

**ΠΑΝΤΕΙΟΝ ΠΑΝΕΠΙΣΤΗΜΙΟ ΚΟΙΝΩΝΙΚΩΝ ΚΑΙ ΠΟΛΙΤΙΚΩΝ
ΕΠΙΣΤΗΜΩΝ**

PANTEION UNIVERSITY OF SOCIAL AND POLITICAL SCIENCES



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**Sustainable development and ecosystems services: Operational criteria
and applications on Mediterranean ecosystems**

**Βιώσιμη ανάπτυξη και οικοσυστημικές υπηρεσίες: Επιχειρησιακά
κριτήρια και εφαρμογές σε Μεσογειακά οικοσυστήματα**

ΔΙΔΑΚΤΟΡΙΚΗ ΔΙΑΤΡΙΒΗ

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Abbreviations

€ - Euro
\$ - United States Dollars
ARIES - ARtificial Intelligence for Ecosystem Services
CBD - Convention on Biological Diversity
CDL - Container Deposit Legislation
CE - Choice Experiment
CES - Cultural Ecosystem Services
CFP - Common Fisheries Policy
CICES - Common International Classification of Ecosystem Services
CLRTAP - Convention on Long-Range Transboundary Air Pollution
COP 21 - United Nations Climate Change Conference
CSR - Corporate Social Responsibility
CVM - Contingent Valuation Method
CWA - Clean Water Act
DCE - Discrete Choice Experiment
DRS - Deposit-Refund Schemes
DSD- Division of Sustainable Development
DSDG - Division for Sustainable Development Goals
EAR - Ecosystem Assessment and Reporting
EC – European Commission
EOL - End-of-Life
EPIs - Economic Policy Instruments
EPR - Extended Producer Responsibility
ESPA - Ecosystem Services for Poverty Alleviation
ESV - Ecosystem Services economic Valuation
EU-28 - European Union (28 member states)
FAO - Food and Agriculture Organization
FEGS-CS - Final Ecosystem Goods and Services Classification System
FIOs - Fecal Indicator Organisms
FTIR - Fourier Transform Infrared Spectroscopy
GDP - Gross Domestic Product
GES - Good Environmental Status
GESAMP - Group of Experts on the Scientific Aspects of Marine Pollution
GIS - Geographical Information Systems
GNP - Gross National Product
GRI - Global Reporting Initiative
GODAC - Global Oceanographic Data Center
GPGP - Great Pacific Garbage Patch
GPI - Genuine Progress Indicator
GPML - Global Partnership on Marine Litter

GUMBO - Global Unified Metamodel of the Biosphere
 HAB - Harmful Algal Blooms
 HDPE - High Density Polyethylene
 HYE - Health Year Equivalents
 ICC - International Coastal Clean-Ups
 IFBs - Infant Feeding Bottles
 IMAP - Mediterranean Sea and Coast and Related Assessment Criteria
 IMDOS - Integrated Marine Debris Observing System
 IMP - Integrated Maritime Policy
 InVEST - Integrated Valuation of Ecosystem Services and Tradeoffs
 I-O or IOTs - Input-Output tables
 IPBES - Inter-governmental Platform on Biodiversity and Ecosystem Services
 IPCC - Intergovernmental Panel on Climate Change
 IUCN - International Union for Conservation of Nature
 IWI - Inclusive Wealth Index
 JAMSTEC - Japan Agency for Marine-Earth Science and Technology
 LCA - Life Cycle Assessment
 LDPE - Low Density Polyethylene
 MAES - Mapping and Assessment of Ecosystems and their Services
 MCAA - Marine and Coastal Access Act
 MDGs - Millennium Development Goals
 MEA - Millennium Ecosystem Assessment
 MIDAS - Marine Integrated Decision Analysis System
 MIMES - Multiscale Integrated Models of Ecosystem Services
 MIT - Massachusetts Institute of Technology
 MPAs - Marine Protected Areas
 MPP - Marine Plastic Pollution
 MSFD - Marine Strategy Framework Directive
 MSP - Maritime Spatial Planning
 Mt - Metric tons
 NAT - Norm Activation Theory
 NEP - National Estuary Program
 NESCS - National Ecosystem Services Classification System
 OECD - Organisation for Economic Co-operation and Development
 OSPAR Convention - Convention for the Protection of the Marine Environment of the North-East Atlantic
 PAYT - Pay-As-You-Throw
 PBDE - Polybrominated Diphenyl Ether
 PBT - Polybutylene terephthalate
 PE - Polyethylene
 PES - Payments for Ecosystem Services
 PET – Polyethylene terephthalate

PML - Plastic Marine Litter
 POPs - Persistent Organic Pollutants
 PP – Polypropylene
 PS - Polystyrene
 PUR - Polyurethane
 PVC – Polyvinylchloride
 QALY – Quality Adjusted Life Year
 RP - Revealed Preference
 SDGs - Sustainable Development Goals
 SDKPUN - Sustainable Development Knowledge Platform of United Nations
 SEEA EEA - System of Environmental Economic Accounting Experimental Ecosystem Accounting
 SP - Stated Preference
 SRC - Stockholm Resilience Centre
 TEEB - The Economics of Ecosystems and Biodiversity
 TEV - Total Economic Value
 TPB - Theory of Planned Behaviour
 UfM - Union for the Mediterranean
 UN – United Nations
 UNCCD - United Nations Convention to Combat Desertification
 UNCED - United Nations Conference on Environment and Development
 UNCLOS - United Nations Convention on the Law of the Sea
 UNCSD - United Nations Conference on Sustainable Development
 UNDESA - United Nations Department of Economic and Social Affairs
 UNFCCC - United Nations Framework Convention on Climate Change
 UNEP - United Nations Environment Program
 UNESCAP - United Nations Economic and Social Commission for Asia and the Pacific
 UNESCO - United Nations Educational, Scientific and Cultural Organization
 USA – United States of America
 VBN - Value-Belief-Norm
 WBCSD - World Business Council for Sustainable Development
 WCC - World Council of Churches
 WCED - World Commission on Environment and Development
 WFD - European Water Framework Directive
 WMO - World Meteorological Organization
 WSSD - World Summit on Sustainable Development
 WTA - Willingness to Accept
 WtE - Waste-to-Energy
 WTP - Willingness to Pay
 WWF - World Wildlife Fund
 WWTP - Wastewater Treatment Plant

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Abstract

In this modern era of progress the objective of achieving sustainable development at a global level is accompanied by a series of substantial sustainability challenges as well. The contemporary ecosystem crisis, mainly attributed to a plethora of anthropogenic environmental pressures, should be mitigated within a new and revised sustainability context worldwide. In this sense, the proposed sustainability criteria ought to be operational and applicable in order to properly serve the purposes and targets set within the framework of environmental policy. To achieve this type of goals there is need for effective environmental policy and management tools that will allow socio-economic development to stay within the safe operating space of planetary boundaries.

For the purpose of achieving sustainable development it is deemed crucial to attain balance between the use of natural resources aiming at socio-economic development and the conservation of vital ecosystem services which are essential for human well-being. In this regard, the UN Sustainable Development Goals (SDGs) constitute a major step towards this direction by means of integrating the concept of ecosystem services and their protection from various environmental risks and stressors. The target of the present thesis is to investigate and specify the relationship between sustainable development and ecosystem services within a framework of efficiency and functionality in terms of environmental policy tools, whilst incorporating contemporary socio-economic aspects regarding selected areas of Greece (Syros Island) to determine the effectiveness of certain proposed policy measures.

In this context, we examine the economic burden of plastic pollution with regard to marine and coastal ecosystems using a synthesis of methods. In particular, a web-based survey was conducted at national level in Greece during the year 2017 to explore citizens' level of awareness regarding the environmental threat of marine plastic pollution (primarily plastic bags) and its negative impact on the environment, while at the same time eliciting information on plastic bag consumption. In addition, a choice experiment was conducted in Syros Island, Greece between the time period 2016-2018 in order to evaluate the effectiveness of information campaigns as an environmental policy tool on people's preferences for reducing plastic waste pollution under different status of environmental awareness. Results indicate that the provision of information contributed to making citizens aware of specific ecosystem services associated with the marine and coastal environment in addition to increasing their general interest in them, thus, assisting

toward effectively mitigating this major environmental problem. However, certain variables such as seasonal experience and the time decay effect may considerably affect this undertaking.

