil contamination in case of disposing them in land fills) these costs are not reflected in the market, nor in the cost of the different alternatives. Unfortunately, due to a lack of resources and data I couldn't evaluate their price for Lebanon.

CONCLUSIONS

Above I have tried to give an overview of the benefits and constrains of some of the choices the Lebanese Government has to handle the huge environmental concern posed by the disposition of a high quantity of hazardous waste. Moreover, this was generated in a fairly limited amount of time and therefore the country did not have enough time to organize itself. The values have to be considered an underestimation of the real costs, since the total amount of waste that will be generated is still unknown. The ongoing clean up activities in fact are producing new debris and contaminated material every day, and it is hard to establish when the process will end.

Adding up all the costs estimated through the above calculations, the cheapest alternative would cost between $27 and 28,4 Million. On the other hand, the second alternative – which applies the extremely expensive Basel Convention for the disposition of the solid waste - will cost to Lebanon around $ 102 Million. However this must be taken as the maxim possible range of cost, since it is likely that not all the solid waste are so heavily polluted to need to be treated under the condition set by Basel. Unfortunately, at this early stage, the nature of the waste collected was not possible to estimate with higher level of accuracy.

		Total cost of restoration of the Lebanese marine and coastal ecosystem contaminated by the oil spill
Clean up activities + Alternative 1	Re-use directly as fuel source of the liquid waste + Re-use as raw material in cement industry of the solid waste	**$27 – 28,4 Million**
Clean up activities + Alternative 2	Re-use directly as fuel source of the liquid waste + disposition of the solid waste under the Basel Convention	**$102 Million**

Tab.7: Cost of restoration for the damages occurred as a direct consequence of oil spill. Proxy of the value of natural capital otherwise spoiled.

Just to have some term of comparison, the clean up of the Haven incident in 1991, occurred off the coast of Italy, when 10.000 to 20.000t of non burnt crude oil spilled close to Genoa coast, the Italian and French authorities spent around $108,8 Million (exchange rate €/$ of the 17th of May 2007) for clean-up operations. Another example is the Erika incident off the French Atlantic coast in 1999, spilling 20.000 tons of heavy fuel and generating response costs estimated by the French authorities at $190,4 Million (IOPC Fund annual reports 1991 to 2004, exchange rate €/$ of the 17th of May 2007).

5.3 LOSS TO FOOD PRODUCTION

An assessment of the damage occurred to this ecosystem in terms of impairment to the function of food production, as a direct consequence of the oil that spilled from the Jiyeh power plant after the two Israeli raids, could be done by looking at the economical loss occurred to the marine fishing industry. In fact, this is the economic sector that capitalizes on the goods (fish) provided by the marine natural capital of Lebanon. The total loss for the sector can be split in two parts: firstly the lack of income generation for the 63 days that fisherman could not undertake their activities. In fact all the fishing activities were interrupted during the 33 days of war, and after that, once the hostilities ended, fishermen were unable to access the sea for other 30 days because of the sea blockade imposed by Israel. In the second place, an economical damage occurred as a consequence of the drop in fish price caused by the decrease in the demand.

The firs part of the damages cannot be directly ascribed to the oil spill per se, since in the first weeks after the oil spill, when a large quantity of fuel was still floating on the Lebanese sea, fisherman were prevented to go out and fishing anyway because of the two reasons mentioned above (hostilities and sea blockade). Hence this loss will not be included in the estimation provided in this chapter. In such a circumstance we assume that the oil pollution didn't impact them until 9 September, when the block was lift. That is indeed the day when I'll start to calculate the impairment occurred. Furthermore, from the interviews with fisherman and with the staff of different organizations involved in the process of clean up (Bahr Loubnan, USAID, MoE, CNRS) it results that on the 9 September fuel had already either deposited on the bottom of sea or along the Lebanese shore, and only small bulks of floating oil were still visible (Chadi Mehanna, MoA). Thus, the fishing operations per se have not been affected. On the contrary, evidences have been presented that catches in September and October were even higher than the baseline data from the same periods in previous years (FAO 2006), probably due to the renovate intensity of the activities, driven by the necessity of recover from two months of no income.

Reassuming, an economical evaluation of the damage occurred to this ecosystem service will take into consideration only the drop of the demand of fish, which was driven by a common belief among consumers that fish could have been contaminated. The lack of demand led to a decline in prices. Evidences, collected personally in the interviews with fisherman and fish retailers and conveyed as well in the FAO Report, shows that prices in the first months after the hostilities were around half the normal level.

SOUCES OF DATA

The data used to evaluate the damage have been collected through a triangulation of sources and methods, in order to assure the highest reliability. Key informants have been met and asked to validate the findings presented below. Quantitative and qualitative data were collected and combined to get an exhaustive picture. The first type was obtained from national institutions as the Ministry of Agriculture for what concerns the design of a baseline scenario to compare with the post-war situation. These were confirmed with information from international institutions, mainly UN agencies (ESCWA, UNDP, UNEP, FAO), which has published reports and made analyses on the legacies of the conflict. But the fuzziness that characterizes the Lebanese accounting system made necessary to validate the information available with interviews to people which had been directly affected by the phenomenon studied. Again, actors belonging to different levels in the fish production chain were interviewed on the same issue. Fishermen, fish marketers and members of Ngos that have worked closely with fisherman cooperatives in the post-conflict emergency formed the sample. Also, I assisted to fish auctions that are daily held to sell the fish caught during the night. The interviews were mostly unstructured, aiming at highlighting the relationship between the sea and the people directly depending on it, and the changes caused by the oil spill. The meaning of the qualitative data collected was double. From one side I wanted to understand which were the important aspects to take into consideration to measure the damages occurred to the ecosystem function of food production. From the other

side I wanted to verify the information about the drop in fish price reported by the different International Organizations (FAO 2006, UNDP 2007) and understand who were the actors that eventually borne this loss.

The lack of resources, the difficulty in communicate, the issue of accessibility to many locations due to the wide deployment of troupes and the suspicion of the fishermen themselves made impossible for me to use revealed methods and contingent evaluations to assess the economical damages.

