Investigating the Potential for a PES (Payment for Environmental Services) System for Marine Turtle Conservation

The Case of Protection of Marine Turtle Breeding Sites in Crete, Greece

Zhang Fan

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Investigating the Potential for a PES (Payment for Environmental Services) System for Marine Turtle Conservation: The Case of Protection of Marine Turtle Breeding Sites in Crete, Greece

by

Zhang Fan

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Thesis Assessment Board

Chairman: Prof. Dr. Ir. Eric Smaling (ITC)
External Examiner: Prof. Dr. Petter Pilesjö (Lund University)
Internal Examiner: Dr. Patrick van Laake (ITC)
First supervisor: Dr. Mike McCall (ITC)
Second supervisor: Dr. A.G. Bert Toxopeus (ITC)

ITC International Institute for Geo-Information Science and Earth Observation
Enschede, The Netherlands

Disclaimer

To my grandfather

献给我的祖父

To my parents

献给我的父母

Abstract

Crete Island, one of the most popular tourism sites in Europe, is also the terrestrial habitat of two out of the seven species of sea turtles in the world: the Loggerhead Turtle and the Green Turtle. Because of the increasing popularity of Crete Island as a tourist destination, human disturbance factors are having more and more influence on the nesting habitat of turtles. To protect the turtles in Crete from the fatal disturbances, many measures have been taken but with minimal success .Economists and ecologists agree in a large extent that measures that combine ecological and economic information will help identifying strategies to reverse biodiversity and ecosystem loss. In this case study, the feasibility of payment for environmental services (PES) is investigated for turtle conservation in Crete.

Firstly, the key disturbance factors to turtle nesting and hatching period were identified and the influence of human disturbance on the marine turtle nesting behaviour was quantitatively analyzed using the night light satellite images. The result showed that the night light and tourist number had a positive correlation which means that artificial night light can indicate the level of human activity. The night light strength and nest numbers of different years along the coastline of Rethymno Beach was analyzed and the result showed that there is negative correlation between these two variables. This result implies that human disturbances influenced turtle nesting behaviour to some extent.

Based on this information, we identified and quantified the key features in the turtle conservation PES scheme, which are, environmental services (ES), ES providers (sellers), ES beneficiaries (buyers) and the intermediaries of the scheme. The investigation result showed that: if getting compensated, potential ES providers such as land owners whose land is near the nesting beach can change their behaviour or land use to provide environmental service to mitigate the disturbance factors. The potential beneficiaries of the PES scheme such as potential marine turtle ecotourism organizers and worldwide population (represented by the tourists on Crete) were willing to pay for these ES. These payments could be channelled through the institutional framework operated by PES intermediaries such as local turtle conservation NGO ARCHELON. A primary economic estimation is made for this PES scheme and the result shows that the PES scheme in this case study is very likely to be promising.

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1. Introduction

1.1. Research background

Marine turtles are known to be among the most important indicators of the health of the world's marine and coastal ecosystems(Hayes June, 2005)and are of great scientific, ethical and intrinsic values (Rolston, 1994). The decline of sea turtle population has aroused worldwide attentions during the past decades; and human activities are considered as one of the most important factors leading to this problem (NOAA-fisheries). IUCN (2007) has put 6 out of 7 turtle species into the endangered or critically endangered species of the IUCN red list since 1994 (SWOT, 2006). Crete Island, one of the most popular tourism sites in Europe, is the terrestrial habitat of two out of the seven species of sea turtles in the world: the Loggerhead Turtle (*Caretta caretta*) and the Green Turtle (Chelonia mydas) (Venizelos 2000), and leatherback turtles (*Dermochelys coriacea)* also appear in the ocean in Mediterranean although they don't nest in Crete (Margaritoulis *et al.* 2001). Because of the increasing popularity of Crete Island as a tourist destination, human activities are having more and more influence on the habitat of marine turtles.

To protect the marine turtles in Crete from the fatal disturbance factors most of which are cause by human beings, many measures have been carried out but only with success in some extent. In recent decades, there has been increased recognition that economic factors are behind many human activities that cause declines in habitats and species. Economists and ecologists agree in a large extent that measures combine ecological and economic information will help identifying strategies to reverse biodiversity and ecosystem loss (Troëng, S., 2004). In this case study, a new method of conservation: Payment for Environmental Services (PES) is proposed. PES is a direct and efficient way to promote conservation of biodiversity by bridging the interests of the local people and external actors (Wunder, 2006). In previous biodiversity PES case studies (Mayrand & Paquin, 2004) researches are mostly concentrated in paying for changing specific land uses that are thought to protect many species or biodiversity. However, there has been few research focused on the application of PES scheme for conservation of one species by changing behaviours of people whose activities occurs near the habitat of species. This thesis is attempting to investigate the potential and feasibility of instituting a PES system for conservation marine turtles in Crete, by identifying and quantifying the key features

in the PES scheme: environmental services (ES), ES providers or managers (sellers), ES beneficiaries (buyers), and the intermediaries of the scheme.

Moreover, although there have been many researches on identifying the disturbance factors to the marine turtles, little research has been done on the quantitative relationship between disturbance and the marine turtle nesting behaviour. In this case study, the natural life cycle of marine turtles and disturbance factors to them are comprehensively reviewed, and the relationship between the human disturbances and turtle nesting behaviour is analyzed using the night light satellite image (Version 2 DMSP-OLS Night time Lights Time Series).

1.2. Research objective

1.2.1. Overall objective

✧ Assess the feasibility for constructing a scheme of PES to protect the marine turtles in Crete

1.2.2. Specific objective

- Identify the key sources of disturbances during critical life stages of turtles (nesting, hatching)
- Quantitatively analyze the influence of human disturbances on turtle nesting & hatching behaviour
- Specify the environmental services related to turtles and the important values of the services
- Specify the environmental service providers (managers) in applying a turtle conservation PES scheme in Crete
- Specify the beneficiaries of the environmental services in a potential Crete turtle conservation PES scheme
- Specify the intermediaries and mechanisms between environmental service providers and beneficiaries
- Specify information and spatial information needed for constructing such a PES scheme

1.3. Research questions

1.3.1. Main research question

✧ Is a PES scheme feasible for marine turtle and marine turtle breeding habitat conservation on Crete Island? What are the key elements of such a PES scheme?

1.3.2. Specific research question

- What are the key sources of disturbances during critical life stages of turtles?

- What are the key quantitative relationships between human disturbances and marine turtle nesting?
- What are the potential environmental services related to conserving sea turtles in Crete and what are the values of these ES?
- Who are the potential providers / managers of the environmental services?
- Who are the potential beneficiaries of the environmental services?
- How to link and organize the environmental services providers and the beneficiaries? / Who are the potential intermediaries for the PES scheme?
- What information and spatial information is needed for constructing such a PES scheme?

More specifically, for key quantitative relationships between human disturbances and marine turtle nesting:

- What are the relationships between tourist numbers and turtle breeding numbers over time?
- What are the sources and scales of human disturbances?
- Does the night light image reflect the level of tourist activities?
- What is the relationship between artificial night light strength and turtle nest numbers?

1.4. Research hypothesis

H_1: PES is feasible for marine turtle conservation in Crete
H_0: PES is not feasible for marine turtle conservation in Crete

H_1: Human activities have significant influence on turtle nesting
H_0: Human activities don't have significant influence on turtle nesting

1.5. Thesis outline

This thesis is guided in the sequence of:

Chapter 1:
Introduction to the research background, research objectives, research questions and research hypothesis

Chapter 2:
Methodology and materials

- Study area introduction
- Introduction to field survey (general information of fieldwork, spatial data collection, interviews)

- Method of investigating the correlation between human disturbance and turtle nesting (data description, pre-process of the data, analyze methodology)
- Method of economic analysis for PES scheme

Chapter 3:

- Review of the disturbance factors to the marine turtles during their life cycle;
- Identify the key sources of disturbances during critical life stages of turtles (nesting, hatching);
- Quantitatively analyze the influence of human disturbances on turtle nesting & hatching behaviour ;

Chapter 4:

Instituting PES scheme, aimed at mitigating the negative impacts of human disturbances on the marine turtles in Crete.

- Introduction to PES concepts
- Identify the ES related to turtles and quantify the important values of the services
- Specify the existed and potential ES providers (managers) in applying a turtle conservation PES scheme in Crete
- Specify the beneficiaries (buyers) of the ES in a potential Crete turtle conservation PES scheme
- Specify the intermediaries in the potential PES scheme
- Instituting the potential PES scheme, analyze mechanisms and ES flow between environmental service providers and beneficiaries
- Specify information and spatial information needed for constructing such a PES scheme

Chapter 5:

- Discussion of the result of the correlation between human disturbance and turtle nesting behaviour
- Discussion of the PES scheme constructed in Chapter 4

Chapter 6:

- Conclusion, limitations of the study and recommendation

2. Methodology and materials

2.1. Study area

Crete ("Kriti" in Greek) Island is located in the Eastern Mediterranean area. It is the largest island in the Greek Archipelago and second biggest after Cyprus (interkriti.org 2007). It lies at the southern Aegean Sea and at the junction of three continents Europe, Asia and Africa. Crete covers an area of 8.336 square kilometres. The length of the island is 260km, and the shore-length is 1 046km. the biggest width is 60 km while the smallest is 12km.

The population of the island is about 630,000 (2005), and over a third of it is found in three major cities, Iraklion (about 150,000), Hania (about 50,000), and Rethymnon (about 30,000) located of the north coast of the island. The excellent climate of the island, the sun and the sea, the beautiful landscape and tourist resorts, attract more than 2 million visitors every year and the number is still increasing (GNTO, 2007). The main beaches that tourists visit are also concentrated in the three cities mentioned before.

The climate in Crete is temperate. The atmosphere is normally quite humid, depending on proximity to the sea. And winter is mild and tolerable. Snow fall is rarely seen in the plains, but frequently in the mountains. During summer the temperature range from high 20 centigrade to 30 centigrade(interkriti.org 2007).

2.2. Field survey

2.2.1. General introduction about field survey

The fieldwork was carried through from September to October in 2007. It was divided into three parts:

1) investigation of the situation of the nests (location, surrounding environment and state of protection);
2) investigation of the disturbance sources near coastline (hotels, resident houses, restaurants, bars, discos);
3) Interview different people (local people, hotel managers, and tourists).
4) Visiting institutions dealing with turtle protection, such as University of Crete, Fishery Department of Marine Institution in Crete, Tourism Office of Crete, Tourism Office of Iraklion, Tourism Office of Chania, Tourism Office of Rethymno, Forest Institution of Chania, Forest Institution of

Iraklion, Forest Institution of Rethymno in Crete, Hotel Association of Rethymno and Hotel Association of Chania in Crete and so on.

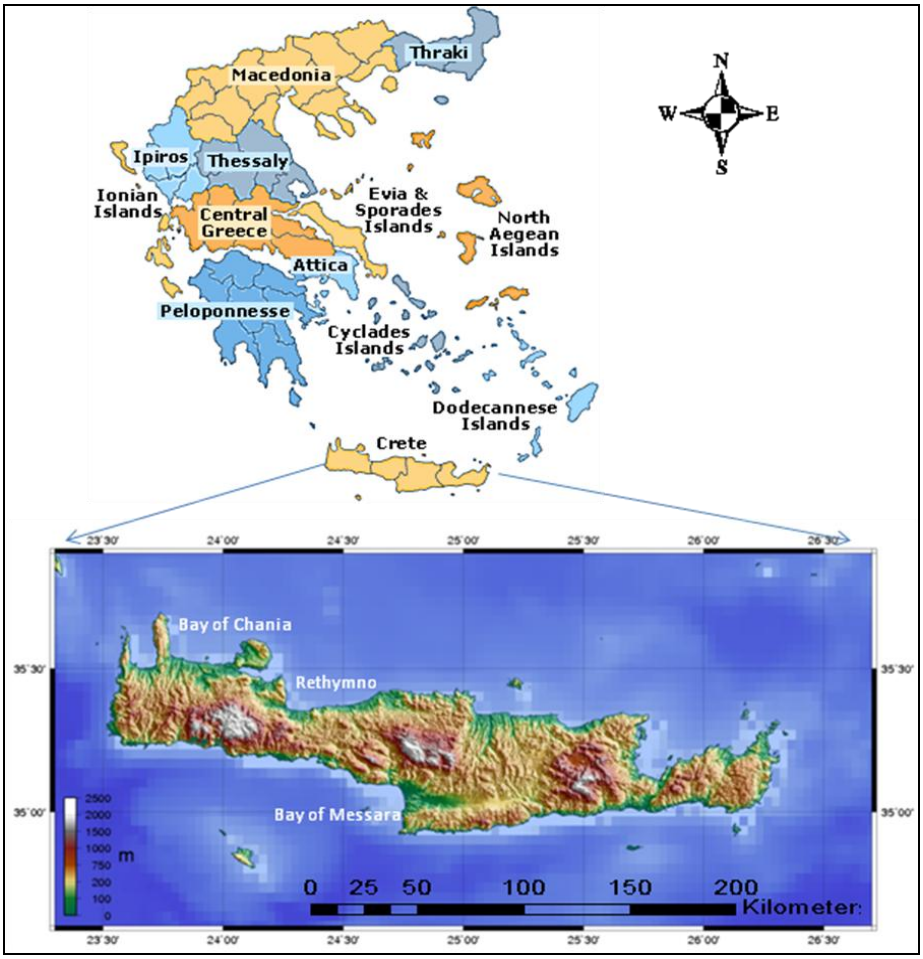

Figure 1 study area, Crete Island, Greece

2.2.2. Spatial data collection

The spatial data collection includes information about turtle nests and the disturbance factors near or on the beach. A GPS and an iPaQ were used to collect the geo-information of the sea turtle nests. Relative information collected included: location of the nests (geographic coordinates), amount of sun bed on the beach, cleanness of the beach, stoniness of the beach, natural barrier height, artificial barrier height and length, the environment around each nest (e.g. distance to the nearest sun

beds, distance to the nearest tourist, distance to the nearest hotel/ bar/ disco/ restaurant /shop parking area/ residence house).

2.2.3. Data collection from tourist interviews

2.2.3.1. General information about interviews

1) Purpose of the interviews: People's willingness to pay one Euro more everyday for two sun beds and one sun umbrella to the sun bed owners to hire people to stack back the sun beds everyday, to give the turtles enough space to build their nests and lay their eggs. Or people's willingness to pay biodiversity conservation tax when entering Crete and how much do they want to pay.
2) Location: Bay of Chania, Rethymno.
3) Tourist choosing: random sampling on the beach

2.2.3.2. Methodology of questionnaire designing

For the interviews to the tourists in Crete, the question designing was based on choice experiment (CE) and CVM (contingent valuation method). Choice experiments are a stated preference methodology that recently has been employed to analyze public preferences towards environmental goods and to estimate their economic value. Choice experiments are a generalized version of the popular dichotomous choice CVM. Whereas CVM analysis presents a respondent with a simple "yes or no" decision for the provision of a particular environmental service at a particular price, CE presents the respondent with a menu of options of different environmental services which are at different prices (Estelle Bienabe & Robert R. Hearne, 2005).

During the interview, the respondents were firstly asked if they are willing to pay for conserving the marine turtle on Crete Island. The respondents who answered yes to this question will be asked in which way and how much are they willing to pay. (Choosing from paying one euro per day for two sun bed and sun umbrella, or paying biodiversity conservation when arriving at Crete airport)

2.3. Method of investigating the correlation between human disturbance and turtle nesting

2.3.1. Method description

The nesting of marine turtles normally happens during night time (Alderton, D. 1988), and with the tourist number increasing (National tourism organization regional tourist office directorate of Crete), the disturbance such as artificial light and noise from the buildings near the nesting beach and increases since the tourists number increase. As C. Chalkias *et al*. (2005) indicate, artificial lighting disturbs the

‘tranquility’ (grade of naturality) of an area. This kind of pollution is directly correlated to the presence of human activities and for this reason is considered of high interest. In this case study, the night light images are analyzed to investigate the influence of human activity to marine turtle nesting behaviour.

Section 2.4 will introduce the methodology and data of investigating 1) the development of night light over all Crete Island, 2) the relationship between the tourist number and the night light of Crete, 3) the relationship between the marine turtle nest number and night light strength along Rethymno beach.

2.3.2. Data description:

A) Night light images:

For the night light study, the satellite data used is Version 2 DMSP-OLS Nighttime Lights Time Series. The files are from the Defense Meteorological Satellite Program (DMSP)/ OLS: Operational Linescan System of the USA. The satellite images are 30 arc second grids, spanning -180 to 180 degrees longitude and -65 to 65 degrees latitude.