As a means of identifying the environmental preferences of specific groups of people, namely the stakeholders (hotel/room rental facilities owners) of Syros Island, regarding the reduction of plastic waste in the marine and coastal environment of the island, a contingent valuation technique was incorporated within the context of a survey concentrating on this particular target group. Based on the results, the majority of these stakeholders support and are willing to further endorse environmental policies aiming at protecting and conserving the local marine and coastal environment of the island. In addition, stakeholders are inclined toward financially supporting the reduction of the negative effects linked to plastic litter and waste on critical marine and coastal ecosystem services, whilst they would assign a higher economic value to the overall (marine/coastal) ecosystem services that directly or indirectly affect the sector of tourism. The amalgamation of the theoretical framework, methods and their results generated within the context of this thesis may contribute to the implementation of efficient environmental policy measures in an effort to successfully fulfilling crucial environmental objectives.

Keywords: Sustainable development; Ecosystem services (ESs); Marine/coastal ecosystems; Plastic pollution; Environmental awareness; Information campaign; Choice experiment; Citizens' wellbeing.

Εκτενής περίληψη στα ελληνικά

Κατά τη σύγχρονη αυτή εποχή προόδου που διανύουμε ο στόχος επίτευξης βιώσιμης ανάπτυξης σε παγκόσμιο επίπεδο συνοδεύεται και από μια σειρά σημαντικών προκλήσεων βιωσιμότητας. Η παρούσα οικοσυστημική κρίση, η οποία αποδίδεται ως επί το πλείστον στην πληθώρα ανθρωπογενών περιβαλλοντικών πιέσεων, κρίνεται σκόπιμο να αντιμετωπιστεί στο πλαίσιο ενός νέου και αναθεωρημένου πλαισίου βιωσιμότητας παγκοσμίως. Υπό αυτή την έννοια, τα προτεινόμενα κριτήρια βιωσιμότητας οφείλουν να είναι λειτουργικά και εφαρμόσιμα ούτως ώστε να εξυπηρετούν αποτελεσματικά τους σκοπούς και στόχους που έχουν τεθεί στο πλαίσιο περιβαλλοντικής πολιτικής. Για να επιτευχθούν αυτού του είδους οι στόχοι, απαιτείται αποτελεσματική περιβαλλοντική πολιτική καθώς και κατάλληλα διαχειριστικά εργαλεία τα οποία θα κατευθύνουν την κοινωνικοοικονομική ανάπτυξη να παραμείνει εντός του ασφαλούς χώρου λειτουργίας των πλανητικών ορίων.

Στο πλαίσιο επίτευξης βιώσιμης ανάπτυξης, κρίνεται ζωτικής σημασίας η επίτευξη ισορροπίας μεταξύ της χρήσης φυσικών πόρων αποσκοπώντας σε κοινωνικοοικονομική ανάπτυξη και της διατήρησης ουσιωδών οικοσυστημικών υπηρεσιών οι οποίες είναι απαραίτητες για την ανθρώπινη ευημερία. Ως εκ τούτου, οι Στόχοι Βιώσιμης Ανάπτυξης (ΣΒΑ) του ΟΗΕ συνιστούν ένα σημαντικό βήμα προς αυτήν την κατεύθυνση μέσω της ενσωμάτωσης της έννοιας των οικοσυστημικών υπηρεσιών και της διατήρησης τους από διάφορους περιβαλλοντικούς κινδύνους και εξωγενείς παράγοντες. Στόχος της παρούσας διδακτορικής διατριβής είναι η διερεύνηση και ο προσδιορισμός της σχέσης μεταξύ βιώσιμης ανάπτυξης και οικοσυστημικών υπηρεσιών σε ένα πλαίσιο αποτελεσματικότητας και λειτουργικότητας σε όρους εργαλείων περιβαλλοντικής πολιτικής, ενσωματώνοντας παράλληλα σύγχρονες κοινωνικοοικονομικές έννοιες και εξελίξεις σε επιλεγμένες περιοχές της Ελλάδας (Νήσος Σύρος) ούτως ώστε να καθοριστεί η αποτελεσματικότητα των συγκεκριμένων προτεινόμενων μέτρων πολιτικής.

Υπό αυτό το πρίσμα, εξετάζουμε την οικονομική επιβάρυνση η οποία απορρέει από την πλαστική ρύπανση αναφορικά με τα θαλάσσια και παράκτια οικοσυστήματα χρησιμοποιώντας μια σύνθεση μεθόδων. Συγκεκριμένα, πραγματοποιήθηκε διαδικτυακή έρευνα σε εθνικό επίπεδο στην Ελλάδα κατά το έτος 2017 με στόχο τη διερεύνηση των επιπέδων ενημέρωσης/ευαισθητοποίησης των πολιτών σχετικά με την περιβαλλοντική απειλή της θαλάσσιας πλαστικής ρύπανσης (κυρίως ως προς τις πλαστικές σακούλες) και τις αρνητικές

επιπτώσεις της στο περιβάλλον, ενώ συγχρόνως αντλήθηκαν δεδομένα ως προς την κατανάλωση πλαστικής σακούλας. Επιπλέον, πραγματοποιήθηκε ένα πείραμα επιλογής στη Σύρο, κατά την περίοδο 2016-2018, προκειμένου να αξιολογηθεί η αποτελεσματικότητα των εκστρατειών ενημέρωσης ως εργαλείου περιβαλλοντικής πολιτικής στο πλαίσιο των προτιμήσεων πολιτών, οι οποίοι τελούν υπό διαφορετική κατάσταση περιβαλλοντικής ενημέρωσης, για τη μείωση της περιβαλλοντικής ρύπανσης πλαστικών αποβλήτων. Τα αποτελέσματα υποδηλώνουν ότι η παροχή πληροφοριών/ενημέρωσης συνέβαλε στην ευαισθητοποίηση των πολιτών ως προς συγκεκριμένες οικοσυστημικές υπηρεσίες που αφορούν το θαλάσσιο και παράκτιο περιβάλλον, καθώς και στην αύξηση του γενικού ενδιαφέροντος αναφορικά με αυτές, συμβάλλοντας τοιούτοτρόπως στην αποτελεσματική αντιμετώπιση του εν λόγω κρίσιμου περιβαλλοντικού προβλήματος. Ωστόσο, ορισμένες μεταβλητές όπως οι εποχιακές διακυμάνσεις και μεταβολές εξαιτίας της παρόδου του χρόνου δύναται να επηρεάσουν σημαντικά αυτή την προσπάθεια.

Αποσκοπώντας στην εξακρίβωση των περιβαλλοντικών προτιμήσεων συγκεκριμένων ομάδων πολιτών, ήτοι ενδιαφερόμενων μερών από τον τουριστικό κλάδο (ιδιοκτήτες ξενοδοχειακών εγκαταστάσεων / ενοικιαζόμενων δωματίων) της Σύρου, αναφορικά με τη μείωση των πλαστικών απορριμμάτων στο θαλάσσιο και παράκτιο περιβάλλον του νησιού, εφαρμόστηκε η τεχνική ενδεχόμενης αποτίμησης ενσωματωμένη στο πλαίσιο μιας ολοκληρωμένης έρευνας η οποία επικεντρώθηκε στη συγκεκριμένη ομάδα στόχου. Λαμβάνοντας υπόψιν τα αποτελέσματα, η πλειονότητα των εν λόγω ενδιαφερομένων μερών υποστηρίζει και είναι πρόθυμοι να ενισχύουν περαιτέρω περιβαλλοντικές πολιτικές οι οποίες στοχεύουν στην προστασία και διατήρηση του τοπικού θαλάσσιου και παράκτιου περιβάλλοντος του νησιού. Επιπλέον, δύναται να υποστηρίξουν οικονομικά προσπάθειες μείωσης των αρνητικών επιπτώσεων που συνδέονται με τα πλαστικά απορρίμματα και απόβλητα αναφορικά με ουσιώδεις υπηρεσίες των θαλάσσιων και παράκτιων οικοσυστημάτων, ενώ αποδίδουν υψηλότερη οικονομική αξία συνολικά στις (θαλάσσιες/παράκτιες) οικοσυστημικές υπηρεσίες οι οποίες άμεσα ή εμμέσως αφορούν και επηρεάζουν τον τουριστικό τομέα. Ο συνδυασμός του θεωρητικού υπόβαθρου, των μεθόδων και των αποτελεσμάτων που προέκυψαν στο πλαίσιο αυτής της διδακτορικής διατριβής δύναται να συμβάλει στην εφαρμογή αποτελεσματικών μέτρων περιβαλλοντικής πολιτικής σε μια προσπάθεια επιτυχούς επίτευξης κρίσιμων περιβαλλοντικών στόχων.