ESTIMATION

The estimation of the economical loss is made by comparing the pre-war income on fisherman with the one they had this year. Calculations, methodology and detailed values are provided in Appendix 2. Figure 9 represents the fluctuation of income for the fisherman, before and after the war. The area between the two curves (coloured in orange) is the loss suffered, which amounts to $ 5 – 7,5 Million.

This figure however must be taken as an underestimation of the real loss occurred. In fact, the curve that should represent the evolution of the demand after the war is very optimistic, as it assumes that the price of fish in March had grown back to the pre-war levels. From the interviews undertaken indeed, and from assisting at the auctions held to sell fish, it was clear that in some area of the country the prices were still below the normal level, and the consumers confidence towards the safety of the local fish was still lower than usual. Foreign fish was still preferred to local fish and sold first, behaviour unlikely to occur before the oil spill (opinion of the interviewees).

Fig.9: Fish bid at the Daura Cooperative in Beirut. Picture taken on the 3rd of March 2007.

• METHODOLOGY, ASSUMPTIONS

The "pre-war income" (the red line in the graph, see Appendix 2 for the values) has been calculated multiplying the fortnight fish catch recorded before the war for the average first-sell price of fish (an average of 8 to 12 $/kg), i.e. the real income for the fisherman. The data about the pre-war fish catches are a mean of the 2000-2004 data for annual marine fish production in Lebanon (ESCWA not yet published), calculated by knowing that 42% of the yearly catches are in summer (FAO 2006). To this value, the "estimated income" obtained in the five months during which time the price has fluctuated is subtracted. The amount of income after the war has been calculated by assuming that fishing activities, halted during wartime and sea blockade, began again the 9 September, day when the price dropped to half. Hence, it remained at this lowest level until the 20 of October, when the MoE and MoA held a press conference where presented some preliminary results indicating that

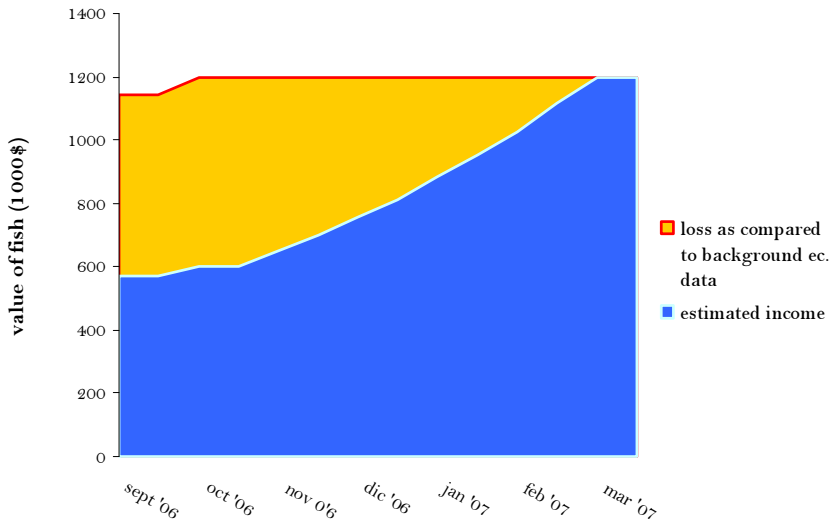

Fig.10: Difference in fishermen income before and after the war. The section in orange represents the real losses of income occurred.

fish was not contaminated with PAH and it was therefore secure for people to eat it. From that moment the price started to grow again, influenced by a gradual restoration of consumers confidence that made the demand increase. I assumed a parabolic pattern of the price trend that led it, in the first day of March, back to pre-war levels. The choice of this precise day is also an assumption based on the information gathered from the interviews with fisherman and fish marketers.

The monthly catch for this years is hypothesized to be unchanged as respect to the previous years, and because of the lack of statistics that made it impossible for me to use real figures, this is the best estimate possible.

Regarding the yearly contribution of the fishing industry to the Lebanese GDP, this figure has been calculated taking the 2002 output value of fishing products (Ministry of Economy and Trade 2005), which amounted to 56 Billion Lebanese Pounds calculated at current prices (2002). Appling to it the yearly price inflation (www.cia.gov/library/publications/the-world-factbook/geos/le.html, retrieved on 20th March 2007) I consequently obtained the estimate value of fishing products for 2006. That is 62,7 Billion Lebanese Pounds, which in 2006 US $ the value would amount to $42 Million.

LIMITATIONS

The result presented in the previous graph includes only the loss for fisherman. In this way it has to be considered an underestimation of the real loss for the sector, since it accounts only for the first round of sales. However it is recognized here that the supply chain which characterizes the Lebanese fishing industry is much more articulated and it encompasses different agents or intermediaries who have of course borne part of the losses. But the impossibility of calculating the added value to the product contributed by each intermediary in the successive passages, due to a chronic lack of statistics and data typical of the Lebanese system, prevented me from calculating in more details the damage occurred, and forced me to provide this as the best approximation possible.

A second assumption I made to be able to calculate the loss is that all the fish caught went sold in the bids with the reduced price. This is not completely true. In fact during the interviews made with fisherman and fish marketers often it has been raised the fact that some of the fish went unsold even at the new very low price. But the impossibility of collecting data on the spoiled fish forced me to make such an assumption.

CONCLUSIONS

Total economic loss for the fishing sector	**$ 5 – 7,5 Million**

Tab. 8: Total economic loss supported by the fishing sector. It represents the loss occurred to the ecological function of food production carried on by the marine ecosystem.

The loss occurred represents between 11,9% and 17,8% of the yearly contribution of the fishing industry to the Lebanese GDP. If we consider the brevity of the conflict (only 34 days) in relation with other previous or on-going wars, as well as the relative value of this loss as compared to the total harms to the Lebanese environment presented in Chapter 3, we have an idea of the potential risk natural resources undergo during armed hostilities.