DMSP uses satellites of the National Oceanic and Atmospheric Administration (NOAA) in low altitude (830km) sun-synchronous polar orbit with an orbital period of 101 min. Visible and infrared imagery from DMSP/OLS instruments monitor the distribution of clouds all over the world twice a day, once during daytime and once at night time (*Cinzano et al.*, 1999).

The OLS radiometer consists of two telescopes and a photo multiplier tube (PMT). The visible telescope is sensitive to radiation from 0.4 to 1.1 μm. The PMT is sensitive to radiation from 0.47 to 0.95 μm, with the highest sensitivity at 0.55-0.65 μm, where the most frequently used lamps for external night time lighting have the strongest emission. Telescope pixel values are replaced by PMT values at night (Chalkias, Petrakis *et al.* 2006， P. Cinzano *et al.*, 2001).

The DMSP satellites, with the onboard OLS, have the capability to detect faint sources of visible near-infrared (VNIR) emissions on the Earth’s surface, making the detection of cities and towns possible (Elvidge *et al.*, 1997; Croft, 1978).

The files are cloud-free composites made using all the available archived DMSP-OLS smooth resolution data for calendar years. In cases where two satellites were collecting data - two composites were produced. The products are 30 arc second grids, spanning -180 to 180 degrees longitude and -65 to 65 degrees latitude.

A number of constraints are used to select the highest quality data for entry into the composites:

- Data are from the center half of the 3000 km wide OLS swaths. Lights in the center half have better geo-location, are smaller, and have more consistent radiometry.

- Sunlit data are excluded based on the solar elevation angle.
- Glare is excluded based on solar elevation angle.
- Moonlit data are excluded based on a calculation of lunar illuminance.
- Observations with clouds are excluded based on clouds identified with the OLS thermal band data and NCEP surface temperature grids.
- Lighting features from the aurora have been excluded in the northern hemisphere on an orbit-by-orbit manner using visual inspection.

The data I used are the series of: F1?YYYY_v2_stable_lights_avg_vis.tif. The cleaned up avg_vis images contains the lights emitted from cities, towns, and other sites with persistent lighting, including gas flares. Ephemeral events, such as fires have been discarded. Then the background noise was identified and replaced with values of zero. Data values range from 1-63. Areas with zero cloud-free observations are represented by the value 255.

B) Coastline of Crete:

Table 1 data description- coastline of Crete

Type	Polygon
Geographic Coordinate System	GCS_WGS_1984
Datum	D_WGS_1984
Prime Meridian	Greenwich
Angular Unit	Degree
Source	Crete University

C) Tourism information
Tourist number in Crete from year 1971 to year 2006.
Source: National tourism organization regional tourist office directorate of Crete, department of tourism development

2.3.3. Process:

In this case study, the technological context of the proposed approach includes GIS and RS techniques, as well as satellite data relevant to night light emissions. The main source of these data is DMSP images. As shown in figure 2. The brighter the point is the higher value it represents, which means at that point the light emission is stronger.

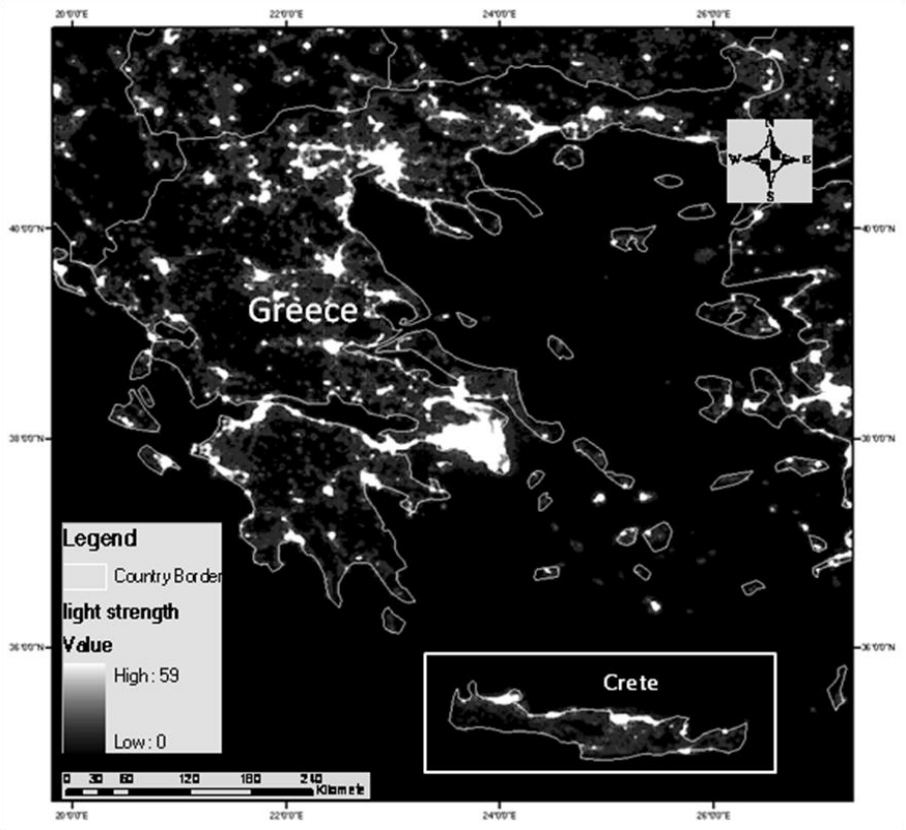

Figure 2 DMSP images of Greece, 2003

2.3.3.1. Data Pre-processing

A) Cut the world night light image into study area:

ENVI is used for this process define the area of interest and cut out the image from the worldwide night light image. Use vector data "cretecoastline" to cut the night light images of year 1992 to 2003.

B) Investigating the quality of the images

1) Use Hawths tools in ArcGIS, generated 1500 random sample points on the Island;
2) Extract values of the night light of every year (year 1992- 2003) using these 1500 points
3) Calculate the mean value and standard deviation of the night light for each year
4) Compare the night light value of the whole time series.

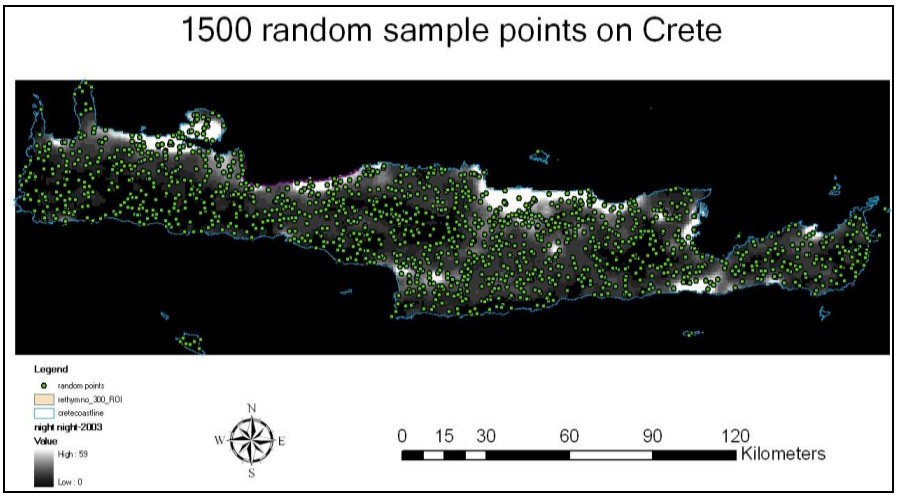

Figure 3, the 1500 random sample points on Crete

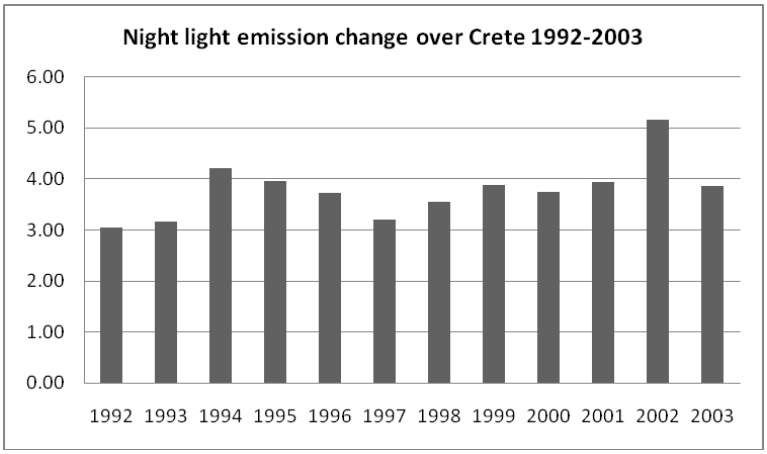

Figure 4 night light emission on Crete Island from year 1992 to 2003

As shown in figure 4, the light trend is for year 1994, 1995 ad 2002, the average values are showing abnormal trend, especially for year 1994 and 2002, the sudden chang of the value is not harmonious among the other values. If we observe the origianal images. Strong noise are detected in the image these three years, there are noises on the surface of the sea (the value of the pixels in the sea are not 0 and much bigger than 0) which is not reasonable because there should be no light where there is no population living and no human presence. so these three night light images are eliminated when analzying other correlations.

2.3.3.2. Investigate the relationship between night light value and tourist number

Use the result from 2.4.2.2, compare with the data from figure 4 (tourist number change), use the statistics to get a regression result.

2.3.3.3. Investigating relationship between turtle nesting number and night light change on Rethymno nesting beach

1) Create region of interest: Duplicate the coastline of Rethymno, make a 1 km buffer zone of it. Intersect the buffer zone with the coastline of Crete (polygon), create a new layer "Rethymno_ROI".
2) Generate 1000 random points in "Rethymno_ROI" using "Hawths tools"
3) Extract values of these 1000 points from the night light images of each year, calculate the mean value and standard deviation for each year.
4) Analyze the relationship between night light and turtle nest number

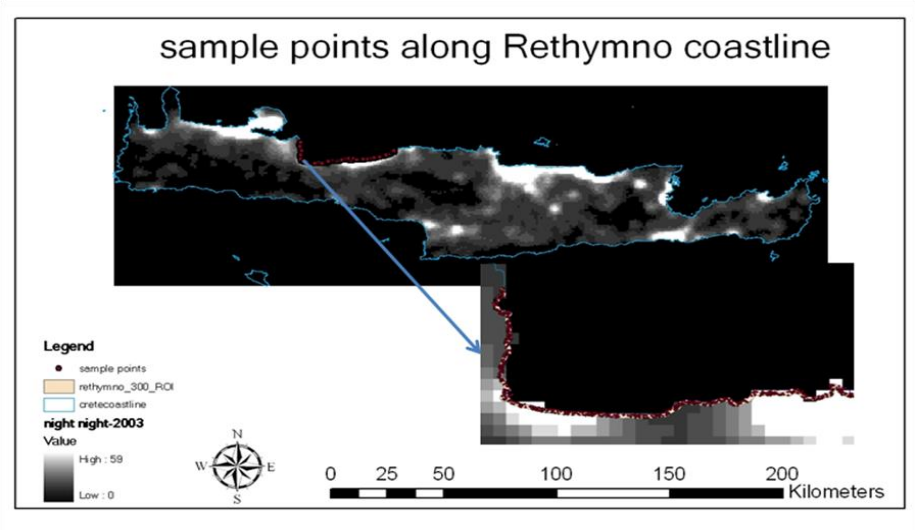

Figure 5 sample points along Rethymno coastline

2.4. Methodology of economic analysis

For the quantifying environmental services to find out the driving force of the PES system, we applied a benefit-cost model, which attempt to determine the net benefit to the PES scheme in monetary terms, based on the gross benefits and costs given certain ES providing ways. The benefit –cost analysis (BCA) follows the framework out lined in Loomis and Walsh (1997), Boardman *et al.* (1996), Nas (1996).

The BCA of the PES scheme involves estimating the monetary value of the benefits measured by turtles nesting area and turtles saved by changing land use near the nesting beach and people's behaviour versus the replacement cost measured in turtle lost.

Determination of monetary values of endangered or threatened species is usually not a straightforward or precious process. For example, it has been deemed "incalculable" in U.S. Supreme Court case law (Tennessee Valley Authority vs. Hill, 1978, Richard M., *et al*, 2002). Even though, conservative monetary values for rare species can be estimated through such means as costs of captive breeding projects divided by the number of healthy individuals produced (Bodenchuk *et al*., in press), or so called replacement cost (Troäng, S., 2004). Captive breeding costs were not available for Crete; however, there are some case studies in Malaysia, Reunion for the replacement cost. Furthermore, there are minimum monetary values (penalties) are clearly specified by statute and administrative code (Florida Statutes 370.021 (5) d-f; Florida Administrative Code 39-27.002 and 39-27.001). These statutes specify minimum monetary replacement costs for marine turtles at US $ 100 apiece, while the administrative code places the value at US $500 apiece. And endangered species are specified with even higher values up to US $ 25,000 for civil cases and up to US $ 50,000 for criminal cases in the Endangered Species Act of 1973, the US federal law. All these numbers can be considered as references when calculating. Another way to assign monetary value to species is contingent valuation, when survey information is available. Whitehead (1992) found that using an ex-ante willingness to pay survey study with supply and demand uncertainties, that individual were willing to pay $32 for conserving one turtle. However, to generalize the study of Whitehead (1992) into this study is not valid due to several reasons such as: his result is neither temporally nor geographically applicable to the situation of the PES for Crete, the individuals being interviewed are from different economic, cultural background; and the US$32 in year 1992 must have been changed after 16 years.

In this case study, we used a combination of several methods which include: people's willingness to pay, replacement cost, potential value for non-consumptive use such as ecotourism and conservation cost.

For the BCA, we need to use a conservative approach, which means after comparing all the reference values use the lowest value to calculate. And the details of the calculation will be discussed in the 4th part of the thesis.

3. Relationship between the disturbance factors and marine turtles

3.1. Turtles on Crete Island

Out of seven turtle species in the world, only three can be regularly found in the Mediterranean (loggerheads - *Caretta caretta*, green turtles - *Chelonia mydas* and leatherbacks - *Dermochelys coriacea*) (Margaritoulis *et al.* 2001). Two out of these three species (the loggerhead turtle and Green turtles) reproduce in the Mediterranean. The green turtle reproduces mainly in Turkey and Cyprus, and loggerhead turtles mainly nest in Greece (ARCHELON). The three kinds of turtles are shown in Table 1.

Table 2 Three kind of marine turtles active around Crete Island

		
Loggerhead turtle	Green turtle	Leatherback turtle
Caretta caretta	*Chelonia mydas*	*Dermochelys coriacea*
Photograph by Brain J. Skerry	Photograph by Timothy G. Laman	Source: National Geographic

a) Loggerhead turtles

The loggerhead sea turtle, is the largest of all species found in the family Cheloniidae (Alderton 1988). “Loggerheads were named for their relatively large heads, which support powerful jaws and enable them to feed on hard-shelled prey, such as whelks and conch. The carapace (top shell) is slightly heart-shaped and reddish-brown in adults and sub-adults, while the plastron (bottom shell) is generally a pale yellowish color. The neck and flippers are usually dull brown to reddish brown on top and medium to pale yellow on the sides and bottom.”(ARCHELON, 2007; NOAA-fishery) Mean straight carapace length of adult loggerhead turtles in the southeastern U.S. is approximately 0.92 m; corresponding weight is about 113 kg (NOAA-fisheries).

Loggerheads reach sexual maturity at around 35 years of age (NOAA-fisheries). In Mediterranean Sea, mating occurs in late April to early July and nesting season usually extends from end of May to late August (Margaritoulis & Rees 2001). According to Dimitris (2003), for the year 2002, the duration of the nesting season (from first to last nest) was 70 days. Females lay 2-3 clutches of eggs in each reproduction season, and sometimes more. The eggs incubate for approximately two months before hatching; and in Crete, the hatchlings comes out during August and October (pers. Comm., Simon Proctor, 2007).