Λέξεις κλειδιά: Βιώσιμη ανάπτυξη, Οικοσυστημικές Υπηρεσίες (ΟΥ), Θαλάσσια/παράκτια οικοσυστήματα, Πλαστική ρύπανση, Περιβαλλοντική ευαισθητοποίηση, Εκστρατεία ενημέρωσης, Πείραμα επιλογής, Ευημερία των πολιτών.

Introduction

Introduction

In this day and age there has been a lot of debate with regard to the increased prosperity which is relished by a certain percentage of humankind and its associated cost for the natural environment and our planet as a whole. The increased demands for food, water, energy, and natural resources, both renewable and non-renewable, are not fulfilled in a sustainable way, if at all. Our present era is closely linked to processes which are detrimental for the natural environment such as climate change, deforestation, ocean acidification, biodiversity loss, plastic pollution and several more, thus, representing a new epoch called “Anthropocene”. This term, originally used by Paul Crutzen, describes the human dominion over the natural environment and resources at a global scale, whilst replacing the Holocene epoch when there was relative climatic stability enduring for approximately 11,500 years.

Our present state of affairs affects multiple critical planetary processes, while simultaneously generating additional crises in terms of overpopulation, development pressures, water vulnerabilities, ecosystem crisis, and climate change, therefore, restricting Earth’s current resilience (Rockstrom and Karlberg, 2010). Consequently, this contemporary and most favourable for humankind state of our planet will irreversibly alter, bearing adverse and deleterious consequences for our modern way of living. In this sense, the conceptualization of sustainable development emerged on the basis of social, economic, and environmental considerations during the 1970s in order to mitigate critical issues such as inequality reduction and poverty alleviation, whilst striving for intra- and intergenerational equity and preserving the integrity of our planet’s ecosystems and their life-sustaining functions (Barbier, 2003; Buriti, 2019).

For this purpose, certain “limits to growth” are required predicated on technological advancements, proper utilization of natural resources and allowing the biosphere to negate the negative impact of human activities. In conjunction with the notion of sustainable development, the concept of sustainability often emerges in relation to a more holistic, adaptive, and generally flexible nature with respect to various environmental issues. Despite the fact that this terminology was initially developed on the basis of the French verb “soutenir”, meaning to support and associated with forestry purposes, it evolved over the years toward an ecological concept, prompting for respect regarding nature’s ability to regenerate itself (von Carlowitz, 1713; Brown

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et al., 1987; Duden, 2015). Challenges linked to sustainability purposes are becoming increasingly important “items of discussion” in the decision- and policymaking domain as well as in terms of strategies regarding businesses and companies worldwide (Acero and Savaget, 2014). Nevertheless, different approaches to sustainability exist, most prominent of which are the strong and the weak sustainability approaches, on the basis of certain doctrines regarding the exploitation of natural capital and the production of welfare for humans.

Within this context novel conceptual frameworks and models have also been formed as in the cases of the Circular Economy approach and the “Doughnut Economy” model. The former relates to a regenerative system within which inputs of resources and waste, emissions and energy outflows are minimized via the application of principles with respect to deceleration, termination and narrowing energy and material loops. In addition, it is deemed crucial to operate in accordance with techniques and tenets as pertaining to maintenance, repair, reuse, refurbish, remanufacture, recycle and long-lasting product design (Geissdoerfer et al., 2017). Although the Circular Economy concept initially appeared during the 1970s, legislation such as the European Circular Economy package (2015) together with the Chinese Circular Economy Promotion Law (2009) strongly indicate its contemporary significance on an environmental policy level as well (EC, 2015; Lieder and Rashid, 2016).

The proposed model of a Doughnut Economy aims at achieving human well-being within the Anthropocene epoch, whilst adapting and respecting Earth’s planetary boundaries. The planetary boundaries concept, introduced by Rockstrom et al. (2009) and Steffen et al. (2015), describe the nine crucial boundaries of our planet which should not be exceeded as they regulate the Earth system functioning. These boundaries are set in order to maintain the Earth system in a safe operating space for humanity and ensure sustainability on an intergenerational level. In terms of terminology relevant to the aforementioned notions the “environmental footprint” emerges in an effort to encompass various footprint concepts, also applied in the Life Cycle Assessment (LCA)-based product of the European Commission (EC, 2013).

In reference to an environmental policy level, the 17 Sustainable Development Goals (SDGs), introduced during 2015, replaced and “upgraded” the former 8 Millennium Development Goals (MDGs) with the purpose of addressing the planetary sustainability issue globally. The need for conceptualizing and operationalizing human well-being in terms of environmental science, policy,

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and management has led to the meticulous exploration of our planet's ecosystems and the ecosystem services associated with them. A more cohesive framework for the proper assessment of human well-being has been deemed necessary entailing a multidisciplinary approach with insights from social sciences within a comprehensive socio-ecological context (Fish 2011; Satterfield et al., 2013; Castree et al., 2014; Levin et al., 2014; Samhouri et al., 2014; Hicks et al., 2016; Breslow et al., 2016).

The investigation of the existing links between ecology and welfare implies a thorough exploration of the social benefits mankind receives from nature's services, that is the ecosystem services. These services mainly describe the several conditions and processes based on which all natural ecosystems preserve life, along with the benefits people derive from ecosystem functions (Daily, 1997; Costanza et al., 1997). The incorporation of ecosystem service assessment and management into decision-making and environmental policy planning can prove to be of outmost importance toward the effective governance of ecosystem services and sustainable use of natural resources for improving human well-being. However, the ecosystem services approach has often been criticized for neglecting social diversity, thus, exacerbating social inequity on certain occasions. Therefore, the adoption of the axioms of environmental justice is essential in order to avoid further marginalization with regard to different social groups (Chaudhary et al., 2018).

As a result, the need for economic as well as non-economic valuation emerges in order to assess use and non-use values (and their respective subcategories) closely associated with the main categories of ecosystem services. The sum total of use and non-use values generates the total economic value (TEV), thus, providing a monetary appraisal of economic and socio-cultural values existing both inside and outside of markets (TEEB, 2010). The effective valuation of ecosystem goods and services can promote conservation, as it is often imperative to first identify the values under consideration and the associated benefits they provide for humans. In this context, several valuation approaches exist (Costanza et al., 1997; Daily et al., 2000; Farber et al., 2002; TEEB, 2009; Lopes and Videira, 2013), though they are frequently criticized on the grounds that the estimated values, they generate do not always reflect underlying environmental threats. Nevertheless, the effective integration of ecosystem services evaluation and assessment in the decision-making processes is essential for optimal environmental and ecological conservation.

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An integral as well as the largest part of the Earth's aquatic ecosystems refers to marine ecosystems, which when combined with coastal ecosystems relate to fundamental components for human well-being. Taking into consideration the wide range of processes and supporting services they provide (e.g. food web dynamics, nutrient cycling and scenery, fisheries, carbon sequestration, climate regulation, etc.) together with laying the foundation for several final ecosystem services, their significance for sustaining human communities and supporting human welfare is immense (Potts et al., 2014). However, in spite of the fact that during the last decades a lot of effort has been made to properly evaluate global marine and coastal ecosystem services, the lack of sufficient data based on accuracy and universal adherence remains a major obstacle (Pendleton et al., 2016).

Bearing in mind the importance of environmental preservation and protection of all the vital ecosystem components for sustaining life, contemporary threats as in the case of marine litter and plastic pollution pose a serious danger. The exponential growth of plastic production coupled with the dramatic increase of plastic use within the context of modern society and the insufficient management of the waste generated, have resulted in its rapid accumulation in the marine environment. Marine litter transported either from land or rivers, sewage systems or drainage and wind into the marine environment has detrimental effects for ecosystem functions and ecological communities (Galgani et al., 2010; STAP, 2011; Galgani et al., 2015). Marine plastic pollution has an adverse impact on the various levels of biological organization as well as certain planetary boundaries, thus, posing a threat in critical Earth system processes as well (Villarrubia-Gómez et al., 2018). Based on evidence from several European Regional Sea Conventions reports, it is deduced that plastic litter and waste account for approximately 50–80% of litter items found on beaches (OSPAR, 2007; UNEP/MAP MEDPOL, 2008; HELCOM, 2009; Veiga et al., 2016).