Such a loss is extremely meaningful also in terms of sustainable development. In fact it has long term outcomes for a poor community based on small-scale activities and a basically subsistence economy as the fisherman community in Lebanon is. If we then summed this result to the amount of money that fisherman did not earn because they were prevented from going out and fishing for more than one month due to the warfare situation, the situation becomes even more serious. Many fishermen not having any other form of income beside the fishing activity, was forced to borrow money, which often came with a very inconvenient interest. This situation locked many of them in a spiral of debt that will be difficult to extinguish (FAO 2006).

5.4 LOSS TO AMENITY SERVICES

Another aspect that makes reasonable to consider nature as a form of capital is the fact that it provides a “spatial configuration of materials to enhance the welfare of humans” (Costanza et al. 1997 B). This is the case of what is called here *amenity services*. The concept is recognized also by the World Bank when

calculating the cost of environmental degradation in the country: "[t]he coastal zones and cultural heritage of Lebanon represent unique cultural, ecological, economic and recreational assets (WB 2004). The principal amenity services accounted in this chapter will be:

- aesthetical and recreation services, namely those services with a potential economic value due to the possibility of exploiting them through tourism and sport activities;
- hedonistic services. These respond more often to non commercial uses, as the possibility to relax, enjoy, reflect, maintain a mental health (de Groot in AAVV 1994) given by nature;
- refugia, that is the habitat for resident and transient populations. In the case of Lebanon these are mainly turtles and migrant birds.

• METHODOLOGY AND ASSUMPTIONS

The monetary value on the damage occurred to the aggregate ecological concept of amenity service is approximated to the sum of the two factors presented below:

$$\text{Cost of Amenity Service degradation due to the oil spill} \approx \text{Loss supported by the tourist sector} + \text{Current and long term damages to sea turtles}$$

A third variable should have been included in the function above, and that is the non-use value of the Lebanese coast. With this concept we refer to the mere value given by the population living in the country to the simple existence of sandy and rocky beaches. This is what in the literature is called hedonistic service. Since this value depends on behavioural, social and emotional features, its quantification needs special techniques that try to bring out consumers preferences which are not revealed in the market. This can be done through methods of contingent evaluation or indirect market evaluation (also called Behavioural Methods). They use figures as the willingness to pay (WTP) or the willingness to accept (WTA) forms of compensation for the availability or loss of these services, as proxies for consumer's preferences[28]. In Lebanon there are records of attempts to revealed the WTP of its population to have cleaner beaches (see Owaygen 2002, included in WB 2004). However, for the sake of the overall calculation of the losses undertaken in this paper, the economical damage in terms of utility lost will no be included. In fact, it is considered to be a possible duplication of the money spent in cleaning the coastal area. In fact these two events (loss in aesthetical value and coast of restoration) are alternative situation and they won't occur together.

Going back to the formula presented above, the first entry was thought a proxy for the damages occurred to aesthetical and recreational services, and accounts for the people that didn't go to the beach or to beach restaurants or yachting clubs because the sea was black (or because they thought it was black). The distinction between the real facts and the perceived ones it is not made, since both are caused by the same event (oil spill) and lead to the same result (economical loss). However, the war caused so many impediments for people, both direct (i.e. destroyed buildings, contaminated beaches) and indirect (i.e. psychological and emotional on the tourists that were afraid for the political instability of the country, and material in terms of roads and bridges destroyed) that it is impossible to distinguish the impact of the oil spill on the decline of tourism from the other damages caused by the war. The losses, as representative of the 2006 season, have been calculated nevertheless, and the results are presented below, but they are not added at the end to estimate the total cost of degradation attributable to the oil spill.

Considering the very strong effect of a negative worth of mouth (this fear, and awareness, has been noticed also in the interviews with beach resorts and restaurants owners), the sensitivity of the demand to the visual conditions of the beaches, and the long time span needed to erase negative visual inputs (which in the case of the Lebanese oil spill flooded the media), long term consequences on tourism are very likely to occur. However it is too difficult to estimate them, since too many variables (elasticity of the demand, political instability of the country, economical losses that pushed some of the beach resorts owners out of the market, etc.) are involved and can influence the final outcome. Hence, only a qualitative prevision of the long terms outcomes is provided.

[28] See Tab.4 above for a more detailed description of these methodologies.

The second variable entering the calculation represents the ecological cost that can be attributed to the impairment of the peculiar function holds by the Lebanese coastal ecosystem to give a refuge to transient animals, caused by the oil spill. This value is calculated in terms of damages occurred to sea turtles that yearly come to nest on the Lebanese coasts. In fact marine turtles' life cycle is linked to onshore and offshore coastal habitats. For this reason, they are important indicators of environmental impacts since their survival depends upon the health of these habitats (Chaudhury et al. 2003, quoted in Aureggi et al. 2005). Moreover they are important animals, both in terms of their relative number compared to the whole Mediterranean region and because they are protected species that use the Lebanese coasts for nesting and reproduction. However, estimating the overall damage is very difficult at this point of time for several reasons. First of all, there is the problem of establishing the magnitude of the danger threatening the turtles community. In fact reliable information on what happen during the war are not available, and data on the actual state of the beaches, where turtles come every year to lay their eggs, are still vague and contradictory. Official sources (MoE and international contractors) claim that "Phase I" of the clean up strategy is complete, that is all the most urgent and contaminated spots have been cleaned, and "Phase II" is about to start. Unofficial spectators I interviewed (journalists, Ngos, environmental activists) have reported instead that on beaches treated as cleaned, are on the contrary still polluted, with oil hiding under the first layer of sand. This circumstance seems to have occurred because of the waves activity that have transported clean sand on the top of the polluted one. If this speculation is proved real, sea turtles that will come to hatch between May and July may be exposed directly to oil residuals. This event would result in acute mortality and/or sub-lethal effects as carcinogenesis, physiological and reproductive impairment (Steiner 2006); or their eggs risks to die due to the contact with the underlying oil strata. Secondly, the cleaning activities, as highlighted before, are still on-going. Hence, the actual scale of impact of the oil contamination will greatly depend on the speed at which the activities will proceed before May and on their quality.