Approximately 99% of the documented nesting effort of the loggerhead turtle, in the Mediterranean occurs in Greece (60.6%), Turkey (27.1%) and Cyprus (11.4%) (Margaritoulis *et al.* 2001)

Figure 6 turtle eggs and hatchlings on Crete (left), ARCHELON volunteers checking an un-hatched nest (right), photograph by Zhang Fan, fieldwork, Sep 27th, 2007

The loggerhead has a wide distribution, ranging from the Pacific, Atlantic, and Indian Oceans, to the Caribbean and Mediterranean seas (Ernst 1972). Although breeding occurs often and the turtles can lay several clutches of eggs a year, loggerhead turtles are still threatened with extinction. They are classified as endangered species by the World Conservation Union (IUCN 1995). The ecological significance of C. Caretta further emphasizes the importance of protecting this species.

b) Green turtles

Chelonia mydas is represented in the Mediterranean by a reduced population nesting on only a handful of beaches in Cyprus and Turkey. It is estimated that only 350 to 1 750 clutches are laid per year (Kasparek, Godley and Broderick, 2001). Broderick *et al*. (2002) results showed a frequency of 2.931 clutches per female green turtle and 339.369 green turtles nesting annually. The numbers given by Groombridge (1990)

are similar (300-400 green turtles), assuming on average three clutches per season. The regional stock seems to be the remnant of a former larger population. For the green turtle both pelagic developmental and demersal habitats are restricted to the easternmost part of the Levantine basin.

c) Leatherback turtles

Dermochelys coriacea is present in the whole area all year round but most of the observations are of isolated individuals (Camiñas, 1998). Leatherbacks observed in the Mediterranean Sea came from nesting areas situated almost entirely in the tropics, usually in an area from Costa Rica to Colombia and in eastern French Guiana. The observed and captured leatherback turtles in the Mediterranean are mainly adults. Only a small number of leatherbacks are thought to nest occasionally in Israel and on the south coast of Sicily (Groombridge, 1990)

3.2. Ecological, cultural value of marine turtles

3.2.1. The ecological value of marine turtles

Marine turtles are keystone species in coastal and oceanic marine ecosystems. Marine turtles transfer nutrients and energy from the ocean to the land at nesting beaches when they deposit their eggs, and they affect the structure and functioning of foraging habitats such as coral reefs, sea grass meadows, algal beds, and soft substrate sea bottom. This ecosystem dynamic contributes to nutrient recycling, as do the vast amounts of waste excreted from millions of turtles worldwide. Loggerhead turtles, which aggregate in pelagic productivity hotspots, likely affect even long-term oceanographic patterns. Moreover, marine turtles are important hosts for parasites and pathogens and are dispersal platforms of various epibionts, including barnacles, tunicates and mollusks. (SeaTurtleStatus.org, SWOT Report)

a) Loggerhead turtle

Loggerhead turtles eat many types of invertebrates, particularly mollusks and crustaceans; they can change the seabed by “mining” the sediments for their favourite prey. Furthermore, loggerhead turtles carry various veritable animals and plants on their shell. There are as many as 100 species recorded living on one single loggerhead turtle. These animals and plants depend on turtles to live and prosper. In consequence, the futures of these species are related to the turtles’ existence (WWF, 2003).

b) Green turtle

Sea grasses and algae are the green turtles' preferred snacks. Sea grasses grow in shallow waters and can cover extensive areas. Seagrass beds are amongst the most productive ecosystems on the planet. Green turtle both help to maintain the health of sea grass and to make them more productive. Green turtles digest sea grass leaves and part of the sea grasses' nutritional content becomes available to other organisms much more rapidly than through normal decomposition (Thayer & Engel, 1982; Thayer, 1984). Sea grass beds are nurseries of many marine species, which include invertebrates and fish. Some of these marine species are of considerable value to commercial fisheries and human food security (WWF, 2003).

c) Leatherback turtle

Leatherback turtles can control population of jellyfish. They mainly feed on jellyfish and they are very important jellyfish predators. The population of Leatherback turtle significantly influences the ecological balance of jellyfish population. As the leatherback turtle population decrease, jellyfish population will increase consequently. As a result, more fish larvae will be consumed and commercially fishery will be influenced (WWF, 2003).

3.2.2. Cultural value of marine turtles

Marine turtles also have an intrinsic value. Turtles play an important part in myths and stories of many cultures and human communities, for example: an ancient Taoist myth tells that far east from the Chinese coast, there are five islands resting on giant marine turtles and inhabited by immoral men and women living in perfect harmony; there are also myths from ancient India, indigenous groups from North America and Papua New Guinea (WWF, 2003). The turtles make the oceans of the world much more spectacular and they should be conserved for future human generation to awe and honour.

3.3. Natural life cycle of marine turtles

Marine turtles are long-lived slow-maturing reptiles adapted to life in the aquatic environment. They spend most of their life time in the sea, but during the reproduction season, they go on to the land and nest in a suitable beach. Comprehensive studies of the nesting environment have been conducted globally, however, the marine habitat of the turtles' remains poorly understood. (Helen Cross 2006)

In figure7, the natural life cycle of marine turtles is demonstrated.

Adult females migrate from a foraging ground to a nesting beach, which is normally the beach where they were born. Mating occurs during the migration, although mating areas are poorly defined by previous studies (Hayes, 2005), fishermen and people who live near the beach in Crete identified that the mating area is near the nesting beach in the shallow water (fieldwork interview).

Nesting mostly occurs on sandy beaches, however, on some stony beaches in Crete there are also some nests. The nesting usually happens during night time, it takes hours for the female turtle to complete the nesting process before returning to the sea (WWF, 2003). In each nest there are about 70-120 eggs, 100 in average, and females normally lay 2-3 clutches per year, it depends on species and geographical location. After the nest is built, the eggs are left to incubate for about two months. The heat of the sand incubates the eggs and they develop without any help from parent turtles. According to the study by Miller (1997), the sex ratio of the turtles is influenced by the temperature of the nest environment. Males result from cooler incubation temperatures and females from warmer temperatures.

On Crete Island, nesting season is mostly between May and August. The start/ end dates and duration of nesting season in three main nesting beach of Crete of year 2002 is shown in table

Table 3 start/end dates and duration of marine turtle nesting season of three main nesting beaches in Crete, 2002

Nesting area	**Date of the first nest**	**Date of last nest**	**Duration of nesting**
Rethymno	June 1st	August 9th	70
Chania	May 30th	August 18th	81
Messara	June 4th	August 21st	79

(source: Dimitris & Rees, 2003)

After hatchlings emerge from the egg chamber, it takes them about 3-7 days to reach the beach surface. They emerge mostly at night to reduce exposure to daytime predators, either en masse or asynchronously in small groups, and orient toward the sea. Their ability to find the sea mainly depends on their weak vision; they search for the lowest brightest horizon (Helen Cross 2006) which should be the reflection of the moonlight by the surface of sea water, if the environment is not disturbed by artificial lights.

After entering the water the hatchlings swim rapidly offshore, the continuous swimming takes place or about 24 to 48 hours after they enter water, this activity get them into deeper water, where it is less vulnerable to predators (Busch Gardens, 2008) and the open ocean zone where the cold current and warm current meet will provide them plenty of food (WWF, 2003). During the first year, many species of sea turtles are rarely seen. This first year is known as the “lost year” (Busch Gardens, 2008). After 5 to 10 years’ open surface foraging, they start their developmental migration for 30- 50 years, then they return to the nesting beach where they were born, to lay their own eggs, then a new life cycle starts. (Helen Cross 2006)

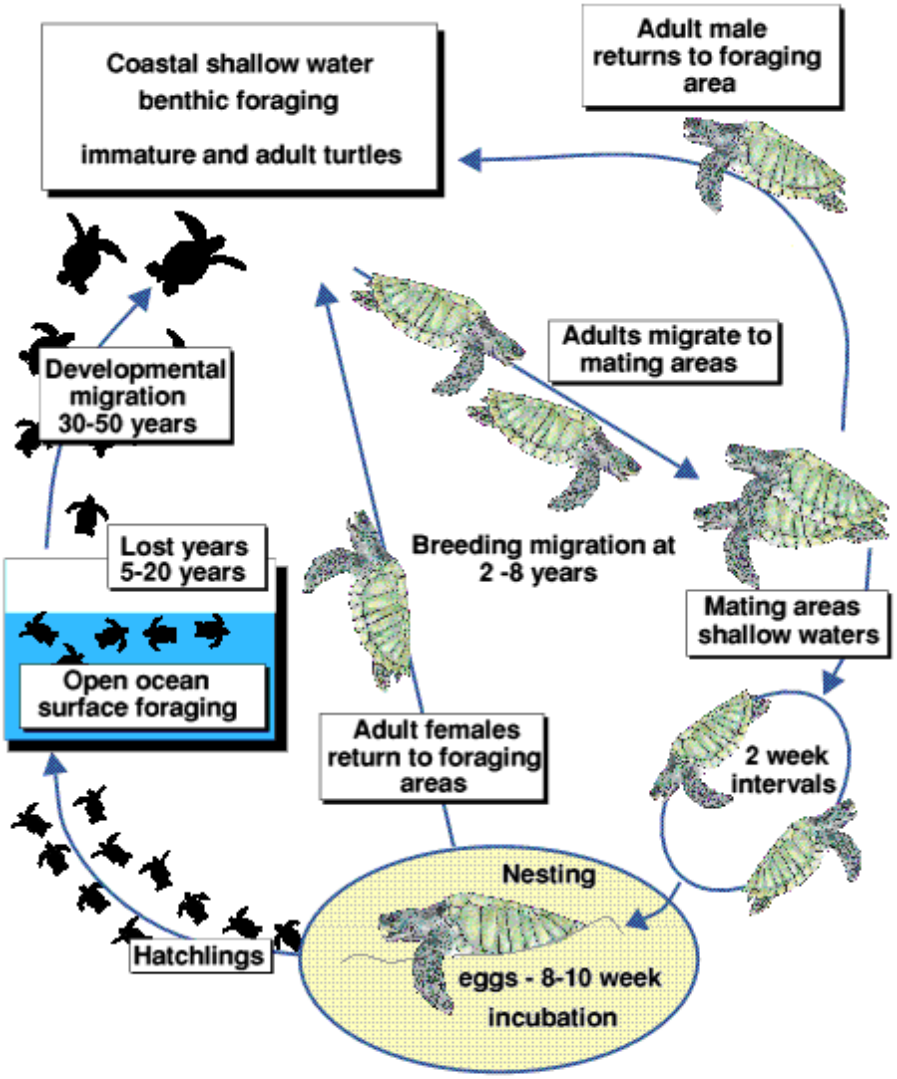

Figure 5 generalized life cycle of sea turtles (Source: www.euroturtle.org)

Adult marine turtles migrate hundreds or even thousands of kilometres between feeding habitats, mating areas and their preferred nesting beach. After nesting the first time, they may return to the same nesting beach to lay eggs every couple of years for over two decades. (WWF, 2003)

Marine turtles face many natural threats as hatchling or juveniles, and their development to maturity takes a long time. As a result, approximately only 1 in 1000 eggs will survive to adulthood. (WWF, 2003)

3.4. Impacts of disturbance factors to turtles in their life cycle

3.4.1. Overview of the disturbing factors to turtles

There are many disturbance factors to the turtles during their life cycle;
An overview about the disturbance factors is made below; description is given to each disturbance factor.

1) Tourism and related activates

Every year, the number of tourists visiting Crete is increasing, from 662758 in 1972 to 2778339 in year 2006, as is shown in figure 8, which is leading to severe problem of the turtle population decreasing. Further more, the tourism season is also the nesting season of the turtles (comparison of figure 9 and figure 10). In Crete, tourist development has had a devastating impact on the marine turtles' habitat on all fronts. Extensive beach use by tourists is a major factor of the ongoing coastal degradation, unplanned development of the urban areas is threatening the terrestrial habitat of the turtles where they build nests and lay eggs. The tourism industry is itself directly responsible for beach destruction through coastal development.

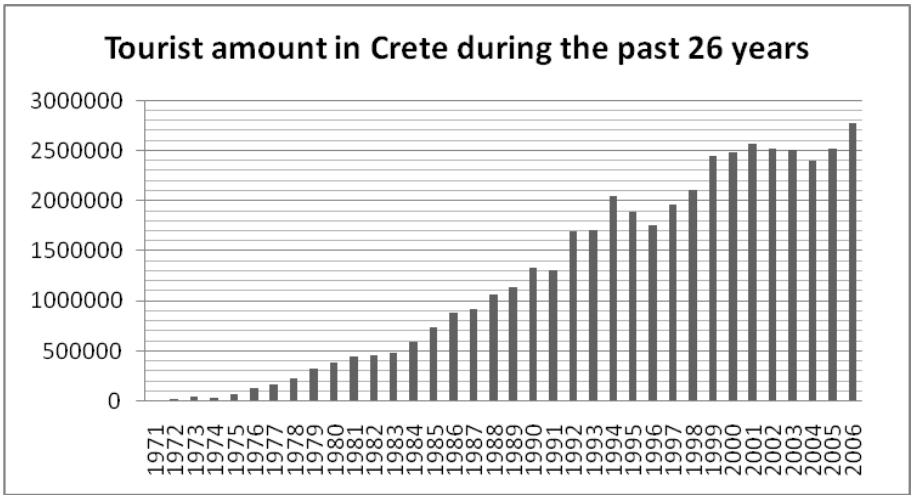

Figure 6 tourist amount statistics: year 1971-2006 (Data source: national tourism organization regional tourist office directorate of Crete, department of tourism development)

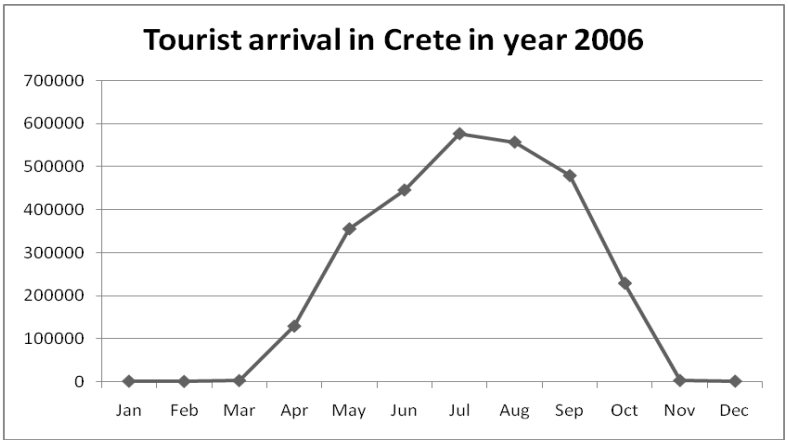

Figure 7 tourists arrival statistics in Crete in year 2006, (Data source: national tourism organization regional tourist office directorate of Crete, department of tourism development)

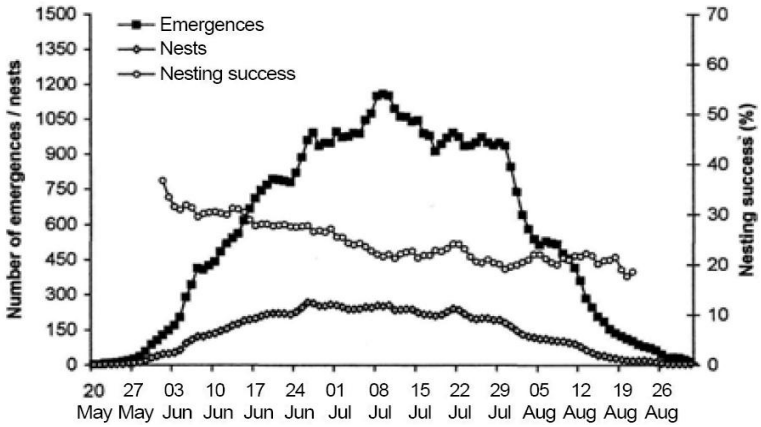

Figure8, monthly change of nesting activity (emergences, nests, nesting success) Combining 11 seasons (1992-2002) in Laganas Bay, Greece (Margaritoulis, 2005)

A) Sun bed and sun umbrella

According to the Management Plan for Crete, Greece, regulated use of beach furniture may reduce sea turtle nesting activity. It is suggested that no more than 50% of the beach should be covered in beach furniture and umbrellas should be set in straight rows and columns, leaving a 5-metre zone at the back of the beach for sea turtles to nest. Sunbeds should be collected at night and stored away from the beach to be replaced the following morning. In 2001, all the major hotels on the nesting

sites of Crete complied fully with these regulations. As a result, 2,063 sun beds were collected at night, representing 17.7% of the total. The Public Land Department and the port authorities fined owners who did not abide to the existing regulations. (Aliki P. & Dimitrios D., 2002) However, in Crete Island, this regulation is not implemented effectively.

In addition, as mentioned in 3.3, the temperature around the nest influences the sex ratio balance of the hatchlings. The sun beds and sun umbrellas near the nest will prevent the sunlight and heat from reaching the sand around the nest and consequently destroy the sex ratio balance of the turtle population (Miller, 1997).

B) Vehicle on the beach

Vehicles on the beach such as the sand motorbikes and the sea grass clean machine can cause the collapse of the nests. According to regulations issued by the Public Land Department and the port authorities of Crete, the use of heavy vehicles on the beach is not allowed between the 31st of May and the 31st of October. Beach cleaning during the nesting/hatching season should be conducted either manually or using light machinery and under the supervision of an ARCHELON representative. Theoretically speaking, 2001 was the first year that no heavy vehicles were used on the beach during the nesting/hatching season. However, during our fieldwork in Crete between September and October 2007, there were still vehicle on the beach, both the motorbike for sandy beach and the heavy vehicles for beach cleaning (fieldwork, 2007).