The negative impacts, marine debris and litter are associated with, inflict damage on wildlife, tourism, the economy, and public health, therefore, necessitating meticulous management and prevention (Kershaw et al., 2011; Schuyler et al., 2018). The presence of “microplastics” in food and air samples, gradually accumulating in the human organism can potentially induce immune responses and impair human health (Wright and Kelly, 2017). Plastic pollution in the marine and coastal ecosystems has become a complicated and widespread societal problem demanding a multitude of approaches acting in unison. The promotion of co-responsibility for marine litter throughout every implicated sector of the economy and associated stakeholder along with the

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optimization of applied practices at every level, production–use–disposal, can prove to be very effective. Social disapproval of littering behaviour is increasing during the last decade, prompted by promising policy tools aiming at enhancing societal awareness.

The application of economic instruments (e.g. container deposit legislation), command and control measures (e.g. plastic bag bans) together with bottom-up governance, state and federal legislation as well as a mixture of hard and soft law efforts may significantly contribute to the mitigation of marine plastic pollution (Schuyler et al., 2018). Raising environmental public awareness, providing people with information regarding the benefits ecosystem services offer to humankind can affect their preferences and possibly their way of living in favour of environmental preservation (Richards et al., 2017). For this purpose, both the degree and accuracy of the information provided substantially affect the outcome in terms of acceptability regarding environmental policy measures.

Information campaigns constitute a potentially effective tool for improving the knowledge base of people with regard to environmental threats and ultimately assist them in making more informed choices in relation to issues which affect their health and well-being. Engaging the general public in contemporary environmental threats, as in the case of plastic pollution, is vital for ensuring success with reference to environmental initiatives and measures on behalf of intergovernmental bodies, states and administrations. In addition, it is crucial to properly translate people's aspiration for environmental protection into action, whilst also prompting government bodies and industries to assume their part of responsibility for alleviating this type of threats.

Structure of the PhD thesis

The structure of the PhD thesis is arranged in three main parts, the first of which **Part I** refers to the basic concepts, while **Part II** explores the operational criteria and **Part III** constitutes an empirical application based on the previous parts.

In particular, the structure of the PhD thesis is as follows:

Chapter 1 presents the fundamental principles and the theoretical framework regarding sustainable development. In particular, the recorded history roots surrounding the terms sustainable development as well as sustainability through a relatively comprehensive overview. In addition, the basic schools of thought generated from this notion are thoroughly described. Furthermore, more contemporary approaches on sustainable development and its evolution over the years are analysed.

Chapter 2 is dedicated to the concept and importance of ecosystem services. This chapter begins with an introduction of the origins of ecosystem services and the underlying precepts characterizing them. The definition and categorization of these services is comprehensively delineated on the basis of the conceptual framework outlining the interactive relationship among biodiversity, ecosystem services, human well-being, and drivers of change. The next step is to present the connection between the notion of ecosystem services and sustainable development via the various approaches relative to this issue and in connection with the policy agenda.

Chapter 3 is formed as an overview regarding the economic valuation of ecosystem services. The chapter begins with an in-depth exposition in reference to the need for ecosystem services valuation. Then, the various methodologies and techniques applied for this purpose are thoroughly described in relation to the Total Economic Value (TEV) framework and the appraisal of both use and non-use values, market and non-market valuation. The chapter concludes with extensive references on the future direction and trends regarding ecosystem services valuation.

Chapter 4 introduces the operational criteria. First and foremost, a description of the particular type of ecosystem services under examination, marine and coastal ecosystem services, takes place. Subsequently, the significance of marine and coastal ecosystem services for human well-being is analysed. In addition, the classification and typology applied for marine and coastal ecosystem services is extensively presented combined with prominent applications. Furthermore,

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the basic postulations regarding the economic valuation of marine and coastal ecosystem services are investigated as well as the policy priorities and targets in terms of policy agenda at a global scale.

Chapter 5 is dedicated to the environmental issue under examination, the global environmental threat of plastic pollution in the marine environment, negatively impacting on coastal ecosystems as well. The chapter begins with an introduction and thorough description regarding marine plastic pollution. Subsequently, the repercussions on marine and coastal ecosystems are extensively examined along with the economic effects of plastic pollution and ways this problematic situation reverberates in relation to human welfare. Furthermore, the human health implications related to plastic pollution and the increasingly immense threat of microplastics are investigated on the basis of the most recent scientific reports and studies published. At this point, the case of plastic bags is presented and analysed, taking into account its high relevance to this issue and the fact that it constitutes one of the most prominent items of plastic waste discovered in the marine and coastal environment. The chapter concludes with a presentation of the most significant policies under consideration or implemented in terms of environmental policy along with promising governance solutions for successfully mitigating this environmental hazard.

Chapter 6 relates to the notion of environmental preferences and how information provision potentially affects and influences them. To this effect, important principles and conceptions with regard to environmental behaviour and awareness are analysed in order to establish the contextual background which enables the formation of environmental preferences based on certain theories and hypotheses. In this context, the case of plastics is further examined as it pertains to the specific environmental threat under examination. The final part of this chapter introduces and examines information campaigns on the grounds of efficiency and reliability as a promising policy tool.

Chapter 7 consists of the last part of the PhD thesis, namely the empirical application bringing together the aforementioned theoretical framework and analysis. In this sense, a first case study is presented (Chapter 7.1), comprised of a national survey on awareness regarding plastic bags and the implications for the marine environment. Chapter 7.2 is principally based on the presentation of the methodology and the results of the published paper of "Latinopoulos, D., Mentis, C. and Bithas, K. (2018). The impact of a public information campaign on preferences for

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marine environmental protection. The case of plastic waste. Marine pollution bulletin, 131, 151-162" and the under-submission paper of "Bithas, K., Latinopoulos, D. and Mentis, C. (2021). Does environmental information matter? Evaluating temporal effects on environmental preferences raised by information campaigns. Ecological Economics". Namely, it presents the analysis of an extensive survey conducted in Syros Island (Greece), bearing evidence and information with respect to this particular subject under consideration, and thus it is included among the few attempted scientific endeavours aiming at evaluating the efficiency of information provision as an environmental policy tool on a global level. Parts of Chapter 7.3 have been presented at the conference paper of "Mentis, C., Latinopoulos, D., Bithas, K., 2018. Preferences and willingness to pay for protecting the marine and coastal environment from plastic waste: a case study of Syros Island, 5th Envecon Conference of Economics of Natural Resources and the Environment, 1-3 November 2018, Volos, Greece". In particular, Chapter 7.3 refers to a specified target group, consisting of certain stakeholders of the island, in the interest of investigating this issue from a different perspective as well and in terms of a significant focus group for a Greek island such as Syros. This analysis is the first of its kind worldwide.

The PhD thesis concludes with the presentation of the most important remarks and observations, thus, recapitulating and summarising the bulk of the main points generated throughout this long-term process of investigation and analysis with respect to sustainable development and ecosystem services from a different and novel academic standpoint.

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Part I: The basic concepts

Chapter 1: Sustainable Development: the theoretical framework

1. Sustainable development: the theoretical framework

1.1 A concise overview

In order to fully comprehend the notion of sustainable development it is deemed important to first analyze, to a certain extent, the concept of environmental sustainability. The term “environmental” is usually distinguished from the adjective “ecological”, taking into consideration the fact that ecological is often associated with the interdependence of elements within a system, while the term environmental denotes a type of human impact on natural systems, as a form of human interaction with the natural environment. Nevertheless, ecological sustainability is often applied as the proper terminology to express notions of biological conservation in the context of *“meeting human needs without compromising the health of ecosystems”* (Morelli, 2011).

However, the term ecological has been applied on various occasions under a broader scope of analysis on an abundance of academic disciplines, most prominent of which are the categories of natural science as well as social sciences. On the other hand, the term environmental is most frequently used with regard to human interaction with the natural environment and the planet’s ecosystems. Thus, it would be useful and more practical to perceive the term environmental as a subset of ecological in terms of content, taking into account that ecological refers to the existing synergy between human activities and a copious number of processes within the ecological systems.

The conception of “sustainability” can be accurately traced back to the term “sustainable yield” and specifically “sustained yield forestry” originally published during the 18th century, as means of fulfilling one’s obligations to his/her descendants, and thus stabilize the associated communities via the maintenance of resources at a high level by each generation in order to bequest them undiminished to their progenies (Grober, 2007). In the context of conservation philosophy two mutually incompatible schools of thought affiliated with sustainability arose, namely resourcism and preservationism. In particular, resourcism defined conservation in terms of mean maximum sustained yield of renewable resources, whilst preservationism perceived conservation as means of excluding humans from inhabiting and exploiting, in economic terms, the remaining areas of undeveloped nature (Callicott and Mumford, 1997).