The UNDP post-conflict report on Lebanon (UNDP 2007) classifies the impact on marine biodiversity from oil spill from Jiyeh power plant as a long term (10-50 years) severe damage (the highest grade of the scale). Acknowledging this fact, the level of uncertainty is nevertheless too high, and it prevented me from accounting for the long term impact of the fuel contamination. In such a circumstance in fact estimating a monetary value for the degradation occurred could be extremely speculative. Thereof I have decided to account only for the turtles directly affected during the 2006 season. The ecological value of these animals is therefore explored and turned into economical terms.

The process of choosing the value of a single turtle affected has not been an easy and straightforward task nevertheless[29]. In fact, them being a protected species in many countries, among those there is also Lebanon, implies that their exploitation is prohibited. They are a resource that is not accounted in the market, and therefore their value is not established by the classical encounter between demand and supply. As previously explained, in economic theories the value of a good (or service) derives from the benefits the society, or the single consumer, can receive from it. In case of public goods it is advisable to consider the whole society. Concerning turtles, the important ecological role they play within the ecosystems that host them is generally widely recognized (Troeng S. et al 2005, Bjorndal 1985). But it is indeed their extraneousness to and almost no interaction with the world of human that complicate the process. Moreover in the case of Lebanon, numerous evidences have demonstrated me that the value put by the society on sea turtles is relatively low. Lack of monitoring activities, the inexistence of structures and initiatives that enhance their tourism value, the inexistence of a strict legislation that punishes who harms the turtles, the lack of post war monitoring on the effects on this specific category of animals are among the examples that made me reach such a conclusion.

Considering all these reasons, a survey on a sample of the Lebanese population for understanding their willingness to pay for assuring to turtles a clean and safe environment where to come and reproduce should be undertaken. Unfortunately the lack of resources and the time constrains did not allow me to do so. Therefore, in the absence of any other parameter to estimate the value I decided to adopt the penalty fee established by the Lebanese Government for whoever is found guilty of killing one exemplar as a proxy of the value of a single turtle. In legal terms the fine is considered as the value lost by the society as a whole

[29] The review of literature on similar cases didn't present any useful suggestion on how to assess the non-use value of natural resources as turtle.

because of the crime, and it can also be considered as the estimated sum that would prevent people from committing the crime, in our case killing turtles. Therefore, in one sense, it could be considered the value the Lebanese ascribe to the life of a single sea turtle. I am aware of the limitations of such a methodology, but I couldn't find a better estimate. The MoA, through decision 125/1 dated 5/10/1999, has prohibited the fishing or killing of sea turtles. The Environmental Lebanese Penal Code has established that violators of this law will be imprisoned from a minimum of 6 months to a maximum of 1 year, and they will have to pay a pecuniary penalty between 10 and 20 Million Lebanese Pounds, that is between $6.700 and $ 1,4 Million.

SOUCES OF DATA

Data concerning the structural characteristics of the Lebanese tourist sector have been drown from the interviews carried on with the President of the Association of Hotels in Lebanon and the President of the Association of Beach Resorts. These information were very useful in order to understand the variables and the main economical drivers of the sector, and hence to foresee the most probable outcomes the oil spill had. Quantitative data that have not been published yet, but have been discussed among the categories and with the MoT, have also been collected during the interviews. These are validated by the documents obtained by the Department of Studies, Research and Documentation of the MoT concerning the total arrivals by nationality for the periods 2004, 2005, 2006 and the firsts months of 2007. Unfortunately all these data are extremely aggregated, and this has created some problems in the analysis.

On the other hand, interviews with beach resorts and restaurants owners have been useful for gathering a more qualitative picture of the situation, for understanding the trend of recovery and the long term effects for the sustainable development of the region. However the data gathered needed a severe process of filtering. In fact it was extremely hard to obtain a level of objectivity in the answers. For instance, it was quite normal to hear from the interviewed that no oil had reached his/her resort, even where on the rocks clear signs of fuel were still present. According to my interpretation, the fear that the negative worth of mouth that had spread after the oil spill occurred and that they had contributed to quench, could have gained strength again, ruining also the up-coming summer season, led them to deny completely all the evidences concerning oil contamination.

ESTIMATIONS

1. Tourism

Tourism and related industries are estimated to account for between 10 and 12% of the GDP (central Bank of Lebanon), amounting to $4,5 Billion (INFOPRO 2006). The category includes: hotels, beach resorts, travel agencies, restaurants, car rental companies (ibid.). WTO in an unpublished report was expecting it to rise in 2006 to the 21% of the GDP, i.e. around $6 Billion, given the performance of the first six months of the year.

Two are main targets of tourists that Lebanon attracts every year. I will call them "cultural tourist", since they principally come to visit the historical and cultural heritage of the country, and "activity tourists", who seek for nightlife, bars and beach parties, water-sports. Hence, we can assert, corroborated by the assertion of the two presidents of the hotel and beach resorts associations and by the World Bank studies on the region (WB 204), that beach tourism for international visitors is very limited.

To these two groups we must add other two typologies of incomers: businessmen and poor and desperate immigrant workers, mainly Syrian labourers and female Asian and East-Asian domestic workers who live in precarious conditions. Estimates talk about more than one million people living in the country (FAO 2006). In fact, being Lebanon an economy based on services it requires a very high number of people for low specialized and paid tasks. Often, and mostly in summer, the occupations available are indeed in the tourist sector, i.e. beach cleaner or waiter, and therefore we can assume that this category was affected, even though indirectly, from the oil spill. The first group on the other hand can be excluded from our analysis since they come directly to five stars hotel in downtown Beirut and never leave the centre of the capital. Thus, most probably they have not at all been concerned for the oil spill that contaminated the coast.

Consequently, if we are to assess the impact of the oil spill on the economic activities that makes use of coastal and sea natural capital as assets to produce an income, we should consider only a portion of the first and the second category of tourist described above, which in their choice could be influenced by the health conditions of the sea, and part of the immigrant workers who might have been penalized as well. However we must add to them the local population that in summertime go to the beach or undertake water related activities.