C) Speed boat strikes

Even thought the marine turtles have hard shells, they still can not be able to with stand the strike of a boat or the cut of a powerful propeller. Marine turtles staying close to the ocean surface to breathe, mate or bask are very likely to collide with speed boats or be bit by propellers. According to the statistics on Zakyntos Island, Greece, at least nice adult female loggerhead turtles were killed by boat strikes when they stay in the shallow water near the nesting beach in year 1993 (WWF, 2003, Wilson and Tisdell, 2000).

D) Unplanned constructions along the beach

Not well controlled development has lead directly to the destruction of critically important marine turtle nesting beaches. The local society has played a significant role too; illegal buildings are very common such as resident houses and small bars, which are often located along the coastline. This situation is tolerated by both local

and national authorities, who fail to impose or implement existing legislation (Dimitris & Rees, 2003).

Beside the occupation of the land, there are some implicative effects of the unplanned constructions, including noise, night lights, pollutions etc., which will be highlighted in the following paragraphs.

E) Noise

The unplanned buildings near the turtle nesting beach have other negative impacts besides occupying nesting beach. Noise is one of them. In nesting sites such as Crete Island, there are many tourism infrastructures along the beach such as hotels, bars, discos, and restaurants. During turtle nesting season there are a lot of tourists. Night life is an important part for the tourists. However, the noise from the bars will disturb turtles from laying eggs. When female turtle comes to the beach, if there is too much noise, it will go back to the sea. Normally the female turtles will try 2 or 3 times, and if there is always noise disturbance, they will give up and lay the eggs in the sea, and the eggs will never have a chance to hatch. (ARCHELON, 2007)

F) Night lights

As is mentioned in 3.1, turtle hatchlings find their way back by following the reflection of the moonlight on the sea. Under natural conditions, the brightest light on the beach at night come from the direction of the sea where the waves break and where there is no vegetation shading the moonlight or the reflection of the stars. However, as urban areas develop along the beaches, the light from buildings and roads attract the hatchlings and disorient them away from the sea. Instead of finding the ocean, the hatchlings will die because of dehydration or eaten by predators. (WWF, 2003)

2) Fishery- by catch

Fishery by catch of marine turtles refers to incidental catches in fishing gear, including shallow-set “pelagic” longlines, trawls, and gillnets.Every year, tens of thousands of turtles are trapped in shrimp fishing operations. Marine turtle are reptiles and use lungs to breathe; when they are trapped in the fishery net and cannot get to the surface of the water to breathe, they drown. Gill nets and long-line fisheries are the main cause of turtle mortality. By- catch in open ocean fisheries is believed to be responsible for the drastic decline in Pacific leatherback turtles. In worldwide extent, hundreds of thousands of marine turtles are caught in trawls, on long-line hooks and in fishing nets. (WWF, 2003)

Fishery- by catch mainly affects the adult turtle population during their migration and foraging.

3) Pollution

A) Plastic materials:

As mentioned in section 3, marine turtles (especially green turtles) eat jellyfish as the main food. However, they can mistake floating plastic materials for jelly fish and choke to death when they try to eat them. It happens in the water near Crete. (Simon Proctor, pers. Comm. 2007)

B) Oil spills:

Oil spills can poison marine turtles of all age levels. Oil leakage from the boats threatened turtles at the peak of the nesting season. Oil spills on nesting beaches affect the nesting adults, the eggs and the hatchlings, which are very vulnerable to oil. (WWF, 2003)

C) Rubbish on the nesting beach:

Garbage on the nesting beach may trap the hatchlings and prevent them from reaching the ocean.

4) Introduced predators

As the tourism develop in Crete, the amount of waste increases. The predators of the marine turtles are attracted or feed on by the garbage is increasing. In Crete people keep many dogs, and they don't lock the dogs at night to guard the house; and there are also many street dogs wandering on the nesting beach, disturbing female turtles laying eggs and eat hatchlings. (Fieldwork, morning survey, 2007; WWF, 2003)

5) Direct consumption by human being

In some part of the world such as Indonisia, people collect turtle eggs for eating and sale, and collect shells of turtles for making souvenirs. (Troëng, S. & Drews C., 2004)

6) Climate change

Global warming and changing climate have the potential to influence the marine turtle population severely. Firstly, the sea level rise can inundating the beach and lead to the decreasing of the nesting area. Secondly, climate change can influence turtle's sex ratio because the turtles have temperature dependent sex determination. (WWF, 2003)

3.4.2. CLD of the disturbance factors and marine turtle life cycle

There are many disturbance factors influencing the life of marine turtle. System dynamics helps us to analyze complex systems with special emphasis on the role of information feedback. Causal loop diagram (CLD) is a technique to portray the information feedback at work in a system. Causal refers to cause-and effect relationships. The word loop refers to a closed chain of cause and effect. In part 3 of the thesis, a CLD is made to analyze how the disturbance factors influence marine turtle during their different development stage. And the descriptions of the disturbance factors are mostly depending on the literature review, other complementary information were obtained through personal communication and fieldwork in Crete.

Figure 11 shows the CLD of the relationship between the disturbance factors and the turtle life cycle, this CLD is the synthesis of part 3.4.1.

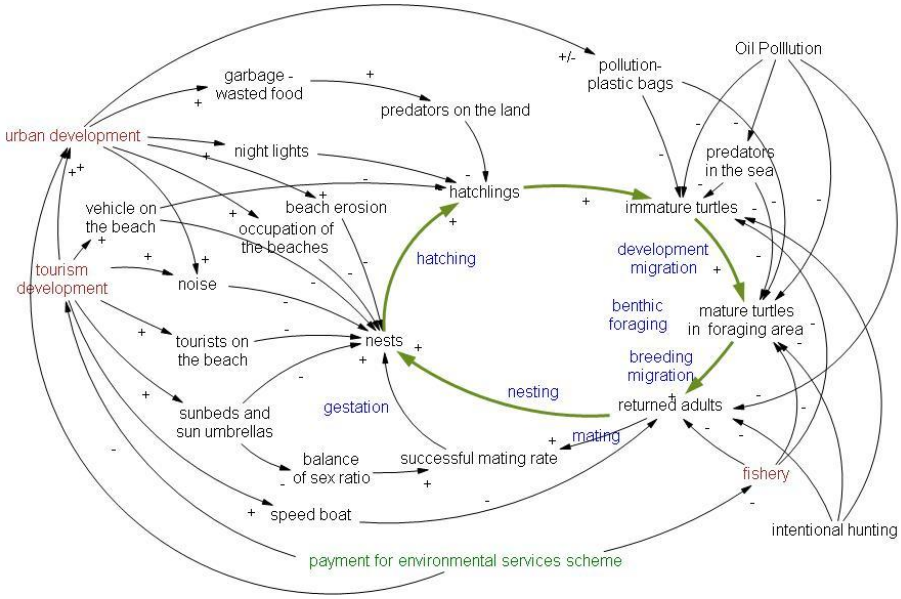

Figure 9: Theoretical model of disturbance factors during the life cycle of marine turtles, green arrows shows the natural life cycle of turtles.
Note: Green arrows are the turtle life cycle of the turtles, blue text is the description of the phases of turtle life cycle; red text is the main categories of the disturbance factors. "+" and "-" represents the positive influence and negative influence.

3.5. Correlation between human disturbance and turtle nesting

There are several reasons to use night light images to analyze human disturbance to turtle nesting.

First of all, there have been many researches done on describing the disturbance factors to the turtles (Dimitris & Rees, 2003; IUCN, 1995; Helen Cross *et al*, 2005, WWF, 2003). As reviewed in section 3.4 of this thesis, most of the disturbance factors to turtle nesting such as artificial light, noise, sun beds on the beach, happens during night time;

Secondly, as *Cinzano et al*. (1999), Chalkias, Petrakis *et al*. (2006) indicated, night light images are reflections of the urban development, concentration of population and economic development level.

So in this case study, I attempt to use the night light images to analyze the quantitative impacts of human disturbance on turtle nesting.

Using the methodology described in part 2.4 of the thesis, the following results will be presented in this section:

- The night light change of the time series;
- Correlation between tourist number and night light strength of whole Crete;
- Correlation between night light strength and turtle nest number along Rethymno beach coastline.

The initial analysis result of the tourist number, night light, and nest number is shown in table3.

Table 4 initial analysis result of the data processing

Year	Average night light on Crete	Standard deviation	Night light Rethymno	Marine turtle nest number in Retymno	Tourist number over Crete
1992	3.04	5.61	11.662	390	1705537
1993	3.15	5.24	12.277	351	1711972
1996	3.72	6.17	13.149	316	1761203
1997	3.20	5.50	11.683	345	1970684
1998	3.53	5.54	11.929	315	2114477
1999	3.87	6.07	12.235	401	2449985
2000	3.73	6.18	12.182	288	2494631
2001	3.94	6.37	12.72	256	2575010
2003	3.85	5.86	12.776	248	2508509

Note: “night light – Crete” means the average night light value of the 1500 random sample points on Crete
“Night light - rethymno”: the average night light value of the 1000 random sample points in the 1000m buffer zone of rethymno beach

3.5.1. The night light emission change on Crete Island

The result of the analysis about the night light change on Crete Island is shown in figure 12. The trend of the mean value of night light strength of the 1500 random points for each year is slightly increasing while fluctuating, but the increasing trend is not much as the expectation.

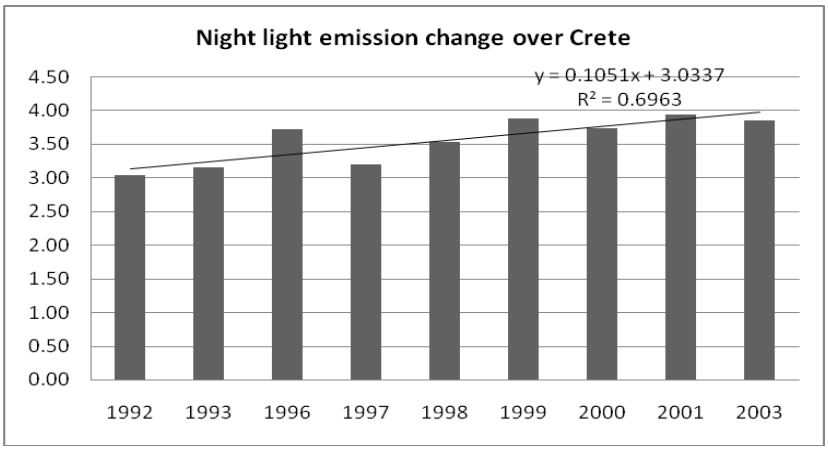

Figure 10 night light emission on Crete

The reasons which cause this result might be explained as:
Firstly, the slightly increase might be caused by the development of the urban area caused by the tourist number increasing. And the increase is not so strong might be because in 1992, Crete is already a very famous tourism site, so most of the facilities are already built. This will lead to the result that in the future 12 years the increasing trend is not very strong.
The fluctuation might be caused by the “market regulation”: if the first year there were a lot of tourists, the second year local people will invest more on constructing new facilities and buildings to host more people, but if the construction is over the consuming capacity of the tourists, the market will force people to change the development and some constructions might be abandoned or out of use, adjusting the capacity of the market (fieldwork, interview to the hotel managers). Furthermore, the tourist number is also fluctuating (figure 8), although the main trend is increasing.

However, there might be a lot more reason which caused the trend of the light emission, such as people's behaviour change due to their conscience and knowledge about environmental protection and energy use control by government.

The result of the night light strength increasing (figure 12) and the tourist number increasing (figure 8) indicate that: the human activities has been increased on Crete Island and it might have significant influence the turtle nesting behaviour. In 3.5.2 this correlation will be analyzed.

3.5.2. Correlation between tourist number and night light strength

The relationship between tourist number and night light strength is also investigated, and the result (figure 13) showed that there is some correlation between the tourist number and the night light strength, the trend that night light strength value increases as the tourist number increase. It proofs that the night light strength is a way of indicating the human activity, which is also observed by C. Chalkias *et al*. (2005).

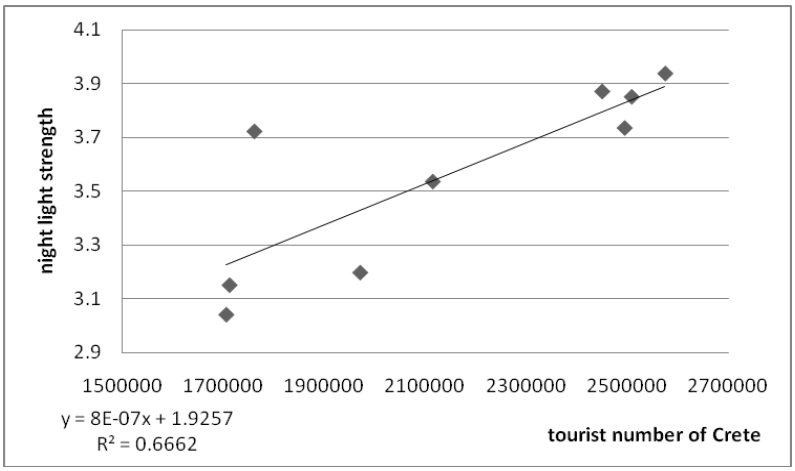

Figure 11 Correlation between tourist numbers and the night light values

3.5.3. Correlation between night light strength and nest number along coastline of Rethymmno beach

The average value of the 1000 points in the 1km buffer zone of the Rethymno coastline is calculated for each year, and regression is made to analysis the correlation between the night light strength along the coastline and the nest number. The result of the correlation analysis is shown in figure 14. It is likely that there are negative correlation between the nest number and night light strength. When the night light strength increases, the nest number decreases. As seen in figure 14, if we

use the logarithmic trend line, the formula would be y= -748.6ln(x)+2200.8, and R^2= 0.326; if we use liner relationship, the formula was y= -60.324+1064.7, R^2=0.32. According to the ecological principle, the logarithmic trend line is more reasonable.

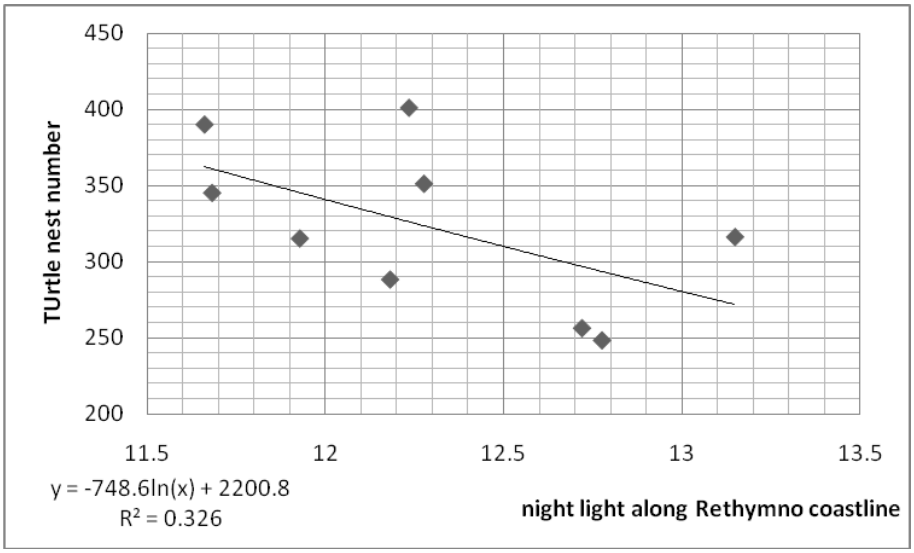

Figure 12 Correlation between night light values and nest number on Retheymno Beach

Although the relationship is not very strong, this could be normal since the life cycle of marine turtles are very complicated, there are much more disturbance factors to marine turtles in the ocean, as is shown in part 3, figure 7 and figure 11. Furthermore, marine turtle has a approximately 30 year migration journey, so the nesting turtle every year will not exactly be the same, it will also cause the uncertainty of the turtle nest number. And the weather of each year is also different, which might influence the nesting behaviour of the turtles.

4. PES scheme for marine turtles conservation on Crete Island

As discussed in part 3 of the thesis, human activities have relatively high impact on the marine turtles' habitat in Crete, the urban development along the coastline due to the increasing of the development of tourism is influencing the turtle nesting. As the disturbance factors to marine turtles are mainly caused by human activities, and economical factors are recognized to be the main reason behind these activities (Troäng, 2004)., the economic measure such as PES which combines the ecological and economic information are supposed to be efficient to help solve the problem.