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Several meanings to the notion of sustainability have since been produced in an effort to express different kind of measures and mechanisms in the context of many professions and areas of expertise. The most noticeable interpretation of the terms “sustainability” and “sustainable” was provided via the publication of a report entitled ***Our Common Future***, published in 1987 by the United Nations through the Oxford University Press, most commonly referred to as ***the Brundtland Report*** in recognition of the former Norwegian Prime Minister Gro Harlem Brundtland, who was at that time the Chair of the World Commission on Environment and Development (WCED).

As a result, the most common and widely applied definition of “environmental sustainability” or more accurately “sustainable development”, since the publication of the **Brundtland Report**, describes this notion as “*meeting the needs of the current generation without compromising the ability of future generations to meet their needs*” (WCED, 1987). In these terms, it is deemed essential to fulfill to the highest achievable level the requirements for natural resources of the current generations, while concurrently allowing future generations access, and thus use to a sufficient amount of natural resources as well in order to meet their own needs. It would prove most efficient to delineate sustainable development as a principle of balance via multiple interactions, which ultimately allows mankind to satisfy its needs without transgressing the capacity of our natural environment and its supporting ecosystems to regenerate and recuperate to satisfy the needs of the existing and all generations to be (Morelli, 2011).

In the course of the following years after the **Brundtland Report** two broad categories regarding the meaning of sustainability and sustainable development as a concept were formed. In particular, the first one refers to definitions in relation to functional applications while the second to definitions characterized as more “systemic”. In the context of the first category a plethora of research and publications exists (Costanza and Patten, 1995; Lele, 1991; Koroneos and Rokos, 2012; Hodge, 1997; Connelly, 2007; Van Marrewijk, 2003; Chambers, 2008; Lippert, 2004; Sandberg, 2010; Zavodna, 2013; Caradonna, 2014), based on which certain key points can be extracted. Most notably, the term “sustainability” and “sustainable development” are usually presented as identical, even though sustainability is often mixed with other terms and notions such as resilience, durability and longevity. In addition, limited knowledge exists regarding the essential parts of sustainability in physical, social and economic terms, resulting in the formation of a wide assortment of meanings, methodologies and indicators for analyzing and evaluating

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sustainability, though, certain limitations exist on a spatial-temporal level as well as on certain occasions on the basis of meticulous scientific interpretation. The second category, associated with the systemic definitions, delineates sustainability in terms of a dynamic system with purpose within certain boundaries affected by a state of induced hierarchy in order to continue to thrive for generations to come. Furthermore, it acknowledges the existence of humans within the planet's ecosystems through a volatile future in terms of managing natural resources (Meadows, 1972, 1993, 2004; Hodge, 1997; Hansen and Jones, 1996; Mebratu, 1998; Sverdrup and Svensson, 2004; Lippert, 2004; Fiksel, 2006; Espinoza, 2008; Espinoza and Porter, 2011; Glavč and Lukman, 2007; Schilling, 2012; Schwaninger, 2014).

The systemic definitions of sustainability have been subjected to criticism on account of not integrating or properly acknowledging potential developments and achievements in science, in general, as well as innovative technologies along with the several “self-incorporated cycles” in the evolution of earth's systems within the context of the Earth System Science (ESS) concept that affect every generation of inhabitants and the planet's ecosystems as a whole (Steffen et al., 2020). Additionally, sustainability is described in a rather abstract manner, lacking practicality in the context of means of achieving it or specific terminology, though several studies also exist that contradict this type of assertions (Opresnik and Taisch, 2015; Geels et al., 2019). Likewise, no differentiation is provided in the process of defining sustainability within a time framework, resulting in a state of confusion concerning the very akin, but essentially different notion of durability (Pater and Cristea, 2016).

1.1.1 The evolution of sustainable development within the context of major Agreements and Conventions

The nowadays classic and most consistent definition of sustainable development produced by the **Brundtland report** is often characterized by controversies and misconceptions as well. In particular, it has been described as deliberately ambiguous in relation to its meaning aiming at achieving widespread acceptance (Middleton et al., 1993; Wackernagel and Rees 1996; Giddings et al., 2002).

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Certain actions and procedures in the context of international organizations, conferences and committees actually preceded the Brundtland Commission chronologically, thus, paving the way for the formation of the concept of sustainable development. Specifically, during the year 1969 a conference called **“Man and His Environment: A View Towards Survival”** was held under the auspices of the **United Nations Educational, Scientific and Cultural Organization (UNESCO)** in San Francisco, USA, where several environmental issues related to food security, survivalism and the threats of nuclear power were presented, as an indirect introduction to the concept of sustainability. However, it was the **Club of Rome** that properly introduced the term “sustainable” into political language, during 1972. The Club of Rome was formed as an international think-tank operating at a global scale, constructing a report titled **“Limits to Growth”**, written by a team of scientists, superintend by Dennis and Donella Meadows of the “Massachusetts Institute of Technology (MIT)”. Within the framework of this report, the authors described a *“state of global equilibrium”* through a sustainable global system of aggregate output without abrupt or irreversible environmental shocks that is capable of fulfilling the basic material needs of the planet’s total population (Meadows et al., 1972; Grober, 2007).

In addition, in the year 1972 the **UN Conference on the Human Environment** took place in Stockholm, Sweden and the Stockholm Declaration was adopted, comprising of 7 proclamations and 26 principles, leading to the creation of the **UN Environment Program (UNEP)**. It is, therefore, considered as a pivotal point within the context of global cooperation on environmental issues, as it involved critical subjects and social issues as well with regard to safeguarding the natural environment and exploring the relationship between climate change and air pollution induced by human activities at a global scale (Caradonna, 2014). A few years later during 1974, at the international **World Council of Churches (WCC) Conference on Science and Technology for Human Development** in Bucharest, Romania the term “sustainable” expressed a new era to be established, where the former WCC sponsored canon “responsible society” was replaced by the new term *“just and sustainable society”*. A basic conclusion of this Conference was that *“the future will require a husbanding of resources and a reduction of expectations of global economic growth”*, thus, depicting an amended society of global welfare based on the idea of intergenerational sustainability (WCC, 1974; Grober, 2007).

Furthermore, in 1979 the **Convention on Long-Range Transboundary Air Pollution (CLRTAP)** was conducted and signed by various countries, currently associated with 51 parties internationally,

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as a worldwide effort to prevent and reduce transboundary air pollution globally, within an early framework of sustainable development, as far as climate change policy is considered. During the following year (1980), the first international document which officially made use of the term “sustainable development” was published, as a product of the collaboration of many scientists and researchers from associations and NGOs; namely, the International Union for the Conservation of Nature (IUCN), UNEP and the World Wildlife Fund (WWF), titled: “**World Conservation Strategy: Living Resource Conservation for Sustainable Development**”. This particular report was mainly commissioned and patronaged by UNEP and further supported, as mentioned above, by WWF, the Agricultural Organization of the UN and UNESCO. It was presented in 34 major cities worldwide, introducing environmental issues in relation to natural resources scarcity and the carrying capacity of Earth’s ecosystems (Grober, 2007; Caradonna, 2014). Subsequently, in 1980 a noteworthy report on environmental issues regarding sustainability and poverty, further distinguishing development from growth, was released by the Independent Commission on International Development Issues titled: **North-South: A Program for Survival**.

On October 28, 1982 the “**World Charter for Nature**” was officially adopted by UN General Assembly based on which “*mankind is a part of nature and life depends on the uninterrupted functioning of natural systems*”. In addition, it also emphasized on mankind’s depleting effects on natural resources and the urgent necessity of stabilizing and conserving them for future generations. During the following years, the **Vienna Conference** and the “**Vienna Convention for the Protection of the Ozone Layer**” respectively took place to mitigate the negative impacts of the stratospheric ozone layer depletion due to high levels of Chlorofluorocarbons (CFCs) and halons, human-made refrigeration, in the atmosphere. The Vienna Convention was a multilateral environmental agreement laying the framework within which international reductions regarding the production of CFCs would be made, due to their deleterious effects on the ozone layer, increasing in turn the threat of skin cancer (Caradonna, 2014).