Unfortunately such a calculation cannot be done in a proper way for a number of reasons. First of all, as mentioned above, the data on the monthly arrivals to Lebanon do not comprise a split for categories of tourists. They include all the people with a foreign passport entering the country, no matter the reason of their visit. Secondly, there are no data that reveals the summer habits of the Lebanese population, therefore it is not possible to estimate how many people go to the beach, rather than choosing other activities or staying at home. Third, as already mentioned previously, the war caused so many impediments for people, both direct (i.e. destroyed buildings, contaminated beaches) and indirect (i.e. psychological and emotional on the tourists that were afraid for the political instability of the country, and material in terms of roads and bridges destroyed) that it is impossible to distinguish the oil spill impact on the decline of tourism from the other damages caused by the war. To control at least for the most important external variables (i.e. impact of the bombings and of the hostilities themselves) I considered the evolution of the tourism from mid August until the end of the tourist season (end of September) in order to avoid wartime. In fact, hostilities have definitely been the major cause that took over all the environmental issues potentially influencing tourists activities. Around 130 thousand people less than the previous year entered Lebanon in that period. This represents a net decrease of 57%. This decline implies as well a decline in strong foreign currency entering the coffers of the State, which is another component of economical loss to take into consideration. Unfortunately no data are available on this issue.

Furthermore, among the people that did entered the country, only a very exiguous number actually went to the beach. Many beach resorts and beach restaurants owners claimed that the Lebanese were the only very few clients they had (data retrieved from interviews with beach resorts owners). As stated before, many are nevertheless the causes that led to this situation. The fear of finding the coast contaminated by fuel is only one of those. In fact, interviews with beach resorts owners highlighted the fact that most of the businesses did not re-open after the war, being too busy in cleaning and fixing their properties, or because the damages to the public infrastructures left them without access from outside, or also because they were pessimistic on the possibility that clients would have shown up again.

Official data on the economical loss that has occurred are not available. Beach resorts owners claim to have lost between 40 and 60% of the yearly income. From my interviews and the unofficial estimates I accessed it resulted that since the end of the war the loss amounted to approximately $32 million/month. That is around $48 Million before the end of the official summer season. This amounts not only represents the loss of income compared to the previous year, but also the investments done expecting “the best summer season since before the civil war” (common feeling found in all the interviewees) and that have not found a coverage, as well as real losses, in terms for instance of the salaries that had to be corresponded to the already recruited personnel.

Forecasts on the long term effects of the oil spill on the 2007 and the next summer seasons are very hard to make, since the internal political instability spread fear and a feeling of insecurity toward Lebanon which still play an important role in halting the recovery of the sector. The opposition sit in that still occupy the whole centre of Beirut, the curfews and the violent manifestation that have bathed in blood the street of the country, the rumour that new clashes between Hezbollah and Israel are likely to occur soon, make the effect that the contamination (real or presumed) of the marine and coastal ecosystem can have on the choice of people to come to Lebanon extremely hard to single out.

The drop in the number of tourists coming from Europe and America documented in the records of the MoT as regards to the decrease in the arrivals from Arab Countries have also implications for the sustainable development of Lebanon and the whole region, directly concerning the social and political pillars of sustainability. In fact it is well known that Lebanon in the past has accomplished an important function of connection between eastern and western culture, between Catholicism and Islamism, it could be considered a laboratory where new forms of integration could be experimented. After the end of the civil war and since the different foreign occupations withdrew from the area, Lebanon was slowly regaining its old role, that, given the new geo-political situation it is now a day even more significant. The July war has definitely interrupted this trend, and the relative decline in arrivals from the different regions of the world stands as a demonstration of this theory. Just looking at the period July – September 2006, western tourists decreased of 31%, while people coming from Arab Countries dropped of 41%. These figures have an even greater meaning when we look at the absolute values of the two types of tourism, being in fact the first category much smaller of the second one. In such a condition the difference in people staying in the country becomes

even more evident. This can be considered a speculation, but from my point of view is instead an important aspect to take into consideration when treating of the future sustainable development of Lebanon, concept that cannot be abstracted from the conditions of the whole Middle-East region.

2. Rifugia

As presented above (see Chapter 3) two species of marine turtles are found nesting along the Lebanese coast: the loggerhead (*Caretta caretta*) and the green turtle (*Chelonia mydas*). Surveys along the entire coast conducted by MEDASSET in 2001 (quoted in Cross et al. 2006) showed that nesting is sparsely distributed, with the southern nesting sites being more important both in a national and regional context. Loggerhead turtle are widespread along the coast from north to south, while green turtles are far less common, and can be observed at specific less developed sites in the south of the country. The nesting season ranges between May and July, and eggs are left to incubate for about two months. Nesting females, once laid their eggs return to foraging areas in the sea (Cross et al. 2006). This implies that when the oil slick reached the shores, around the 20th of July, no adult turtles were likely to be there and therefore to be contaminated. The effect indeed was on the eggs still laying in the nests and on the hatchlings that in that period were probably trying to reach the open ocean.

With these premises, to calculate the plausible damage inflicted by the oil spill to the turtle population, since no data are available on this issue, I proceeded estimating the number of eggs that were most probably laid during the 2006 season.

Loggerhead nests are reported to be, along all Lebanon, between 21 to 100 per year (Aureggi 2005). MAP monitoring program in the South of the country during the 2005 season has found that the minimum estimate has increased. Therefore we can most probably assume a number of nesting in Lebanon for the 2006 season as between 37 and 100. Green Turtles nesting activity, as previously specified, is far less common and according with MAP nesting is confined to the less developed areas in the South, where during the 2002-2005 survey between 0 and 16 nests per year have been recorded. Hence, since the contamination of the shores caused by oil has affected only beaches north of Jiyeh (see Fig.6), this specie will not be included in the calculation of the damages to the population of transient animals. Each nest is known to be formed of a clutch of around 100 eggs, which are deposited in the sand, usually at night. This makes up a total of 3.700 to 10.000 eggs laid along the coast of Lebanon just before the oil spill has occurred. These numbers however have to be considered an underestimation of the real quantity, as they exclude nests outside monitored areas, and the Lebanese coast is largely unmonitored (Kasparek 2004). Assuming that 50% of the nests occurred in the very south of the country, the number of affected eggs (or new born) is between 2.000 and 5.000.