In this part of the thesis, the feasibility of building up a PES scheme for sea turtle protection on Crete Island is investigated. In 4.1, basic logic of PES system and the rationale of building PES system for marine turtle protection in Crete is described; 4.2 to 4.5 is for identifying the four key items in PES system, the environmental service, the services providers or managers, the beneficiaries, and the system intermediaries. And section 4.6 is about the institutional framework building and basic ES flow in the PES system.

4.1. Introduction to PES scheme

4.1.1. Basic concepts in PES

Environmental services (ES) are whatever nature provides that are valuable for human-beings. However, there are differences between services provided by nature on its own, and through human husbandry. The benefits of ES reach users or beneficiaries at many scales, from local, national to international.

There is no formalized definition of payment for environmental services in the literature until now. As S. Wunder (2005) discussed, the core idea of (PES) is "external beneficiaries of ES make direct contractual quid pro quo payments to local landowners and land users in return for adopting better land use practices, technologies, resource use and management that secure ecosystem conservation and restoration". It is a new and more direct way to promote conservation. It clearly recognizes (Wunder, 2005) the need to address difficult trade-offs of the

environmental services by bridging the interests of landowners and external actors through compensation schemes.

Wunder (2005) pointed out five criteria based on the theoretical literature for prescriptive definition of the PES principle, The core items of a PES are (1) a voluntary transaction (Alvaro & Welsh, 2006) in which (2) a well defined environmental service (or a land use which is likely to secure that service) (3) is bought by a (minimum of one) buyer (4) from a (minimum of one) provider (5) if and only if the provider continuously secures the provision of the service (conditionality).

There are four key features in a PES system, which are the Environmental service, the environmental services providers or managers, the environmental services beneficiaries, the intermediary or coordinator of the PES system, and mechansims for certification, measurement, validation, transfer, etc.

There are four types of environmental services have been sold until now (K. Mayrand & M. Paquin, 2004; Wunder, 2007), they are:

a) Carbon sequestration and storage (e.g., electricity companies in developed countries pay the farmers in tropical area to plant or maintain additional trees for CO_2 emissions compensation)
b) Watershed protection (e.g., downstream water users pay the farmers whose farmlands are upstream for multiple benefits, e.g., not using pesticide in order to reduce the pollution to the water and soil)
c) Protection of landscape beauty (e.g. tourism operators paying a local community not to start developing a zone used for beautiful landscape viewing)
d) Biodiversity protection (e.g., conservation donors pay the land owners for creating set-aside areas for ecological corridors or stop exploring the area where the biodiversity can be conserved)

And sometimes in one area there is PES scheme which combines more than one service together and form the markets for **bundled** services (K. Mayrand & M. Paquin, 2004).

An example of basic PES logic is shown in figure14. For example land users receive few benefits from forest conservation -- normally less than the benefits they would receive from alternative land uses, such as conversion to pasture. But deforestation can impose costs on downstream population, who no longer receive the benefits of ecological services such as water filtration. A payment by the downstream beneficiaries can make conservations more attractive for land users

upstream. The payment must obviously be more than the additional benefits to land users of the alternative land use so the upstream land users will be willing to change their land use, and the payment has to be less than the value of the benefit to downstream beneficiaries so the beneficiaries will be willing to pay for it (S. Pagiola *et al.*, 2005).

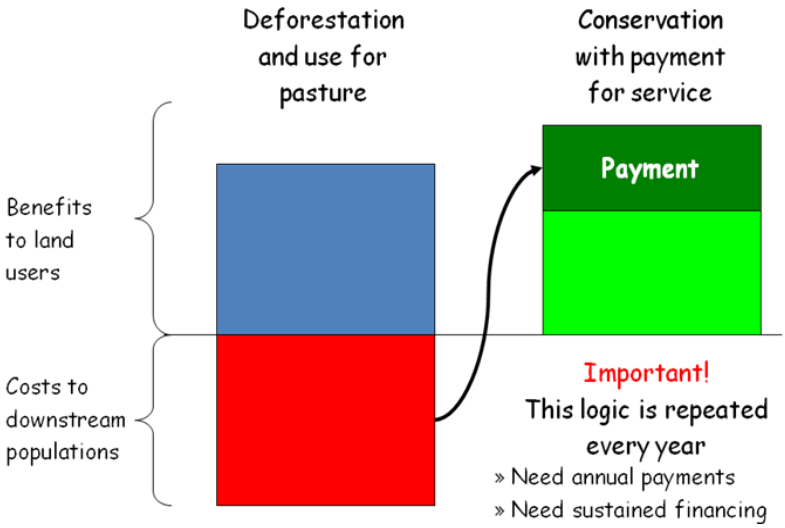

Figure 13 basic logic of PES scheme, (S. Pagiola *et al*., 2005).

The purpose of this study is to proposing a PES system to protect marine turtles in Crete, and to justify the feasibility of this PES scheme. The proposed PES system to be built in this study to protect marine turtles falls in the category of biodiversity protection.

The market for biodiversity conservation was characterized by Michael J. *et al*. (2004) as a nascent market. Many approaches are emerging to financially remunerate the ES providers. They also summarized the potential market solutions and some of the complexities involved in a figure, shown in figure 16.

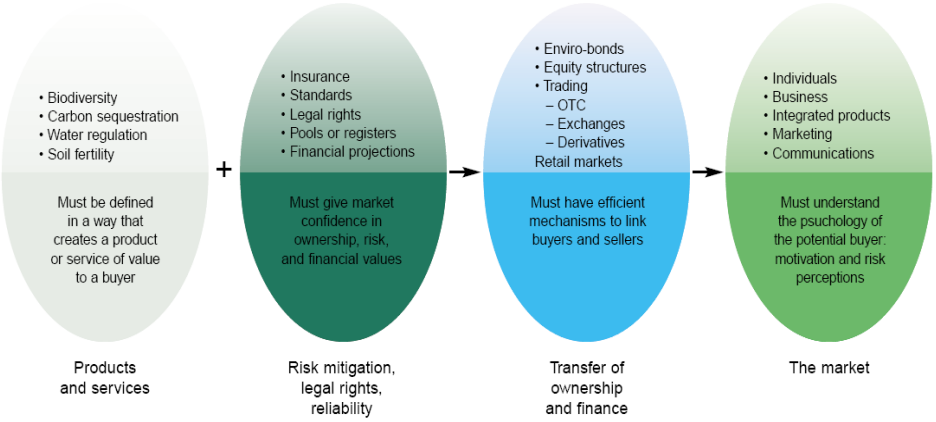

Figure 14 Market solutions to conserve biodiversity

4.1.2. Why PES is needed for protecting marine turtles in Crete

There are some NGOs on Crete Island establishing many measures and advising municipalities to make policies to protect the marine turtles, which have some positive consequences. However, the negative activities which lead to the decrease of the turtle population such as the occupation of the turtle terrestrial habitat still exist and somehow increase (fieldwork survey, Simon P. pers. Comm. 2007). The conflict between tourism and turtle protection is a dilemma in Crete. Tourism is the main income of Crete Island, but Crete government and local people receive little or no income from protecting turtles until now. This makes sense that local government and local people will ignore the real economic and non-economic values of ES of turtle protection when they make decisions about local development.

The mechanisms are needed by which the resource owners are rewarded for their role as stewards in providing biodiversity and environmental services. Anticipation of such income flows will enhance the value of natural assets and thus encourage their conservation. Compared to previous approaches, experience with market-based mechanisms promise increased efficiency and effectiveness, at least in some situations. Experience with market-based instruments in other sectors has shown this kind of mechanisms, if well organized, has the ability of achieve environmental goals with significant less cost than conventional “command and control” approaches, while creating positive incentives for continual innovation and improvement. However, to achieve this goal, careful designing and implementation is needed (M. Jenkins *et al.*, 2004).

In recent decades, there has been increased recognition that economic factors are behind many human activities that cause declines in habitats and species. Economists and ecologists agree in a large extent that measures combine ecological and economic information will help identifying strategies to reverse biodiversity and ecosystem loss (Tröng, S., 2004). Since the conservation measures taken before in Crete was not efficient enough to reverse the decline trend of the marine turtle habitat and marine turtle population, PES could be an effective way for the conservation. PES is proposed for the protection of the marine turtles in Crete because of its advantage such as:

Firstly, PES can play an important role in showing the deteriorating state and supply of environmental services. PES refers to the various arrangements through which the beneficiaries of ES pay back the ES providers to ensure the sustainable and timely provision of environmental services.

Secondly, by highlighting the values of marine turtles to the society, PES can increase the awareness of the public, and promote peoples' willingness to pay for the conservation of marine turtles.

Thirdly, PES will clearly identify the environmental service to the actors in the system, the beneficiaries and buyers will be more aware of what they are paying for, suppliers would have to improve their delivery of ES, consequently increasing the efficiency of conservation expenditures.

Moreover, if scaled up, PES could provide an important source of income for local people and become an important leverage for sustainable local development. (WWF, ES & PES: why should businesses care?)

4.2. Environmental services in the PES scheme

To build a payment for environmental services scheme, the basic thing to do is to identify what is the environmental service being traded in the system. Quantification of the ES can clarify the driving force in the PES system. Furthermore, quantifying the environmental service of marine turtles will make people understand the ecological impact of different turtle use options, and consequently has significant influence on people's behaviour. In section 4.2.1, the environmental services of turtles in the PES scheme for turtle protection are being analyzed; and in section

4.2.2 we attempt to quantify the value of these ES in the turtle protection PES system of Crete. The structure of section 4.2 is shown in figure 17.

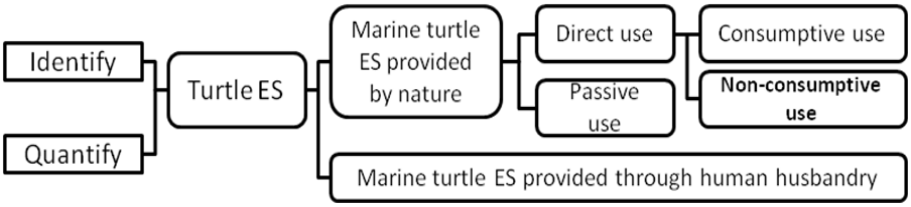

Figure 15 structure of section 4.2

4.2.1. Identifying ES

The environmental services provided by marine turtles can be divided into different aspects due to turtles' various use values to different human communities.

In this study, the turtle ES can also be divided into categories similar as figure 17; however, the situations for PES schemes vary from case to case. So in this case study we divided the ES into three categories: ES of direct use, ES of passive use and human husbandry ES.

4.2.1.1. Direct use:

A) Consumptive use:

On Crete Island, there are NGOs protecting the turtle nests, so most of the consumptive use has already been forbidden. Residents on Crete mainly depend on the tourism income, and their life standard is good enough. So they don't need to sale eggs, meat or turtle shells to make money. Consequently the ES of consumptive use of turtles doesn't exist in Crete.

B) Non-consumptive use:

Non-consumptive use the marine turtles usually refer to ecotourism related to turtles. Turtle can be either the major attraction or one of many attractions in the tourism.

Ecotourism, also known as ecological tourism, is a form of tourism which appeals to the ecologically and socially conscious. Generally speaking, ecotourism focuses on local culture, wilderness adventures, volunteering, personal growth, and learning

new ways to live on the planet; typically involving travel to destinations where flora, fauna, and cultural heritage are the primary attractions.
There has been few turtle ecotourism developed until now in Crete. In this non-consumptive use part we want to investigate the possibility of marine turtle ecotourism in Crete.

Currently there are some agrotourism and ecotourism in Crete. However, these ecotourism are mostly about the local culture, hotel in local farm (Blue Aegean, 2006; Crete TOURnet, 2007), there are also some diving tours (Blue Aegean, 2006); but none of them is about the turtles.

According to experience in other countries such as Australia (Wilson & Tisdell, 2000), Costa Rica, Brazil, Oman, Malaysia, Sri Lanka (Troëng, S. & Drews C., 2004), in long term run, exploiting marine turtle resources for non-consumptive wildlife-oriented recreation (NCWOR) to conserve marine turtle can be effective as is shown in table 4, at most sites where ecotourism is developed, the nesting trends are increasing. According to four case studies where consumptive sue was continued or replaced with non-consumptive use by Troëng (2004), the gross revenue of non-consumptive use is 7- 3039 times of the revenue of consumptive use. And where the consumptive use is stopped, both the turtle population trend and the gross revenue trend are increasing, such as Sabah in Malaysia and Ostional in Costa Rica. The revenue are up to 6, 714,483 US$ in year 2002 in Tortuguero, Costa Rica.

And to develop non-consumptive use such as tourism is especially important in cases where wildlife resources are declining due to habitat destruction, poaching and other human threats, as is so for sea turtles. Economic benefits from the turtle eco-tourism can provide a rationale of conserving the remaining turtles. However, appropriate management is needed to sustain the eco-tourism. (Wilson & Tisdell, 2000)

Crete has the potential of organizing marine turtle eco-tourism, because Crete is one of the most important tourism destination sites in Europe, there are over 20 million tourist come to visit every year. If the advertisement is being well designed, the source of the tourist won't be a problem for Crete.

Some basic ideas about the ecotourism in Crete are listed as below.

- The nesting, egg laying process and hatchling go back to the sea of marine turtles could be observed if well organized; and turtle can also be observed

as part of the diving tour. However, the nesting observation has to be very carefully organized or else it will disturb and stress the female turtles.

- The tourists can also help NGO to dig sea turtle eggs which were laid in a not suitable area and put them back to safe places which are carefully selected and specially built by the NGOs
- Fishermen can provide their ships to tourists to go further into the sea, watching sea turtles which are floating on the surface of the water, which can compensate their profit decrease of reducing the fishery. However, it requires the maintaining and increasing of the turtle amount. If the turtle population is lower than certain level, people will stop paying for this kind of activities.

The income of the marine turtle ecotourism is benefiting the ecotourism company, it is another driving force of the PES system, and it is one kind of environmental service provided by the marine turtles.

4.2.1.2. Passive use:

Marine turtles have a wide range of passive use ES values. These include option, intrinsic, ethical (Rolston 1994), existence and bequest values.

Option value represents the value of maintaining options for direct and passive uses that may emerge in the future (Troäng *et al.*, 2004). For biodiversity, a commonly mentioned option value is the potential of harbouring chemical compounds that could yield active ingredients for future pharmaceutical products. Even though there are difficulties in determining the probability of marine turtles containing such compounds, the importance of the option values should not be underestimated. And recently there are studies about the ability of the turtles navigating themselves using the Earth's magnetic field (Kenneth J. Lohmann), which could be valuable for the future technology. There might be potential beneficiaries for studying this technology.

From the view of conserving biodiversity, the turtle specie itself is one kind of environmental services, or it can be called the existence value. As mentioned in section 3, Marine turtles are important component of the marine ecosystem and play an important role on maintaining the biodiversity in the ocean. And marine turtle has in-direct influence on fishery economics. Plus, since marine turtle is a creature which lives since the age of dinosaur they are of great significant scientific value for the study of ancient animals.

The cultural and ethical use ES of marine turtles is already discussed in part 3 of the thesis.

4.2.1.3. Human husbandry ES

For protecting the marine turtles, and to maintain their ES for the human communities, not only the ES provided by nature need to be analyzed, but also the ES provided through human husbandry need to be investigated.

In the third part of the thesis, the human disturbance to marine turtles" was discussed. To minimize these disturbance factors, ES should be provided by human communities. Table 3 shows some detail of the disturbance factors, short information related to PES scheme is given. The information include: the importance of the influencing factors to the marine turtles; if the factor is caused by human; if the phenomenon exists in Crete; can the minimizing of this factor be included in the PES system for turtle protection, who will be involved into the PES system/ or who will sacrifice their benefits if the factor is included.

Table 5 disturbance sources to the marine turtles

Period	Disturbance factors	Influence extent	Human caused	Exist In Crete	**Involve in PES of Crete**	People involved / ES providers
Nesting	Artificial night light	High	Y	Y	Y	Owners of buildings near the nesting beach such as residents house, hotels, bars, discos, etc, and government
	Noises	Medium	Y	Y	Y	
	Occupation of nesting beach	High	Y	Y	Y	
	Sun bed and umbrella	Medium	Y	Y	Y	Sun bed and sun umbrella owners
Incubating/ hatching development	Sun bed and umbrella	Medium	Y	Y	Y	
	People walk around the nest	Medium	Y	Y	N	-
	Unorderly parking	Low	Y	Y	N	-
	People dig out eggs for curiosity	Low	Y	N	N	-
	Animals eat the eggs	Low	Partly/ indirect	Y	N	-
	Collect and sell turtle eggs	High	Y	N	N	-

Hatchlings go back to the sea	Lights near the beach	High	Y	Y	Y	Owners of buildings near the nesting beach such as residents house, hotels, bars, discos, etc, and government
	Unplanned buildings	High	Y	Y	Y	
	Parking area – car lights	Low	Y	Y	N	
	Introduced predators on the beach (e.g. dogs from resident houses nearby)	Low	Partly/ indirect	Y	N	
Migration development, mating period, marine forage	Pollution plastic bags	Medium	Y	Y	N	
	Fishery	High	Y	NA	N/ but will be discussed	Fishermen
	Speed boat	Low	Y	Y	N	
	Predators in the ocean	Medium	N	Y	N	

Summarizing the table, the major disturbance factors which might involve into PES system are: night light, noises, occupation of the nesting beach, sun beds and sun umbrellas.