Within the same context, in 1987 the “**Montreal Protocol on Substances that Deplete the Ozone Layer**” was brokered by UNEP, further expanding the Vienna Convention. However, it is deemed important to mention that the **Montreal Protocol** is characterized as a legally binding treaty in conjunction to the Vienna Convention which is not. The **Montreal Protocol’s** goal is to phase out the production of various substances accountable for the stratospheric ozone depletion, mainly

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CFCs, and as a result it has been signed by all UN member states. It indicates a great success in international environmental cooperation, having been amended multiple times, taking also into consideration the gradual reported reconstitution of the ozone layer, since it was entered into force (Caradonna, 2014).

As mentioned above, the WCED was established by the UN in 1983 initially, while the Brundtland report was published in 1987. During the period 1983-1987 the foundations for this most important document were laid, with the purpose of providing a suitable framework for sustainable development at a global scale. For the first time, the existing relationship between the environment, society and economics was officially stated. The following year (1988) saw the creation of the **Intergovernmental Panel on Climate Change (IPCC)** by UNEP and the **World Meteorological Organization (WMO)**, as an international collaboration of scientists and researchers analyzing contemporary events of anthropogenic climate change. The IPCC publishes “assessment reports”, which tend to be widely consulted on the impacts of man-made climate change, primarily due to high-level emission of greenhouse gases (GHGs). In addition, the **14th G7 Summit** was held in Toronto, Canada during the same year (1988), addressing anthropogenic climate change in the context of the world’s seven richest industrialized countries regarding environmental issues and decision-making of economic interest (Caradonna, 2014).

Nevertheless, the term “sustainable development” officially appeared for the first time at a global conference during the 1992 **United Nations Conference on Environment and Development (UNCED)**, also known as “**Earth Summit**” in Rio de Janeiro, Brazil. The Earth Summit led to the creation of several policy documents such as the “**Forest Principles**”, “**Agenda 21**”, “**Rio Declaration on Environment and Development**”, “**Convention on Biological Diversity**” and the “**Framework Convention on Climate Change**”, as well as the formation of the following Conventions: the **United Nations Framework Convention on Climate Change (UNFCCC)**, the **Convention on Biological Diversity (CBD)** and the **United Nations Convention to Combat Desertification (UNCCD)**. The Rio Convention was attended by many NGOs and several UN member states mainly aiming at the preservation of natural resources and mitigation of environmental pollution in order ensure a sustainable planet for generations to come. It contained 27 principles accompanied by specific details for the implementation of a more sustainable development (Principle 3). The UNFCCC and the CBD are characterized as legally binding treaties, though many states did not ratify the agreements. However, the **Kyoto Protocol**

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in 1997 superseded the UNFCCC, resulting in the establishment of legally binding obligations regarding GHG emissions limitations for the states that signed the treaty (Grober, 2007; Caradonna, 2014).

In 1993 the General Assembly formed the **UN Commission on Sustainable Development** to oversee the implementation of Agenda 21 as well as other measures from the Rio Convention, while in 2012 the **Division of Sustainable Development (DSD)** was created. A few years later, specifically in 1997, the aforementioned **Kyoto Protocol** was produced, which entered into force in 2005, covering two distinct commitment periods in terms of reducing GHG emissions: 2008–2012 and 2013–2020 respectively. The **Kyoto Protocol** is closely linked to the UNFCCC as an international agreement, associated with binding emission reduction targets and responsibilities for its Parties. It is based on the main principle of differentiating its Party's obligations towards mitigating the negative impacts of climate change (reduction of GHGs emissions), taking into consideration the different capabilities and characteristics of each country. In that sense, developed countries are not equally responsible compared to developing countries in terms of contributing to global warming, as their current high levels of economic development are closely related to equivalently high GHGs emission levels.

As mentioned above, the Protocol's first commitment period started in 2008 to be completed in 2012. The second commitment period, agreed in 2012, is also known as the **Doha Amendment**, based on which 37 countries are linked to binding targets. In particular, the European Union (EU-28), Belarus, Liechtenstein, Norway, Switzerland, Ukraine, Iceland, Kazakhstan and Australia, though Belarus, Ukraine and Kazakhstan may withdraw or alternatively not put into force the Amendment with second round targets. It is worth mentioning that Russia, Japan and New Zealand have participated in the first commitment period, but effectively not (have not accepted second round targets) in the second commitment period. Moreover, Canada withdrew from the Kyoto Protocol in 2012 and the United States has not ratified it yet. As of May 2019, 128 countries have accepted the **Doha Amendment**, though it has not entered into force yet (UNFCCC, 2019; Caradonna, 2014).

In 2000 a document titled the **"Earth Charter"** came into fruition, supported by the UN as the result of an international commission, which attached the concept of ecological sustainability to the notion of global ethic in terms of social equality, peace and justice for a *"sustainable global*

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society” (Earth Charter Initiative, 2019). On the same year, the “**Millennium Summit**” was conducted at the UN headquarters in New York City, USA, where the **United Nations Millennium Declaration** was ratified by 189 world leaders. In addition, the **Millennium Development Goals (MDGs)** were agreed, as a framework comprised of specific targets and dates for achieving those targets, in order to assist citizens in the world's poorest countries to achieve a better quality of life by the year 2015. The 7th Goal of the **MDGs** refers to “*ensuring environmental sustainability*” (UN, 2015).

After two years, the “**World Summit on Sustainable Development (WSSD)**” or alternatively “**Johannesburg Summit**” or “**Earth Summit 2002**” took place in Johannesburg, South Africa. This particular summit marked a 10-year anniversary for the Rio Earth Summit of 1992 and produced the “**Johannesburg Declaration on Sustainable Development**”. The **WSSD** mainly resulted in the formation of approximately 300 “Type II partnerships”, as initiatives and instruments of achieving the **MDGs**. However, the U.S.A. did not participate, thus, diminishing the overall credibility and efficiency of the summit. The next notable environmentally-wise global summit was the **2009 United Nations Climate Change Conference**, also known as the “**Copenhagen Summit**”, held in Copenhagen, Denmark, respectively. The **Copenhagen Summit** was characterized by intense ambiguity in terms of the appropriate methods of reducing GHGs emissions, as developed countries evaded responsibility, condemning the developing countries and vice versa. Eventually, no fruitful measures were produced or adopted, as the **Copenhagen Agreement** is not legally binding in any way regarding actions or resolutions towards the drastic reduction of GHGs emissions (Caradonna, 2014).

Nevertheless, in 2012 the **United Nations Conference on Sustainable Development (UNCSD)**, commonly referred to as “**Rio 2012**”, “**Rio+20**” or alternatively “**Earth Summit 2012**” in Rio de Janeiro, Brazil, marked a 20-year anniversary of the Rio Earth Summit. The **Rio 2012 Conference** produced “*The Future We Want*” within which 192 countries renewed their political commitment for sustainable development, reaffirming previous agreements, such as Agenda 21. This particular document paved the way for the forthcoming Sustainable Development Goals (SDGs), while it promoted the UN Environment Programme (UNEP) as the main environmental authority internationally via the reinforcement of its financial resources as well as its status in vital UN coordination bodies. In this context, alternatives to GDP, as a global indicator of wealth and progress, were agreed to be explored in an effort to integrate all the associated social and

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environmental factors, such as the notion of environmental services. The conference also facilitated the formation of the **Division for Sustainable Development Goals (DSDG)** within the **United Nations Department of Economic and Social Affairs (UNDESA)** (UNDESA, 2014).

Four years later during 2015, the **Paris Agreement** was reached within the UNFCCC at the **2015 United Nations Climate Change Conference** or **COP 21** which took place in Paris, France. The **Paris Agreement** is best described by its long-term goal of maintaining the global average temperature rise below 2 degrees Celsius above pre-industrial levels and further limit the temperature increase to 1.5 degrees Celsius in order to diminish the negative impacts of climate change. As of March 2019, 195 UNFCCC members in total have signed the agreement, with 185 of them also becoming parties, though, the U.S.A. have announced their intention to withdraw from the agreement. In this case the efficiency of the agreement will be severely impaired, taking into consideration the fact that the earliest feasible date of withdrawal for the U.S.A. would be November 2020, having affected in advance all the related to mitigating climate change policy measures. In addition, based on results from contemporary studies (Victor et al., 2017; Rogelj et al., 2017) very “*modest progress*” has yet been achieved, without fulfilling the initially agreed goals of reducing GHGs emissions and with serious reservations concerning the maintenance of the global average temperature rise below 2 degrees Celsius above pre-industrial levels.