The environmental costs have been calculated with the methodology explained in the "Methodology and Assumptions" paragraph. Eggs laid in the area contaminated by the fuel coming from Jiyeh are considered as spoiled and the hatchlings dead. In fact it is documented that exposure to residual oil on beaches as well as offshore waters may result in sub-lethal effects including carcinogenesis, physiological and reproductive impairment (Steiner 2006 and UNDP 2007). Using the amount of money that the Lebanese Government has set, together with a period of confinement, for whoever kills a turtle as a proxy of the value this animal has for the Lebanese society, the total cost supported by the country ranges between $ 13,4 and $ 67 Million.

Turtles species	**Average nests/year**	**Estimates eggs laid in Lebanon**	**Contaminated eggs**
Loggerhead	37 – 100	3.700 – 10.000	2.000 – 5.000
Green Turtles	0 – 16	0 – 1.600	0
Environmental Cost			**$ 13,4 – $ 67 Million**

Tab. 9: Estimates of the total number of eggs laid by turtles during the 2006 season, and quantification of the amount that is more likely to have been contaminated by oil, evaluated in accordance with their environmental cost.

CONCLUSIONS

As already explained above, the figure about the loss for the tourism sector is too aggregate to be meaningful for the sake of this thesis. Therefore I decided not to included it in the economical assessment of

the damages occurred to the Lebanese marine and coastal ecosystem as a consequence of the oil spill caused by the Israeli bombing. Hence, highlighting once more the fact that the value obtained is an underestimation, the loss to amenity services provided by the ecosystem ranges between $ 13,4 and $ 67 Million.

5.5 CONCLUSIONS

Environmental costs of degradation	
Cost of restoration	$ 27 – 102 Million
Loss to food provision	$ 5 – 7,5 Million
Loss to amenity services	$ 13,4 – 67 Million
Total	**$ 45,4 – 176,5 Million**
% of Lebanese GDP	**0,25 – 1**

Tab.10: Total cost of degradation of the Lebanese marine and coastal ecosystem as a consequence of the oil spill.

Total cost of degradation of the Marine and Coastal Ecosystems due to the Israeli attack to the Jiyeh Power Plant can be assumed to vary in the range of $ 45,4 – 176,5 Million. The very wide range is principally due to the choice of how to dispose the hazardous waste deriving from the process of clean up. In fact, as shown above, the adoption of the Basel Convention can be an extremely expensive option, even though probably more environmentally sound than the other choices. It must be acknowledged that the cost of the environmental degradation connected with the different waste treatment solutions have not been accounted in the calculation. Of course it would have increased the value of the first option vis-à-vis the second, therefore decreasing the gap between the two.

The overall environmental cost presented equals the 0,25 – 1% of the Lebanese GDP. This value shows its significance especially when we look at it in relative terms. First of all, it is interesting to compare it with the total cost of environmental degradation estimated by the WB for Lebanon (WB 2000). This, considering all the environmental categories, amounted to 2,8 – 4% per year. Our assessment instead, as shown in Fig.4, accounts only for a very limited part of the much wider environmental damage caused by Israel attacks. On the second hand, this damage occurred in only 34 days of hostilities. We can therefore image what could otherwise happen when the hostilities last longer time.

These final considerations eventually leaves no doubts on the risk for the environment being seriously harmed during armed conflicts.

5.6 DISCUSSION

The evidences collected personally in Lebanon, as well as from secondary sources (UNEP, UNDP, FAO, WHO, etc.), show the negative consequences that the damages occurred to the marine and coastal natural capital had for the sustainable development of the country. Some of the negative effects are likely to protract in the long term as well. All of the different dimensions of human life which concur to the idea of sustainability, that is the social, the economical, political and also the inter-temporal sphere, have been affected, even though indirectly, by the oil spill.

The economical growth of the country has been slowed down by impoverishing the fishing sector and halting the tourism, which is one of the principal source of foreign currency in the country. In the first case, in only few months between 11,9% and 17,8% of the yearly fishery production has been lost, and even more dangerous, a feeling of insecurity has spread among the consumers who started to buy imported fish instead. In addition, concerns are still high regarding the potential for delayed manifestations of persistent ecological impacts, in the form of sub-lethal and chronic effects. In fact, in some case, as for instance the Exxon Valdez Oil Spill in Alaska, fish population collapses did not occur until 3 years after the initial spill (Steiner 2006, quoted in UNEP 2007). If such a situation would occur, fishermen that are already locked into a spiral of debt because of the immediate losses, would also be neglected the natural capital on which to base a future recovery. Hence, this loss of income and income-generating assets threatens both the immediate livelihoods of the most vulnerable sectors of the population and the sustainability of micro-credit institutions (FAO 2006). However, the present situation not only has economic outcomes. Political tensions and social concerns are other indirect consequences as well. Riots and demonstrations which have frozen the Lebanese political system since November 2006 can be read in this light as well.

The loss of tourism reinforces even more the situation described. Bringing foreign strong currency into the national market, it was one of the striving sectors for the economic recovery of the country after the long civil war that destroyed the economy (WB 2005). When this asset starts lacking we assist to the beginning of migrations among the most educated and wealthy strata of the population toward richer countries where more opportunities could be found. This human and financial capital drain prevents the sustainability of a potential economical growth.

Another concern deriving from the shortage or spoilage of natural capital is the emergence of refugees and displaced people, both at a national and international level. This is exactly what occurred in Beirut after the conclusion of the hostilities. A huge number of fisherman, peasants, kids have moved to the capital searching for other forms of income, since their activities were impaired or destroyed during the war. The difference between targeting natural capital vis-à-vis to human made capital (i.e. shops, small businesses, etc.) is that the latter can most likely be rebuilt with some financial aids, but the first is injured forever, or at least for a longer period. That is why displacement usually concerns people employed in the first sector.