To build up PES scheme for mitigating the night light and noise disturbance for turtles in Crete, the environmental service should be provided by the land owners whose possession is near the nesting beach, they can be private land owners such as the local residents, or they can be the owners of the hotels, bars, restaurants and discos which are near the beach. The Environmental services they can provide include many aspects, and this is a list of actions or conducts that providers need to change:

a) Turn off the light of the buildings which near the nesting beach after mid-night during nesting season and the season when hatchling goes back to the ocean. (From June to October). However, it might require high compensation cost because June to October is the high season of tourism.
b) Close the bars, restaurants, and discos after mid-night to reduce the noise disturbance to the nesting marine turtles (from June to August).
c) Rebuild the road which is too far away from the beach to mitigate the disorientation of the road light to the turtles.
d) Take back or stack the sun beds every night to provide the nesting female turtle enough place to choose their nesting site and protect the turtles being trapped by the sun beds.

e) Remove the sun umbrellas near the nests to make the temperature around the nest natural, keep the sex ratio balance of the hatchlings natural.
f) Remove the unplanned constructions near the beach.

To provide the environmental services in a) and b) requires PES scheme to compensate the owners of the involved bars, discos and restaurants for sacrificing their income after mid night during the nesting season.
To provide the environmental services in c) requires the government to pay extra money to reconstruct the road.
To provide the environmental services in d) requires the sun beds owners to pay extra money to hire people to do the stacking job everyday.
To provide the environmental services in e) requires the sun umbrella owners to sacrifice the benefit of several sun umbrellas during the nesting season.
To provide the environmental service in f) requires the land owner of the unplanned constructions near the beach to change the land use.

An EEA (European Environmental Agency) report (2006) indicates that marine turtles are commonly caught in nets in the Mediterranean, and this may be linked to their declining numbers. However, in my personal communication with Dimitris Margaritoulis (fieldwork, 2007), the manager of Fishery Department of Crete, the information was given that fishery is forbidden during the nesting season in Crete. And they use large circle hooks during the fishing season to reduce by-catch. When asked if PES can be built in the fishery system in Crete, Margaritoulis (pers. Comm. 2007) indicate that using the new hook, only larger fish will be caught, it will increase the efficiency of fishing, so it is already kind of compensation to the fisherman. So fishery is not discussed in detail in this case study.

Although it is not officially discussed in this case study, fishery can also be part of the PES system. Fishermen provide ES by stop fishing during the nesting season when marine turtles swim back to the nesting beach. Or they can change their way of fishing to reduce sea turtle capture and mortality in pelagic long-line gear to negligible levels, for example, there are studies about reduce capturing and injuring turtles by using large 18/0 circle hooks instead of 9/0 “J” hooks (figure 18), and setting gear below 40 m appear to be solutions for some fisheries. But implementing these measures are limited because large hooks and deeper setting are not economical everywhere. And this requires the PES system to compensate.

Figure 16 9/0 J hook (left) and 18/0 circle

4.2.2. Quantification of the ES

Here, the importance of the turtle value estimation is to define a baseline for the turtle protection PES scheme. Furthermore, it can also provide the decision-makers with a better understanding for defining adequate conservation policy. There have been a number of authors who have evaluated the environmental services for marine turtles (Bjorndal *et al.* 2003; Troëng *et al*. 2004; Green & Short, 2003). They measured the costs of various environmental services of marine turtles such as passive and direct use and came up with varying figures as described below:

Troëng *et al*. (2004) divided the use of the turtles into several categories and set up an analytical framework to quantify economic aspects of marine turtle use and conservation. As shown in figure 19.

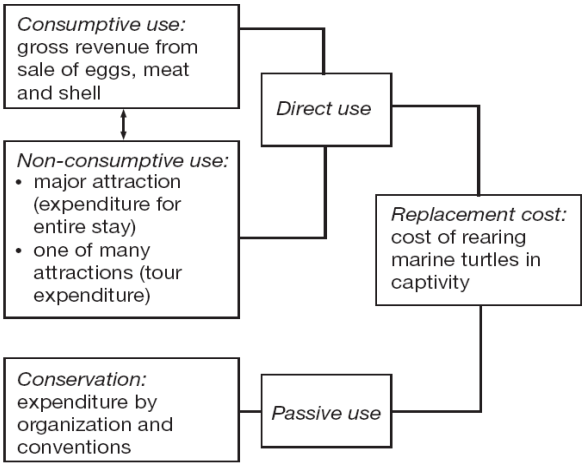

Figure 17 Analytical framework to quantify economic aspects of marine turtle use and conservation (Source: Troëng, S., 2004)

4.2.2.1. Direct use:

A) Consumptive use:

Troëng *et al*. (2004) estimate gross revenue from consumptive use of marine turtle meat, eggs, shell, leather and bone at nine cases in developing countries. Gross revenue from consumptive uses varies from US$ 158 to US$1,701,328 yr^{-1} per case study with an average of US$ 581,815 yr^{-1}. Direct beneficiaries from consumptive use vary from a handful to several hundred.

However, on Crete Island, the consumptive use of marine turtles is very rare, so this part can be ignored.

B) Non- consumptive use

The nine case studies of Troëng *et al*. (2004) shows that the area where non-consumptive use of marine turtles dominates the major revenue, has gross revenue ranging from US$41,147 to US$ 6,714,483 yr-1 per site with an average of US$ 1,659,250 yr^{-1}. Gross revenue at four sites where marine turtles are one of many attractions varies between US$ 3,387-US$ 105,997 yr^{-1} with an average of US$ 40,791 yr^{-1}.
Direct beneficiaries from non-consumptive use range from ten tourism operators to 1,280 persons per case study.

Case studies about the income of non-consumptive use in other countries:

Table 6, non-consumptive use of marine turtle case studies (Troëng *et al*., 2004)

Case study of the ecotourism where marine turtle is the major attraction								
Case study	Year	Major species	Nesting trend	Visitors	Spending per visitor US$	Estimated gross revenue US$	Adjusted to 2002 using US CPI	Direct beneficiaries
Tortuguero, Costa Rica hostels	2002	Cm	+	26,292	255.4	6,714,483	6,714,483	owners of 25 hotels and hostels,~265 hotel employees,
Projeto	2001	Cc Ei	+?	N/A	N/A	2,635,656	2,677,326	1,280 employees

TAMAR, Brazil		Lo						
Playa Grande, Costa Rica	2002	Dc	-	4,234	338-676 **	2,113,176	2,113,176	business owners and employees,41 tourism operators
Ras Al Hadd, Oman	1997	Cm	±	11,558	98.3	1,136,151	1,273,481	tour company owners and employees
Sabah, Malaysia	2002	Cm	+	8,450	113.7-115.5	975,044	975,044	tour company owners ~54 persons including park rangers, resort staff,boat captains, tour guides
Matura,Trinidad & Tobago	2001	Dc	+	10,693	21.2-390.0 **	559,014	567,852	beach monitors, turtle taggers, tour guides, business owners and employees
Rantau Abang, Malaysia	2002	Dc	-	12,259	26.3-65.5	480,149	480,149	Concession holders, business owners and employees
Gandoca, Costa Rica	2003	Dc	+	610	151.3*	92,300	90,588	taxi drivers, shop & bar owner and employees, tour guides, owners
Rekawa, Sri Lanka	2003	Cm	?	1,710	24.5	41,925	41,147 17	taxi drivers, shop & bar owner and employees, tour guides, owners and employees of 7 hostels,6 conservation project employees

Case study of eco-tourism in which marine turtle is being one of many attractions								
Barbados	2003	Cm,Ei	+	1,400	20-100	108,000	105,997	tour guides,13+ hostel and resort owners, business owners and employees One of many attractions
Maputalan,	20	Cc,	+	~1,75	7.1-	45,597	44,751	4 tour companies and

South Africa	03	Dc		0	94.1			employees
Brazil	2002	Cc	+?	260	13.6-45.9	9,031	9,031	tour companies and employees
Cape Verde	2003	Cc	?	~300	11.5	3,451	3,387	10 tourism operators

*Direct income fro community **Extrapolated from tour fee

Major species: Cc- loggerhead turtle, Cm-green turtle, Ei-hawksbill turtle, Dc-leatherback turtle, Lo- olive ridley

4.2.2.2. Passive use:

Because of the complexity of the ecological interactions between marine turtles and the ecosystem, it is difficult to quantify the value of the ecological services provided by marine turtles.

The value that turtle passive use service can obtain depends on people's conscience about the environment because this kind of ES cannot be clearly quantified.

Many studies aimed at quantifying passive use values use the measure of contingent valuation methods (CVM), which in essence is how much respondents state that they are willing to pay to maintain or avoid something. For example: a study in North Carolina in 1991 stated that people interviewed were willing to pay US $ 33.2 per year to protect loggerhead turtles (Whitehead, 1992). And in this case study, tourists in Crete are also interviewed about their willingness to pay for the turtle conservation.

In this study, we went to Crete, interviewed people about their willingness to pay for turtle protection. There are two options for them to choose if they are willing to pay:

1) Pay one euro more per day for the each suit of sun umbrella and two sun beds (current price range from 5-10 Euros per day). This money is used to hire people to stack sun beds every night.
2) Pay some biodiversity conservation tax at the airport when entering Crete.

In the interviews the tourists can choose whether to pay or not and how much they are willing to pay (if they choose to pay biodiversity tax).

From the result of interview, interview result graph shows that 97.80% people (89 out of 91 people) are willing to pay for the turtle conservation ES.

Out of the 89 people who are willing to pay, 32 people chose the way to pay one euro each day, 14 people chose the way of paying biodiversity tax when they enter Crete, and the rest (43 people) think either way will be OK. For the people who choose to pay one euro per day, I asked the length of their staying in Crete, so the money can be calculated; and for those 57 who choose to pay biodiversity tax and who chose either way would be OK, they were asked how much they were willing to pay. The method of the interviewing and questionnaire designing is described in the second part of the thesis.

As a result, out of the people who were willing to pay for the biodiversity conservation, 9 people would pay €1 – 10, 13 people would pay €11 – 20, 22 people would pay €21 – 30, 7 people would pay €31 – 40, 5 people would pay €41 – 50, and 1 people would pay 100 Euro. **The average value of people's willingness to pay for marine turtle conservation in Crete is €28.77**.

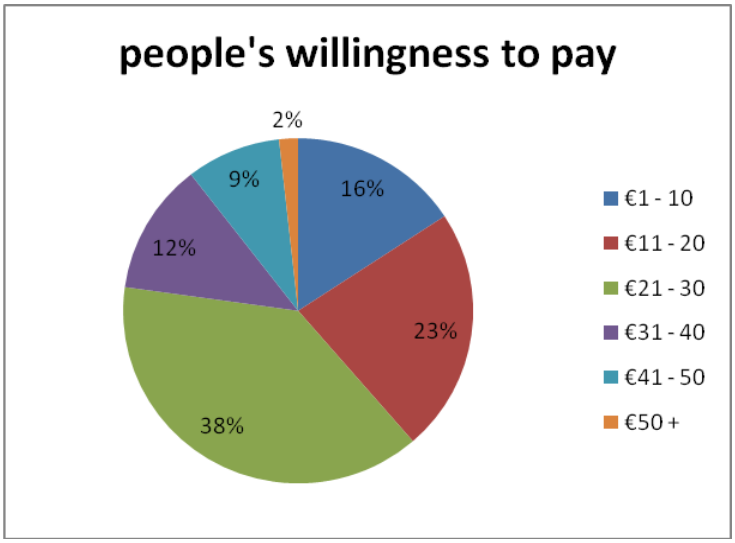

Figure 18 people's willingness to pay

And for people who were willing to pay one euro more for the sun beds, the average of their holiday in Crete is 11.3 days.

The two people who are not willing to pay suggest that after using they can put back the sun beds back to the specific place by themselves, instead of paying one Euro.

As a result, if we use the financing mechanism of paying biodiversity conservation tax when tourists entering Crete, and use the tourist number of 2006: 2,778,339, the total payment for each year collected will be:

€ 28.77 * 2,778,339 = € 79,932,813

And if we use the financing mechanism of collecting one euro per day for each sun bed en suit, which means each of them will pay 0.5 euro more per day (1 euro per en suit). Use the holiday length of 11.3 days, and tourist number 2,778,339, the total payment collected for each year will be:

€ 0.5*11.3*2,778,339= € 15,697,615

The result of this interview can be used both for the valuating of the passive use of marine turtles and for estimating the beneficiaries' willingness to pay for conserving the marine turtle's passive use.

And according to Tröng (2004), the expenditure of marine turtle conservation was also considered as a way to assess the passive use value of the turtles. And annual expenditure for marine turtle conservation in Europe and Mediterranean reached US$ 116,971 at international level, US$ 1,784,298 at national level, and US$ 45,333 at local level. And to generate one job, the cost range from US$ 7,311 to US$ 22,666.

4.2.2.3. Replacement cost:

As is mentioned in 3.2, marine turtles play an important role in both coastal and oceanic marine ecosystems. For example, green turtles digest sea grass leaves par part of sea grass nutritional content becomes available to other organisms much more rapidly than through normal decomposition (Thayer *et al*. 1984; Tröng, 2004). The presence of green turtles contributes to healthy sea grass beds (Bjorndal *et al.* 2003). Seagrass bed ecosystems are one of the most valuable ecosystems on the planet, the ES is estimated to worth US $ 19.004 ha^{-1} yr^{-1} in 1994 (Costanza *et al*., 1997), and their global value reached US $3.8 trillion yr^{-1} (Green & Short, 2003). Marine turtles also transfer nutrients from marine to terrestrial ecosystem which can benefit numerous species of fauna and flora (Bouchard & Bjorndal, 2000).

In order to maintain these intrinsic values of marine turtles, so as to maintain their roles in ecosystem functioning and in providing benefits to people, their populations need to be restored worldwide to healthy levels. The replacement cost for example

of nesting females through captive breeding has been estimated at US $ 245.9 – US $263.3 million for green and US $ 2.5 billion for leatherback turtles in global extent. One method of calculating this replacement cost is to estimate the cost of raring marine turtles in captivity and studies have shown that the cost of rearing turtles in captivity is more expensive than their natural growth in the wild (Troëng *et al*., 2004).

To justify the use of the replacement cost method, three criteria should be fulfilled (Freeman, 2003):

1) The replacement method must be the least costly alternative for maintaining the environmental service provided;
2) The replacement method must provide a service of equivalent quality and magnitude;
3) Individuals must be willing to incur the cost of the replacement.

Considering the three criteria above, to calculate the cost of replacing the population of turtles whose terrestrial habitat is on Crete Island, one of the most conservative ways is to count in only the nesting female turtles. The calculating process is shown in table 4.

As is mentioned in Section 3, a female turtle lays 2-3 nests per nesting season, so we calculate the female turtle population as "nests number÷2.5".

And according to the case studies of Reunion (Seminoff, 2002) and Rantau Abang , Malaysia (Spotila *et al*., 1996), cost of producing one adult marine turtle range from US$ 1,672 to US$ 72, 632 depending on different species and different areas. Since there is no data related to the replacement cost of loggerhead turtles, here we use the number for green turtles instead: US$ 1,672.

Table 7 calculation of replacement cost for nesting turtles in Crete

Nesting area	Nests number	Female Turtle	Cost per turtle	Total value of the turtle nests (US$)	Nest amount Data source:
Rethymno	316-516	105-172	US $ 1, 672	176,117-287,584	Margaritoulis 2000 ; Margari-toulis *et al*. in press
Chania	77-192	26- 64		42,915-107,008	
Messara	15-80	5-27		8,360-44,587	
Total	408- 788	136-263		227,392-439,179	

In this replacement cost calculation of Crete Island turtles, we used the one for green turtles because lack of data for loggerhead turtles. And this value is determined in

2002, the currency ratio has been changed so the value is not exactly the same. Plus, the replacement cost of leatherback turtles (US$72,632) is much bigger than green turtle (US$ 1,672), which makes the estimation of value of loggerhead turtle even harder.

4.3. ES providers

When we talk about the environmental service providers in a PES scheme, we talk about the people or communities who sacrifice part of their benefits to meet some conservation levels and they are paid for compensating these sacrifices in the PES scheme; usually the payment is higher than their beneficiaries from other alternative use of the land. So the non-compulsory negotiated PES system can operate properly.