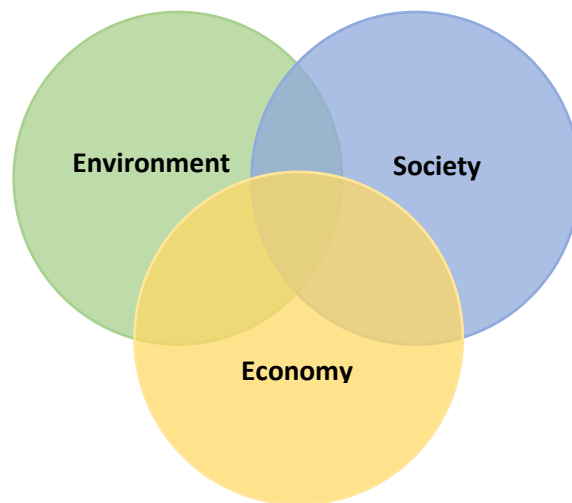
As stated in a current report by UNEP, the emission cut targets during November 2016 will further stimulate a temperature rise of 3 °C above pre-industrial levels (UNEP, 2016), while in accordance with the most recent studies from 2018, a temperature rise of 4-5 °C above pre-industrial levels is possible via *self-reinforcing feedbacks* in the climate system (Steffen et al., 2018), therefore, most probably to induce high river flows resulting in flood risks in areas located in South and Southeast Asia, South America, Central Africa and Western Europe (Paltan et al., 2018). Regardless, the lack of legally binding enforcement mechanisms in the context of the **Paris Agreement** has also been heavily criticized, taking into account the promises made resembling certain types of “voluntary agreements” in the case of the planet’s highest polluters, such as China, U.S.A., India, Japan, Brazil, Canada, Russia, Indonesia and Australia.

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1.1.2 Perspectives of sustainable development

The various global Conferences and Summits pertaining to sustainable development led the institutional foundation based on which the concept of sustainable development currently combines elements from three major sectors that evolved after a rather arduous process: i) the economy, ii) society and iii) the environment. The amalgamation of these three elements is the result of an effort, first envisioned by the economist Renè Passet in 1972, where the notion of sustainable development is presented via a figure characterized by three intersecting spheres, where the sector associated with society encloses the economic sector and the environment or nature (as alternatively presented) encloses society respectively. As a result, the conjoint intersection of those three spheres represents the notion of sustainable development, based on which in order to be categorized as sustainable it is necessary to simultaneously fulfill these 3 prerequisites. However, the depiction of those three sectors further involved to form a type of interconnected rings, thus, creating a model where sustainable development reconciles conflicts among them, either presented as equally sized rings in a symmetrical interconnection (Figure 1-1) or separately from each other, therefore, prioritizing the sectors according to the intended policy implications at each time (ICLEI, 1996; du Plessis, 2000; Barton, 2000; Giddings et al., 2002; Folke et al., 2016).

Figure 1-1: The three interconnected sectors of sustainable development



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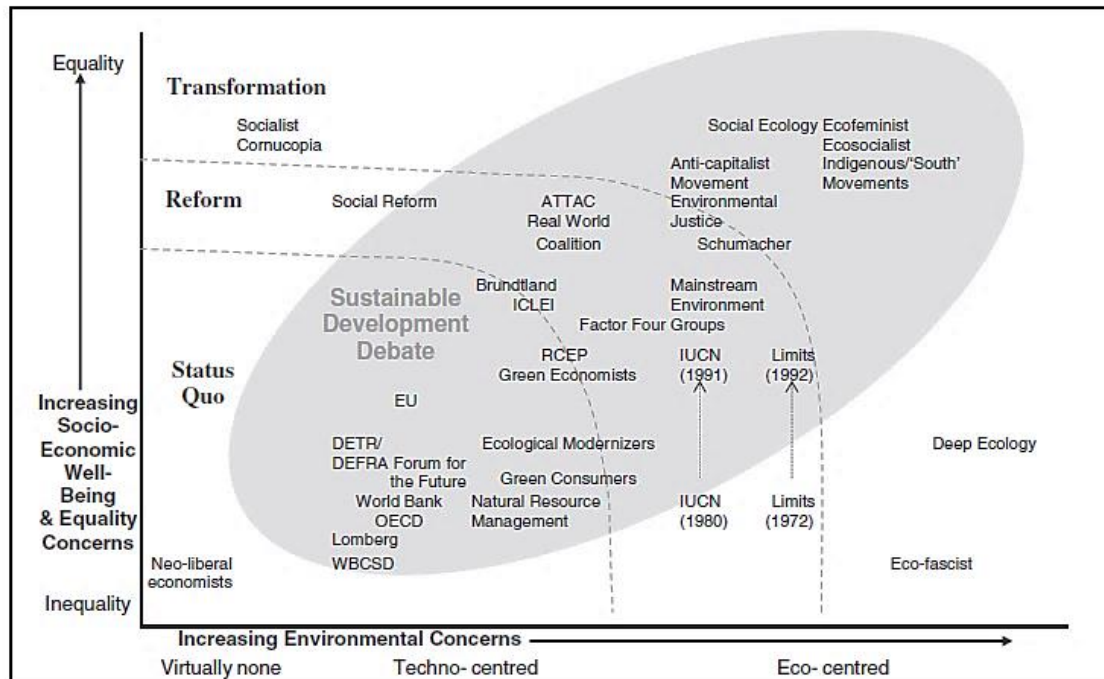
Taking into consideration alternative approaches to the concept of sustainable development under a broader scope of analysis, the terms “technocentrism” and “ecocentrism” arise. In that sense the level of environmental concern during the process of economic growth is examined, as socio-economic and environmental issues are interconnected. In Figure 1-2 two separate axes are presented, the socio-economic and the environmental one, respectively. The vertical axis depicts the socio-economic aspect via the level of importance associated with human well-being and equality, while the horizontal axis represents the level of environmental concerns, from low environmental concern that is deemed techno-centered to higher, characterized as eco-centered accordingly.

As proven by the meticulous illustration depicted in Figure 1-2, an extensive range of concepts exists within the process of interpreting the notion of sustainable development, prioritizing different attributes at each case according to their system of beliefs. The central shaded area of the diagram displays views where both socio-economic and environmental issues are acknowledged within different axiomatic scales at each time. However, three useful and practical perspectives in terms of achieving sustainable development can be extracted: a) sustainable development is possible within the *status quo* (current socio-economic conditions), b) a structural reform (mainly in social terms) is necessary, but without completely altering the current arrangements, and c) a fundamental and cardinal reform is needed in order to alleviate the negative effects of the contemporary socio-economic structures.

In this sense, these three categories, which represent a plethora of views under a broader scope of examination, contain the majority of all the predominant concepts of sustainable development. Therefore a very important conclusion can be drawn: “sustainable development exists within the synergistic framework of socio-economic development and environmental conservation” (Hopwood et al., 2005).

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Figure 1-2: The most prevalent views of sustainable development



Source: Hopwood et al., 2005.

Sustainable development and sustainability ought to integrate the interests of all generations, current and future ones, in order to be efficient, thus, acknowledging the associated environmental impacts and relevant externalities that occur. The procedure of internalizing externalities via the reflection of their costs in market prices of goods and services is common in the field of traditional economics and their related environmental policies (Bithas, 2006). However, it is not possible for future generations to express their interests, and so it is impossible to properly reflect them while estimating the relevant environmental costs. As a result, it is deemed vital to preserve the "environmental rights", which correlate with certain environmental infrastructure and ecological functions, of those future generations in order to ensure their ability to participate in the process of efficiently co-existing with the natural environment and acquiring all the necessary resources for their survival.

Through the preservation of the environmental rights future generations inherit the necessary environmental infrastructure which will ultimately allow them to fulfill their needs without any environmental constraints inflicted by previous generations (Spash, 1993; Bithas, 2011).

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Subsequently, disregarding these environmental rights environmental externalities arise that cannot be effectively "treated" via traditional policy measures. In that sense, the solution lies in the preservation of all the environmental functions, ecosystem services and infrastructure through the achievement of all the associated to this purpose environmental targets and goals, accurately expressed in ecological and biological terms to avoid complications during the process of economic valuation.