Finally, there are also inter-temporal implications deriving from the environmental losses described. In fact, in case turtles will not return anymore to the Lebanese beaches, or fish catches would decrease permanently, or beaches will remain partially black (as they were when I left Lebanon), the future generations will also be deprived from the possibility of enjoy them. This discourse, which has some weak point, can be drawn back to Sen's perspective (Sen 1999 and 2003) on "individual freedoms" as one of the most relevant human rights. To this extend, the safeguard of today natural resources, even the one that to date have a low utility as regard to the present human needs, can be read in terms of preserving individuals' freedom of choice.

These evidences corroborate the thesis that natural resources must be protected from the harms caused by anthropogenic actions, specially in extreme cases as armed conflicts are, since they provide a fundamental base for reaching a sustainable development.

CHAPTER 6: CONCLUSIONS

The experience I had this summer in Lebanon, at the outbreak of the hostilities with Israel, urged me to seek the reasons why the international community stood immobile in front of the obvious environmental damages that Lebanon was suffering as a direct consequence of the hostilities. Moreover, the evident targeting of the environment compelled me to try to measure the magnitude of the damage and the consequent outcomes for the sustainable development of Lebanon. The results had to shed light on the dangers deriving from situations of non-compliance with IHL. The concept of natural capital used in ecological economic theories was an appealing tool to reach the goal. However, and this is the first conclusion which can be drawn, the definition of natural capital presents some fundamental ambiguities which mostly affect the process of evaluation. In this case study the main concern rose when assessing how much of the loss could be ascribed to natural capital and how much was instead the rate of return on it. The best solution seemed to be evaluating the two aspects together. In the case of beach and sediments contamination, for example, I accounted for the potential losses to natural capital while in the other instances I accounted for the temporary impairments of the ecological goods and services provided. Therefore, the final ecological loss, equal to 0,25 – 1% of GDP, is a combination of the two elements.

Beside highlighting some theoretical matters related to the consideration of nature as an economical asset, the distinctiveness of this work relies on the fact that there are no significant examples of post-conflict assessments or compensation mechanisms that have looked at the environment as a form of capital for the population living in the area. Therefore, damages have never been assessed in terms of natural capital or ecological services and goods lost. Two are the outcomes of this lacuna. First of all, it leads to forms of compensation which does not foresee the main and primary form of reparation: *restitution in integrum* (Aznar-Gomez 2001). The case of the United Nation Commission for Compensation, established by the UN Security Council in response to the environmental disaster occurred in the Persian Gulf during the first Gulf War (see Chapter 2), is an example. *Restitutio par equivalent* has been in fact adopted in that circumstance, and environmental losses have been calculated only using market prices. In this way the environmental harm itself has not been compensated for (Aznar-Gomez 2001). Hence, from an environmental standpoint this solution is highly controversial. It is based on the neoclassical assumption of substitutability of natural

capital with other forms of capital (in this case financial capital). Ecological economists have long argued against this paradigm[30], claiming that ecological services and goods cannot be surrogated by technological progress. Also Sen, fostering the idea of individual freedom, has provided a very enlightening argument for the safeguard of natural resources and for their non substitutability (Sen 2003). In the second place, these types of evaluations have often failed to represent some of the societal categories actually affected by the damages. The poorest layer of society, often working in the informal sector and relying on natural resources to survive, are likely to be excluded from this form of compensation.

Additionally, the methods proposed either by ecological or environmental economics to assess the monetary value of natural resources, once applied to the reality of Lebanon, showed a level of complexity which sometimes made them impossible to be used. Therefore, drawing on the existing literature and on the neoclassical theories of value, I set up peculiar accounting methods which have conversely shown higher handiness and applicability in a complex case as the Lebanese's was. To this extent, this thesis not only has a normative value, enhancing the discourse on the need for better accounting systems to reveal the outcomes of anthropogenic actions on natural capital, but also has an instrumental significance. In fact, it tries to contribute to the establishment of new accounting methods, by showing some preliminary attempts in this direction.

Other main conclusions of this work follow the topics which have been the red thread throughout the whole thesis. That is: (a) the inefficiencies of international humanitarian law when it comes to protect natural resources during armed conflicts, and (b) the direct link between armed conflicts, environmental degradation and the hindrance of the sustainable development process. These claims has been supported using evidences derived from the case of Lebanon and discussed in details in Chapter 4 and 5.

The first issue is an elaboration of the positive answer to the first research question, posed at the beginning of the thesis. Objective damages to the Lebanese marine and coastal ecosystem have occurred, and their assessment has been undertaken by measuring levels of PAH on bio-indicators such as mussels and on fish muscles; by measuring the levels of *Chlorophyll a* in the sea as an indicator of primary production and by assessing the effects of contamination on biodiversity. In spite of this, no international interventions has been carried out to regulate a situation of non-compliance with the Geneva Convention or with any other Convention, as described in Chapter 2. This is indeed a proof in support of the reformist paradigm (see Chapter 2) which claims the lack of efficient enforcement mechanisms for the norms put forth by IHL.

Moving to the second point, the destructive potential that methods and means of warfare in use in the world's arsenal today have on the environment (Bouvier 1991) has been demonstrated both with a biophysical evaluation of the contamination of the marine and coastal ecosystem after the oil spill, and with an economic assessment of the damages occurred. From these findings, the trickle down effect on the whole Lebanese society has been explored as well. In fact, the environmental degradation, equal to 0,25 – 1% of GDP (for what concerns the oil spill disaster only), does not end in itself, but has negative social, economic and political outcomes as well. The dimensions are evidently all interconnected and emphasize each other. In fact, limiting the analysis to the consequences of the oil spill, the Lebanese economic growth has experienced a slackening caused by the impoverishment of the fishing sector and the halt of tourism, which is one of the principal source of foreign currency for the country. In the first case, for instance, the outcomes are not just of economical concern, even though losing in few months between 11,9% and 17,8% of the yearly fishery production should not be underestimated. But the spiral of debt which many fishermen are facing and the unavailability of natural capital on which to base a future recovery, for the reasons explained in Chapter 5, create social concerns and political tensions that can have long term consequences. The riots and demonstrations, which have frozen the Lebanese political system since November 2006, can be read also in this light. The loss to tourism has reinforced even more the situation described. The tourist industry in fact, by bringing foreign strong currency into the national market, was one of the striving sectors for the economic recovery of the country after the long civil war. When this asset starts lacking we assist to the beginning of migrations among the most educated and wealthy strata of the population, that move toward richer countries hoping for more opportunities. This situation, acknowledged in the neoclassical discourse, has emerged also during some of the conversations I had with key informants (the President of the Association of Beach

[30] See for instance Daly 1994.