The International Institute for Environment and Development (IIED) studied 72 cases of markets for forest biodiversity protection services in 33 countries. The result showed that the main sellers of biodiversity services (in declining order of prevalence) were communities, public agencies, and private individuals (Michael J. *et al.*, 2004).

In this case study of turtle protection PES in Crete, theoretically speaking, the service providers for the non-consumptive use such as turtle tourisms would be the nature. However, the current status of marine turtles requires reversing the declining trend of the turtle to develop the potential ecotourism. As a result, to maintain both the direct use ES and the passive use ES, the service providers should the owners of the land which is near the nesting beach and has significant influence on the nesting beach. Depend on the ownership of the lands; the ES sellers can be municipalities in Crete, communities or private land owners. They can change the land use of their land to protect the nesting beach and conserve the turtles.

As mentioned in 4.2.1, to maintain the human husbandry ES of marine turtle protection in the PES system, the providers of the services are mentioned in 4.2.1, the environmental service should be provided by the owners of the hotels, bars, restaurants and discos which are near the nesting beach, or the local residents whose house is near the nesting beach.

The owners of the sun bed and umbrellas are also the ES providers since they provide ES by hiring people stacking sun beds to make place for turtles; they also remove sun bed and sun umbrellas near the nests and sacrifice their benefits from these sun beds and sun umbrellas. Plus, because the business of these ES providers have considerable impact on the marine turtles reproductive habitats, they may find that paying to increase the flow of ES (biodiversity offsets) is an economical way to neutralize their footprint. Since the biodiversity decrease, the attraction of the tourism site will decrease in some extent.

In Crete, the beaches actually belong to the municipalities, and the hotels or other business corporations rent the beach from local municipalities (pers. Comm., Mr Papadpourakis, Mayor of Rethymno municipality). The business corporations has the right to rent the beach in front of the hotel, and put sun beds and sun umbrellas on the beach, every day they charge people for using these facilities normally the prices range from 5-10 Euros per day, depend on the location and the conditions of the facilities (pers. Comm., people charging for the sun beds, hotel managers, bar managers). From this point of view, the municipalities are also providers for the marine turtle conservation ES.

Turtle conservation NGOs on Crete such as ARCHELON is providing conservation measures for protecting the turtles. To certain extent, they are also the environmental service providers, although they also play other roles the PES system, such as potential intermediary or potential ES beneficiaries. In this section (4.3) we only discuss about their role as the environmental service providers.

As mentioned in 4.2.2.2, the expenditure of marine turtle protection in Mediterranean reached US$ 116,971 at international level, US$ 1,784,298 at national level, and US$ 45,333 at local level. And to generate one job, the cost range from US$ 7,311 to US$ 22,666 (Troëng, 2004). However, the cost for turtle conservation of ARCHELON on Crete is not provided.

If fishery is forbidden in Crete during the turtle nesting season, fishermen should be compensated for this, in this situation they are the service providers. However, as mentioned in the marine turtle tourism part, they can offer their boat to the tourist to observe marine turtles offshore and participate into the ecotourism and benefit from it, and from this point of view they can be beneficiaries of the PES system.

4.4. ES beneficiaries

When talking about the ES beneficiaries in the PES system, we often seek for the buyers of the ES. They receive the environmental service and pay for it. When beneficiaries of the ES are known, a means has to be devised to capture their willingness to pay. It is straightforward when the beneficiaries are easy to identify and are already organized, making it relatively simple to negotiate with them and to collect payments. For instance, an additional fee can easily be added to water bills paid by municipal and industrial water users. In contrast, beneficiaries of biodiversity conservation are not easily identifiable, and have no chance to be organized, and there is no pre-existing mechanism for collecting payments from them.

According to the investigation result of a team from McKinsey & Company, the World resources Institute, and The Nature Conservancy, the annual international

finance for the conservation market (conservation defined as protecting land from development) at US$2 billion. And predominantly buyers of biodiversity conservation are development banks and foundations in the United States and Europe (Michael J. *et al*., 2004). The result of an IIED study showed that the main buyers of biodiversity services (in declining order of prevalence) were private corporations, international NGOs, research institutes, donors, governments and private individuals. (Michael J. *et al*., 2004)

In this case study, for the direct use ES of the turtles, if ecotourism can be set up in Crete, the ES beneficiaries of the ecotourism are companies or people who will organize the ecotourism, sometimes, local communities can also benefit from the ecotourism by selling food or renting vehicles. Because they benefit from the conservation of the marine turtle nesting habitats and marine turtles which attract their clients. However, currently the turtle tourism hasn't been set up yet, so the ecotourism organizers remain to be potential beneficiaries. However, according to the case studies in the section 4.2.2.1, the benefit from ecotourism is showing a promising future, moreover, ecotourism itself is a conservation measure.

For the passive use ES and human husbandry ES of marine turtle protection in the PES system, the beneficiaries are not easy to define. Speaking in a large extent, all human beings could be potential beneficiaries for the conservation. The beneficiaries of the marine turtle conservation are hard to identify, not easy to organize, and there is no pre-existing method to collect payment for the ES of turtle conservation in Crete.

Currently there are organizations and donors who are supporting the sea turtle conservation NGOs on the Island. If there will be developing banks or other foundations that will pay for the environmental services which are provided by the sellers in Crete, these foundations can be considered to be representing the world population.

However, there is another way of relating people to the turtle protection in Crete. There are over 2.7 million tourists visiting Crete every year, this group of people are related to Crete. As described in 4.2.2.2, the tourists' willingness to pay can be also considered to be the potential payment from the beneficiaries. And if the PES scheme will be implemented on Crete, the possible money could range from € 15,697,615 to € 79,932,813, depends on the efficiency and the institutional framework of the PES scheme.

4.5. PES intermediaries and institutional framework

Intermediaries or coordinator is a necessary part of the PES scheme. The intermediaries need to initiate and maintain a supporting institutional framework for the PES scheme. Its duty include: provide scientific information and technical assistance, initiate and implement the PES system; set up some supervision system to ensure the environmental service is provided continuously; organizing the direct

payment system and help connecting the ES providers and beneficiaries, organizing the negotiation of the conservation concession; providing technical advice and reconciling different interests (Maveneke, 1998)

The institutional framework theoretically should minimize transaction costs and allow the maximum transfer efficiency from beneficiaries to ES providers/ resource owners. However, in practice, such governance structures need to take root into existing local institutions or communities. Establishing a new institution might lead to local conflicts over access to resource or land uses. In order to build trust, the institutional framework must be as accessible and transparent as possible. But this will increase the transaction costs. Here will be a trade-off between transparency and minimum transaction cost. (Mayrand & Paquin, 2004)

In previous case studies (Michael J. *et al*., 2004; Mayrand & Paquin, 2004), most of the intermediaries of the PES scheme are the conservation agencies, such as: Conservation International negotiated direct payment for the conservation concessions, and forest conservation easements negotiated by the Cordao de Mata ("linked forest" in English) project with dairy farmers in Brazil's Atlantic Forest, some other cases created new institutions to support new PES schemes.

In this case study of Crete Island, since there are NGOs such as ARCHELON and WWF who are making efforts on protecting turtles, being ES providers on one hand, on they other hand they can be the coordinator or intermediary of the PES scheme for marine turtle conservation, to supervise the behaviour of the ES providers, and to help ES sellers and buyers communicate and negotiate. In addition, they can provide scientific information and technical support.

From the economic point of view, ARCHELON operates mainly depending on the money from donations and might partly depend on the volunteers – the participation fee of each volunteer cost from €150 to €250 depending on the different time of year (ARCHELON volunteer website, 2007), and there are around 140 volunteers come to Crete Island for protecting the turtles (pers. comm. Simon Proctor, the coordinator of the ARCHELON volunteer in Rethymno, Crete, 2007). There is no payment to the people who is running the survey of the turtles, and volunteers live in camping sites with outdoor very basic sanitary and cooking facilities, and sometimes face harsh conditions. If ARCHELON will be involved into the PES system, the volunteers will check the providing condition of the ES, and they will get paid for the surveying. It will help with the improvement of the living condition of the volunteers and indirectly help improving turtle protection in Crete.

4.6. Possible scheme of marine turtle conservation PES in Crete

After specifying the ES, ES providers, beneficiaries and the system intermediaries, in this section (4.6), the scheme of the PES will be discussed.

First of all, the basic flow in the PES scheme should be clarified. As shown in figure 21, receiving the compensation distributed through the payment mechanism, ES sellers sell the ES, and then the beneficiaries receive the ES and pay ES providers through a financing mechanism.

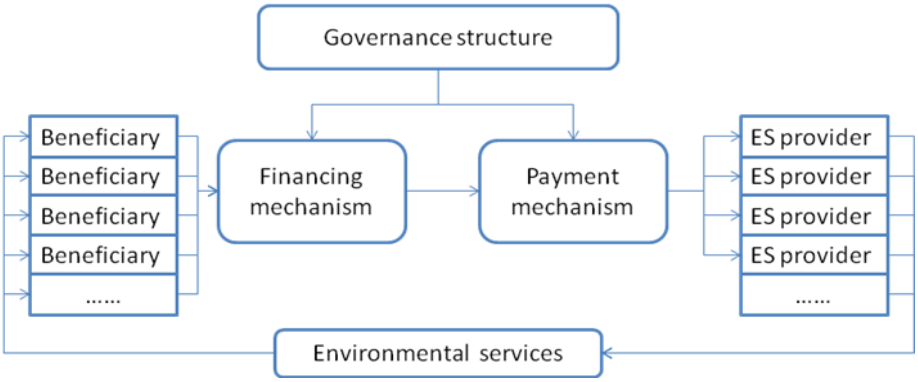

Figure 19, the flow of ES and compensations between beneficiaries and ES providers
(Source: S Pagiola. et al., World Bank, 2002)

Generally speaking, this PES scheme can be divided into several parts according to different ES flow, and each of them has its own beneficiaries and providers.

Based on previous discussions in this chapter, the potential sub-PES-schemes of this case study include:

1) If the marine turtle tourism will be organized, the ES is theoretically provided by the nature, and the potential beneficiaries are the ecotourism organizers. However, due to the current situation in Crete, to develop and maintain this business, protection for the turtles is needed, so people have to get involved taking measures to conserve turtles as the service providers. Local turtle conservation NGOs such as ARCHELON are providing this kind of service. Moreover, owners of the lands which are near the turtle nesting beach will have to change their behaviour in some extent such as remove some buildings, turn off the lights after mid-night during the nesting season, the ecotourism organizers will benefit from the non-consumptive use of the marine turtles so they should pay for the ES. And according to the ecotourism income review, the payment from the ecotourism operators will be very likely sufficient. As reviewed in section 4.2.2.1, the result of nine case studies showed that the area where non-consumptive use of marine turtles dominates the major revenue had gross revenue ranging from US$41,147 to US$ 6,714,483 yr-1 per site with an average of US$ 1,659,250 yr-1. Gross revenue at four sites where marine turtles

were one of many attractions varies between US$ 3,387-US$ 105,997 yr -1 with an average of US$ 40,791 yr -1 (at level of 2002).
Furthermore, ecotourism itself is a good way for conservation the marine turtles.

2) For the passive use ES sub-scheme, the ES is theoretically provided by nature too. However, similar to the direct use ES, to maintain these passive use ES, there has to be people involved to provide ES of conservation. Because the passive use ES of the marine turtle is intangible it is hard to identify or quantify the values of the environmental service. Moreover, it is also difficult to define or organize the beneficiaries since the beneficiaries could be the human being all over the world. In this case study I tried to relate the tourists in Crete into this PES system. According to the interviews to the tourists, and asked about their willingness to pay, it was showing optimal result that 98% tourists are willing to pay for the PES scheme in different way of payment. If this scheme can work, payment from beneficiaries of this source can reach € 15,697,615 to € 79,932,813 at the level of 2007. Other payment for this service might be from international NGOs, governments, donors etc, these ES buyers can be considered as representative of the global beneficiaries in some extent.

3) For human husbandry ES, the services varies a lot, such as: removing constructions or roads near the nesting beach, closing bars, discos near the beach after mid-night, turning off the light of the buildings near the nesting beach , stack the sun beds at night during the nesting season, remove the sun umbrellas near the nests. The services providers are the local residents, business managers or municipalities. And the beneficiaries are mostly from the sub-scheme 1) and 2).

4) There are other sub-schemes such as fishery PES scheme discussed in the thesis, but they are not feasible according to the current situation so we don't list them here.

According to the discussion above, it can be found that if we combine these sub-schemes, the environmental services, beneficiaries, ES providers are forming a complete **PES scheme**, which can be described as figure 22:

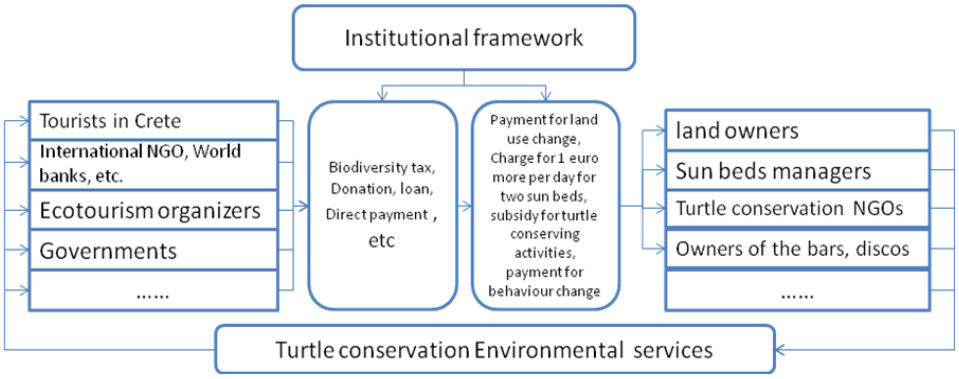

Figure 20 potential PES scheme (sketch map)

4.7. Information needed for constructing the PES scheme

After clarify the framework of the marine turtle conservation on Crete, the following step will concentrate on the quantification of the ES and payment flow. As demonstrated in Figure 23.

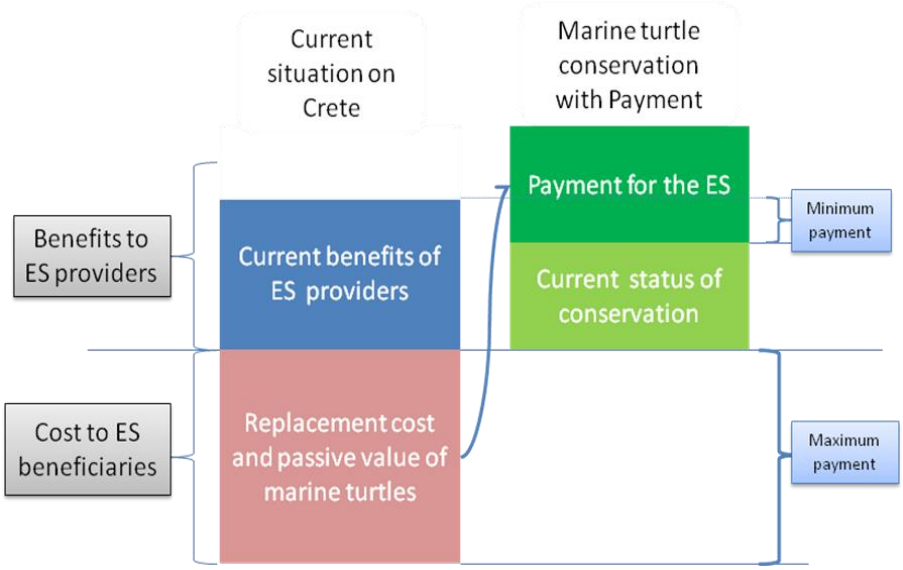

Figure 21 marine turtle and habitat conservation PES scheme

To investigate if this PES scheme will work properly, we need to find out the payment is in the range of "larger than the minimum value" and "smaller than the maximum value+ the transaction cost", the PES scheme will work in Crete.

1) what we need to know are:

- Current benefits of ES providers (after mid-night income of hotels, bars, restaurants etc. value of resident houses and other buildings), income of direct use of turtles
- Replacement cost and passive value: if the turtles on Crete distinct, how much will people have to pay for replacing them, and the passive value of the turtles
- Current conservation status of marine turtles, such as how much money does the NGOs spend on protection turtle and turtle habitat every year.
- How much will the potential ecotourism beneficiaries (ecotourism organizers, maybe sometimes local communities) gain and how much will they pay for the environmental services from which they benefit?