Resorts, the President of the Association of the Hotels and Restaurants and some university students). This human and financial capital drain prevents the economical growth to be sustained in the long term.

Another concern deriving from the shortage or spoilage of natural capital is the emergence of refugees and displaced people, both at a national and international level. This is the reality Beirut had to face after the conclusion of the hostilities. A huge number of fishermen, peasants and kids moved to the capital searching for other forms of income, since their principal activity was destroyed during the war. The difference between damaging natural capital vis-à-vis human made capital (i.e. shops, small businesses, etc.) is that the latter can most likely be rebuilt by means of financial aids, while the first is injured forever, or at least for a long period. That is why displacement usually concerns people employed in the first sector.

These findings have corroborated the statement that "warfare is inherently destructive of sustainable development" (Stockholm Declaration, Principle 24).

A last consideration concerns the inconsistency between the post-conflicts initiatives assessing environmental impacts that have been registered so far[31], and the international recognition of the relevance of accessing natural resources to achieve sustainability. The case of UNCC has already been mentioned, but it is not an isolated case. In fact, the direct damages to the environment are often described just in qualitative terms, without pointing out their links with the other spheres of sustainability indirectly injured. Moreover, in no cases monetary assessments of the losses to natural capital have been undertaken. Therefore, the present thesis opens interesting opportunities for furthers researches, which could contribute to a better understanding of the effects of armed conflicts not just for the victim States, but also for the whole world community, since many environmental disasters have transboundary components.

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[31] See among the others the post-conflict reports undertaken systemically in the last decade by the UNEP office in Geneva. They can be downloaded directly from www.postconflict.unep.ch

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- 6 Members of the fishing sector. February-March 2007

APPENDIX 1: ECOSYSTEMS SERVICES AND FUNCTIONS

Table 1 Ecosystem services and functions used in this study

Number	Ecosystem service*	Ecosystem functions	Examples
1	Gas regulation	Regulation of atmospheric chemical composition.	CO_2/O_2 balance, O_3 for UVB protection, and SO_x levels.
2	Climate regulation	Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels.	Greenhouse gas regulation, DMS production affecting cloud formation.
3	Disturbance regulation	Capacitance, damping and integrity of ecosystem response to environmental fluctuations.	Storm protection, flood control, drought recovery and other aspects of habitat response to environmental variability mainly controlled by vegetation structure.
4	Water regulation	Regulation of hydrological flows.	Provisioning of water for agricultural (such as irrigation) or industrial (such as milling) processes or transportation.
5	Water supply	Storage and retention of water.	Provisioning of water by watersheds, reservoirs and aquifers.
6	Erosion control and sediment retention	Retention of soil within an ecosystem.	Prevention of loss of soil by wind, runoff, or other removal processes, storage of stilt in lakes and wetlands.
7	Soil formation	Soil formation processes.	Weathering of rock and the accumulation of organic material.
8	Nutrient cycling	Storage, internal cycling, processing and acquisition of nutrients.	Nitrogen fixation, N, P and other elemental or nutrient cycles.
9	Waste treatment	Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds.	Waste treatment, pollution control, detoxification.
10	Pollination	Movement of floral gametes.	Provisioning of pollinators for the reproduction of plant populations.
11	Biological control	Trophic-dynamic regulations of populations.	Keystone predator control of prey species, reduction of herbivory by top predators.
12	Refugia	Habitat for resident and transient populations.	Nurseries, habitat for migratory species, regional habitats for locally harvested species, or overwintering grounds.
13	Food production	That portion of gross primary production extractable as food.	Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming or fishing.
14	Raw materials	That portion of gross primary production extractable as raw materials.	The production of lumber, fuel or fodder.
15	Genetic resources	Sources of unique biological materials and products.	Medicine, products for materials science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants).
16	Recreation	Providing opportunities for recreational activities.	Eco-tourism, sport fishing, and other outdoor recreational activities.
17	Cultural	Providing opportunities for non-commercial uses.	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems.

Source: Costanza et al. 1997 B.

* We include ecosystem 'goods' along with ecosystem services.

APPENDIX 2: DATA USED TO CALCULATE THE LOSSES TO THE FISHERY SECTOR

Months	Baseline Price ($/ kg)	Post war Price ($/ kg)	Estimated Income (1000$)		Pre-war Income (1000$)		Loss (1000$)	
sept '06	8 -12	4 - 6	572	858	1144	1716	572	858
	8 -12	4 - 6	572	858	1144	1716	572	858
oct '06	8 - 12	4 - 6	600	900	1200	1800	600	900
	8 - 12	4 - 6	600	900	1200	1800	600	900
nov 0'6	8 - 12	4,32 - 6,5	648	975	1200	1800	552	825
	8 - 12	4,66 - 7	699	1050	1200	1800	501	750
dic '06	8 - 12	5,04 - 7,56	756	1134	1200	1800	444	666
	8 - 12	5,42 - 8,2	813	1230	1200	1800	387	570
jan '07	8 - 12	5,9 - 8,8	885	1320	1200	1800	315	480
	8 - 12	6,36 - 9,54	954	1431	1200	1800	246	369
feb '07	8 - 12	6,84 - 10,26	1026	1539	1200	1800	174	261
	8 - 12	7,44 - 11,16	1116	1674	1200	1800	84	126
mar '07	8 - 12	8 - 12	1200	1800	1200	1800	0	0
	8 - 12	8 - 12	1200	1800	1200	1800	0	0
TOT			**11.641 - 17.469**		**16.688 - 25.032**		**5.047 - 7.563**	

Source: FAO 2006, ESCWA unpublished and personal communications with members of the fishing sector and with Chadi Mehanna, Head of the Marine Fishery office at the MoA.