2) What we have obtained in this study are:

- The estimation of people's willingness to pay for the service showed that payment from tourists will range from € 15,697,615 to € 79,932,813
- The result of conservative calculation of marine turtle replacement cost ranges from US$ 227,392 to US$439,179.
- Annual expenditure on marine turtle conservation in Europe and Mediterranean is US$ 116,971 at international level, US$ 1,784,298 at national level, and US$ 45,333 at local level. And to generate one job, the cost range from US$ 7,311 to US$ 22,666.
- From previous case studies, the area where non-consumptive use of marine turtles dominates the major revenue had gross revenue ranging from US$41,147 to US$ 6,714,483 yr-1 per site with an average of US$ 1,659,250 yr-1. Gross revenue at four sites where marine turtles were one of many attractions varies between US$ 3,387-US$ 105,997 yr -1 with an average of US$ 40,791 yr -1 (at level of 2002). And ecotourism has a promising potential development in Crete.
- In the fieldwork, we got the geo-information and basic information of the turtle nests and the disturbance factors such as bars, restaurants, hotels near the beaches; sun beds, playground on the beach of Rethymno, Chania and Bay of Messara (figure 24, figure 25, figure 26, Table 1), details such as the incomes and accurate inventory still need further investigation.

3) What will still be needed for further study

- Current benefits of ES providers/ ES managers (income after mid-night of hotels, bars, restaurants etc. near the nesting beach, value of resident houses and other buildings near the nesting beach), income of direct use of turtles (very small, could be ignored in Crete)
- The exact annual expenditure on marine turtle conservation of the NGOs and the governments
- The official market analysis of marine turtle ecotourism in Crete
- The accurate replacement cost of loggerhead turtles and the exact turtle species constitution (how many loggerhead turtle, how many green turtle, how many leatherback turtle, etc)

With current data, an approximate estimation is made, people's willingness to pay for turtle conservation ES is very high, and payment might exceed the maximum payment limit. More important the payment is voluntary. It makes the PES scheme for turtle conservation on Crete very promising. However, further analysis is needed if a practical PES scheme will be built up.

5. Discussion

5.1. Correlation between human disturbances and turtle nesting

The night light change of the time series on Crete has a slightly increasing trend, although it has some fluctuation. In the extent of whole Crete Island, there is positive correlation between the tourist number and the night light strength. The trend that night light strength value increases as the tourist number increase proofs that the night light strength is a way of indicating the human activity, which is also observed by C. Chalkias *et al*. (2005)

The quantitatively analysis of human influence on turtle nesting is being investigated by observing correlation between night light strength and turtle nest number along Rethymno beach coastline. And the result showed that it was very likely that the human activities near the nesting beach had negative impact on the turtle nesting behaviour. However, because of the complicated life cycle of the turtles, there must be more disturbance factors influencing their population and consequently influencing the nesting number change. Moreover, it takes approximately 35 years for a marine turtle hatchling to grow mature and return to the beach where it was born, the nest number might also be influenced by the turtle population 35 years ago. It can explain the low R^2 value of the logarithm formula.

5.2. About the PES scheme in this case study

1) The interview of people's willingness to pay for the turtle conservation showed an optimal result, 98% of the respondents are willing to pay. However, there might be some problems with this enthusiastic willingness to pay.
   When interviewing people in Crete, the author always started with a introduction of the endangered status of the turtles, this might influence people's answer to their willingness to pay. Furthermore, when doing interview, people don't really need to pay, there will be possibilities that they are easier to say "yes" to the payment.

2) Although the key features in the PES scheme are proposed, possible scheme is instituted, its feasibility is investigated and showing an positive result, if the scheme can work efficiently still depends on a lot of things, such as:

   PES works best when services are visible and beneficiaries are well organized, and when land user communities are well structured, have clear and secure property rights, strong legal frameworks, and are relatively wealthy or have access to resources (K. Mayrand & M. Paquin, 2004); clear scientific evidence linking land uses to the provision of services, the provision of services are closely mentioned, etc.

   All these factors can not be controlled or expected in this thesis. So the efficiency of the PES scheme will remain questioned.

3) As mentioned in part 4.5, some of the fund has to be used for running PES system. According to a case study about wild life conservation PES in Zimbabwe (Frost and Bond), these funds helped to meet the costs of project administration by program contractors (20.9% of total expenditure, including audit costs and contigencies); community development, including infrastructure (24.4%), technical support for wildlife conservation (11.8%) ; planning and applied research (6.9%), communications and training (3.6%); and grants to the participating NGOs (19.7%). However, none of the funds was spent on subsidizing the basic transaction between the producer communities and ecotourism operators. (Wunder, 2006)

   In the case study of Crete, because there are many actors involved, especially the charging 1 euro from each people for the sun beds and sun umbrellas, and hire people stack the sun beds everyday along the entire beach of Crete, the transaction fee might be very high.

   Furthermore, the supervision of the work of stacking sun bed, and the supervision of turning off the lights near the nesting beach are also difficult. And cost high transaction fee.

6. Conclusion

6.1. Human activities influence on marine turtle nesting

The night light change on Crete has a slightly increasing trend, although it has some fluctuation. In the extent of whole Crete Island, there is positive correlation between tourist number and the night light strength. The trend that night light strength value increases as the tourist number increase proofs that the night light strength is a way of indicating the level of human activity.

The quantitatively analysis of human influence on turtle nesting was investigated by observing correlation between night light strength and turtle nest number along Rethymno beach coastline. And the result showed that it was very likely that the human activities near the nesting beach had negative impact on the turtle nesting behaviour. However, because of the complicated life cycle of the turtles, there must be more disturbance factors influencing the nest number on the beach.

6.2. Feasibility of the PES scheme for marine turtle conservation on Crete Island

Generally speaking, it is feasible to construct PES scheme for marine turtle conservation in Crete.

The environmental services in this scheme include: removing constructions or roads near the nesting beach, closing bars, discos near the beach after mid-night, turning off the light of the buildings near the nesting beach, stack the sun beds at night during the nesting season, remove the sun umbrellas near the nests, taking measures to ensure the safety of the nests, etc. Except the last ES others are all potential ES which needs to be started in the new PES scheme, the last one already exists in Crete.

When talking about ES providers in the scheme, the environmental services for protecting turtles will be provided by: Local turtle conservation NGOs such as ARCHELON; owners of the land which is near the turtle nesting beach (change their behaviour in some extent such as remove some buildings, turn off the lights after mid-night during the nesting season, etc.)

The beneficiaries of the PES scheme include: if ecotourism will be developed, marine turtle ecotourism organizers will become beneficiaries; tourists in Crete, as a representative of the world populations, are willing to pay for the turtle conservation, become another source of ES buyers.

For the intermediaries of the PES scheme, ARCHELON have the potential to take this role. Or new institution specifically for the new scheme can be built.

Other potential schemes such as fishery PES scheme were also discussed in the thesis, but they are not feasible according to the current situation.

Figure 22 is a brief demonstration of the PES framework, combining all theses actors / key features in the scheme.

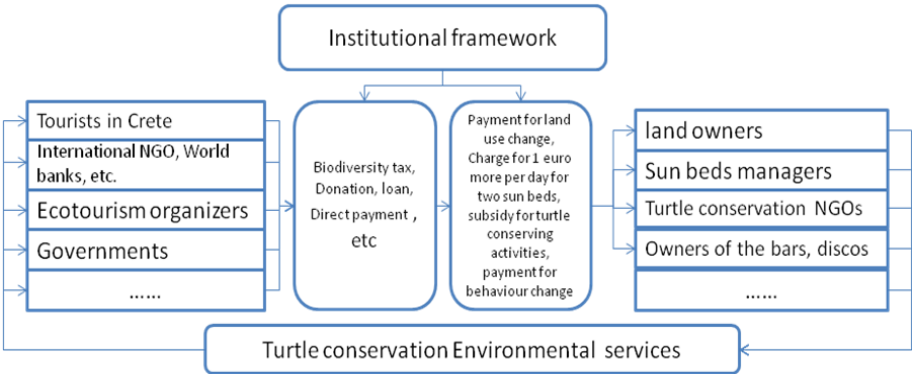

Figure 22 Potential PES scheme (sketch map)

Basic economic estimation based on available data was made and the result shows that people's willingness to pay for turtle conservation ES is very high, and payment might exceed the maximum payment limit, and the payment is voluntary. It makes the PES scheme for turtle conservation on Crete very promising. However, further analysis is needed if a practical PES scheme will be built up.

6.3. Limitation of the research

For the analysis of correlation between disturbances and turtle nesting, the main obstacle of the disturbance- turtle nest correlation analysis is lack of data, only the nest number of Rethymno was available for one decade.

Due to the long and complicated life cycle of marine turtles, more marine turtle population data will be needed for a more accurate and comprehensive analysis; however, the available data are only from year 1992 to year 2003. The ideal data should have more than 70 years (it takes approximately 35 years for a hatchling to grow mature and return to the beach where they were born) and data of two life cycles can give us a contrast and provide possibility for comparison. Moreover, there are many more disturbance factors such as the ones occurs in the ocean are not considered. Although there is some quantitative correlation between disturbances on Crete and the nesting numbers, artificial night light strength can only present the human activity in some extent, it is not the only way to disturb the turtles. More comprehensive models will generate more accurate result.

The nest data of Chania and Messara are not available, which is another obstacle. If there are nest data for three places, we can compare the disturbance to the turtle nesting horizontally / for the same period. Even though all the area has the fastest development along the coastline, the development of each area is different; the result for Rethymno might not present other area such as Chania and Bay of Messara.

And for PES scheme, the limitaton is mainly the lack of time in the fieldwork, one month time is too short for investigating a big island like Crete, especially when both social interviews and spatial data information are needed to be collected. If more detail data are collected for the disturbance factors, the primary estimation in section 4.6 can be more accurate. And this case study is mostly based on scientific generalizations, and real market investigation is very important for a new economic system which can not be complete in this thesis. However, a PES scheme is normally a large project; this MSc thesis can only investigate the feasibility of it.

6.4. Recommendations

6.4.1. For PES scheme:

If there will be further studies about setting up the PES scheme practically, the information below is strongly recommended to obtain:

- Current benefits of ES providers/ ES managers (income after mid-night of hotels, bars, restaurants etc. near the nesting beach, value of resident houses and other buildings near the nesting beach), income of direct use of turtles (very small, could be ignored in Crete)

- The exact annual expenditure on marine turtle conservation of the NGOs and the governments
- The official market analysis of marine turtle ecotourism in Crete
- The accurate replacement cost of loggerhead turtles and the exact turtle species constitution (how many loggerhead turtle, how many green turtle, how many leatherback turtle, etc)

Another important thing for PES is to attract the interest of the ES buyers. To promote interests of the beneficiaries (ES buyers), the ES providers and coordinators should make turtle PES more attractive through many ways of advertisements.

6.4.2. For studying correlation between disturbances and turtle nesting

For further studies about the correlation between disturbance factors and marine turtle nesting bebaviour, time series should be extent as early as possible, for example, 1950s, when tourism has not been developed in Crete, so there will be much more contrast to indicate the impact of the human disturbance. There might be a problem since the turtle observation data in Crete starts since late 1980s, so another solution could be keep the observation in the future and hopefully get the data longer than a turtle life cycle.

The details about disturbance factors are needed to be collected in the field, such as the real night light strength on the beach, the strength of the noises. These specific and accurate data will be more valuable to this kind of study.

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(http://www.ngdc.noaa.gov/dmsp/gcv2_readme.txt

Appendix

1. Spatial data collection from fieldwork

Table 8 total turtle nest number on three main beaches in Crete

Location	NO. of Nest	NO. of Sun bed	Source
Rethymno	98	5859	Field survey
Chania	55	2611	Field survey
Messara	52	463	ARCHELON in Messara

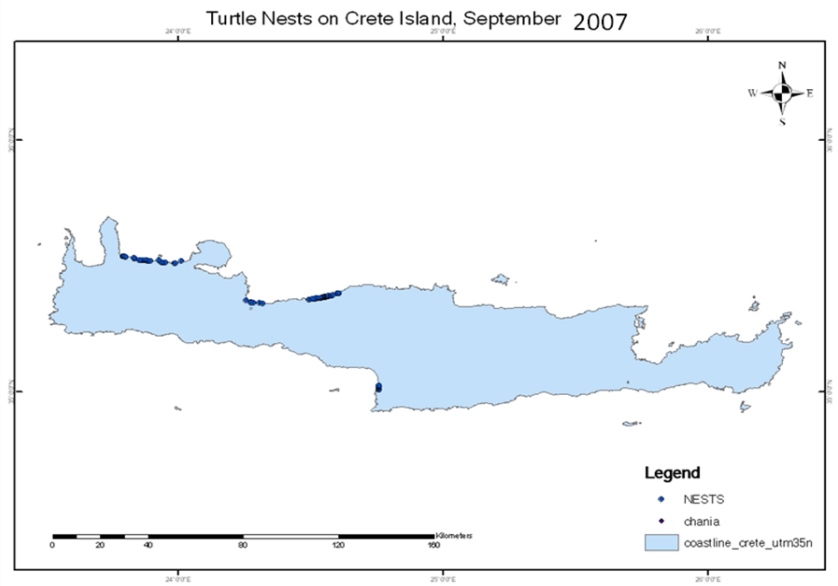

Figure 22 fieldwork 1- turtle nests locaton on Crete Island, September 2007

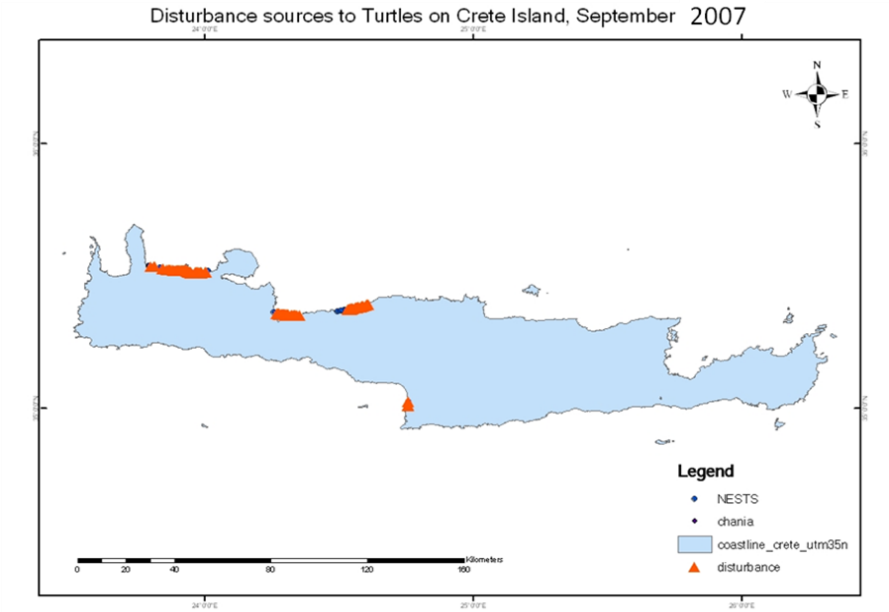

Figure 23 fieldwork 2- disturbance factors near the nesting beaches, Sep 2007

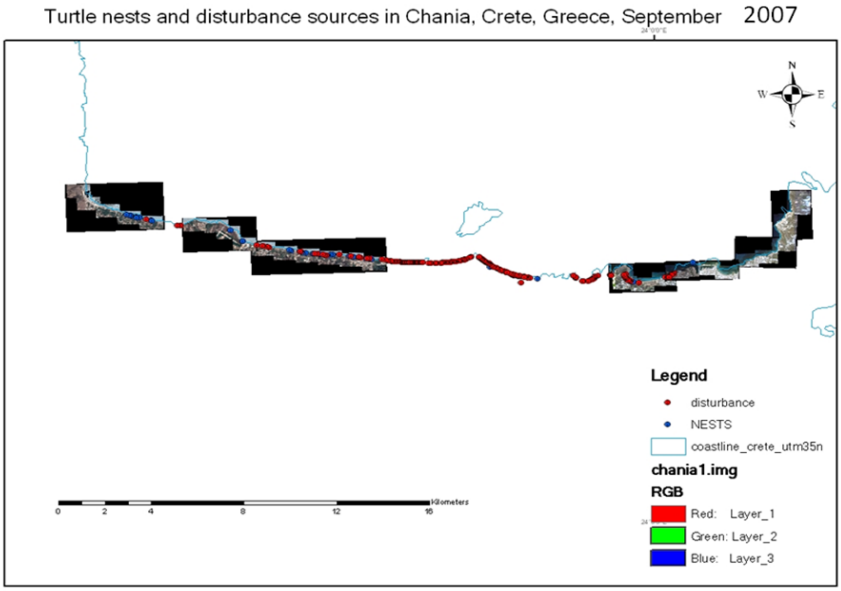

Figure 24 fieldwork 3- turtle nests and disturbance factors in Chania, Crete, Sep 2007