However, along with the preservation of the environmental infrastructure the productive base of every economy consists of assets of capital (human-made, human, natural, intellectual, cultural and social). These different forms of capital represent the source and vehicle for society's well-being (Dasgupta, 2007). Hence, sustainability can be best defined as a comprehensive concept, integrating aspects acceptable by environmental scientists and economists alike in the context of combining "dynamic efficiency" and intergenerational equity. In particular, dynamic efficiency is best described as an attainable path of consumption where the economy is on the Pareto frontier. The main notion in that case is to avoid the unnecessary degradation of natural resources, while simultaneously aspiring to maximize total welfare, defined via a utility function, which is comprised of direct consumption and use of non-market goods and services based on a social rate of time preference. As a result, sustainability can be interpreted as a policy goal of normative descent, where dynamic efficiency is combined with the appropriate intergenerational transfers (Stavins et al., 2003).

The notion of achieving sustainability/sustainable development in the context of a pragmatic framework produced specific areas in the field of economics, as the so-called "Sustainability economics". In that sense, sustainability promotes justice in the human-nature systems and existing interactions, whilst, acknowledging important long-term goals. In particular, the need for intergenerational, as well as intragenerational justice (justice between humans of the same generation). In addition, it is vital to preserve and ensure justice between humans and the natural environment as a prerequisite to safeguard the survival of our planet along with the continuation of our species (Baumgärtner and Quaas, 2010). In order to accomplish these goals economics aims at satisfying human needs based on maximizing efficiency, to minimize unnecessary expenditure and wastefulness, taking into consideration the aggregate scarcity of natural resources. Therefore, sustainability economics addresses both efficiency and justice with regard to the relationship between humans and nature which is beset in a future of inherent uncertainty,

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deriving certain elements and attributes from both neo-classical and ecological economics (Solow, 1974; Dasgupta and Heal, 1979; Howarth and Norgaard, 1990; Woodward and Bishop, 1995; Pearce and Dubourg, 1996; Pezzey, 1997).

Subsequently, both the concepts of sustainability and externalities are associated with systemic characteristics, in the sense that in order to fulfil the fundamental requirements for sustainable development, system responses and feedbacks should be properly identified and acknowledged. These feedbacks are associated with social interactions and human preferences under actual environmental constraints (natural resources scarcity, energy, environmental rebound effects). Toward this effort, Kenneth Boulding's *"Economics of the Coming Spaceship Earth"* and Herman Daly's *"steady-state economy"* have been recognized as definite examples of sustainability economics (Boulding, 1966; Daly, 1991). As a result, the notion of "unsustainability" has been formed in relation to current decision-making and the associated future repercussions, thus, denoting the existence and impact of intertemporal environmental externalities. In the absence of environmental externalities unsustainability ceases to exist, though, sustainability does not explicitly require zero externalities. In particular, zero externalities as a goal are unrealistic and almost impossible, taking into account spatial scarcity and the laws of thermodynamics (Georgescu-Roegen, 1971). Though, sustainability and sustainable development at a global scale have drawn attention, spatial sustainability is usually and ineffectively neglected as an environmental issue, whilst relevant studies exist (Krugman, 1992).

The operational objective of sustainability economics is closely related to offering efficient and applicable solutions, via comprehensive analysis and through environmental policy, to contemporary environmental problems and threats, both on a global and regional level. In that sense, it is possible that certain policies may actually discourage time preference regarding social discounting. Nevertheless, it is important to recognize and improve current policy inadequacies and misconceptions often associated with conventional measures and tactics of environmental policy. In any case, further research is necessary on distinguishing among different types of sustainability policies, as part of environmental policy in general, to pinpoint operational and effective criteria, which differentiate from idealistic and impractical solutions (van den Bergh, 2010).

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1.2 The notion of weak and strong sustainability

Two main economic approaches to sustainability, with regard to economic growth and development, exist and are prominently based on the notion of utility, as far as human well-being is concerned. Consequently, two major schools of thought emerged from those two approaches, namely weak and strong sustainability, each of them endorsed by a plethora of acclaimed scientists and researchers. In this context, a most important rule, associated with intergenerational applications, is the non-declining per capita utility for all generations (Neumayer, 2003). Utility is provided via the function of capital, nowadays presented in more contemporary terms as manufactured/man-made or produced, financial, natural, human and social capital (Spangenberg, 2001; Goodwin, 2003).

1.2.1 The weak sustainability approach

The weak sustainability approach can be presented as an extension of the neoclassical theory of economic growth where non-renewable natural resources are integrated in the production function. The main concept behind this approach is the direct application of the Hartwick-Solow rule from growth theory models with exhaustible natural resources, essentially resulting in identifying sustainability as the non-declining consumption/wealth per capita, whilst acknowledging natural resources (the natural capital) during the production process (Solow, 1974; Dasgupta and Heal, 1974; Hartwick, 1977; Cabeza-Gutés, 1996). Thus, based mainly on aggregated growth models they concentrated on the optimal use of income originating from the extraction and use of non-renewable resources and the optimal allocation of those resources between consumption for the contemporary generations and investment in manufactured capital in order to increase consumption for the generations to be. In that way optimal growth is sustainable when the welfare is constantly considered to be non-declining. As a result, the maintenance of a capital stock, including natural capital, is crucial to prevent the danger of declining welfare in the long-term. For this purpose, the Hartwick rule was established based on which rents derived from non-renewable resources ought to be re-invested in the formation of

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manufactured capital resulting in preventing total net capital investment from being persistently negative (Hartwick, 1977; Hamilton, 1994).

It should be mentioned that an investment in total net capital is comprised of gross investment in all forms of capital which can be measured, minus the depreciation of capital and capital consumption. Furthermore, based on the Hartwick-Solow models, non-renewable and renewable resources were integrated into a Cobb-Douglas production function, associated with a particular elasticity of substitution between factors of the production function, thus, adopting as an axiom the fact that natural capital and manufactured capital are essentially substitutable. This assumption is more clearly expressed in the Cobb-Douglas production function which follows (Solow, 1974; Solow, 1986):

$$Q = AL^a K^b N^c \quad (1)$$

where Q represents a single aggregate output produced, A is the efficiency parameter, L refers to labor, K to the manufactured capital, and N to the flow of natural resources, as the main inputs of production. In addition, a, b and c constitute the elasticities of production in regard to labor, manufactured capital and natural capital, respectively.

In that sense, technological advancements could increase the productivity of stock in natural capital at a faster rate compared to its depletion rate (Dietz and Neumayer, 2007). The approach of weak sustainability hypothesizes in favour of a full substitutability of natural capital with manufactured capital with no differences in the forms of well-being they produce for humans (Neumayer, 2003; Ekins et al., 2003; Neumayer, 2012; Pelenc, 2015). The main rule is that the total value of the aggregate stock of capital is maintained for the least part with deliberate efforts to further increase it for the future generations (Solow, 1993). The maximization of compensations in monetary terms for environmental degradation and the perpetual technological progress will suffice for “correcting” any environmental problem caused by the intensive use of non-renewable resources as well as the production of goods and services. Nevertheless, proponents of the weak sustainability approach have claimed that this substitution is indeed associated with cost and in some cases the opportunity cost can be great for obtaining an extra unit of capital (Atkinson et al, 1997). In this regard, the foregone benefits that would or could have been derived by an alternative substitution option are not always evaluated or

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properly weighted against other options, thus, undermining the overall outcome whilst aiming at achieving sustainable development.

1.2.2 The strong sustainability approach

On the other hand, according to the strong sustainability approach the substitutability of natural capital with manufactured/man-made capital is very limited due to the fact that the former is comprised of certain elements and characteristics absent from manufactured capital, but rather essential for the human well-being (Ekins et al., 2003). Natural capital is non-substitutable to an extended degree because it is essentially an assortment of dynamic and complex systems, properly described via a group of biotic and abiotic elements, which evolve in a network of constant interactions that ultimately form and regulate the capacity of every ecosystem in the planet, by means of a series of direct and indirect functions and services, the ecosystem services later to be called, which are vital for human survival and well-being (Pearce and Turner, 1990; Victor et al., 1994; Noël and O'Connor, 1998; de Groot et al., 2003; Brand, 2009).

Natural capital is essentially consisted of all the raw materials critical for the process of producing goods and services. In that sense, it also absorbs and efficiently assimilates the waste by-products of production as well as consumption. Through the existence of natural capital, the vital and crucial in terms of life-support functions and services are performed in order to sustain human existence. Furthermore, services most important for achieving human well-being, such as the visual amenity provided by a beautiful landscape, are carried out as a result of the preservation and healthy functioning of natural capital (Turner et al., 1994; Ekins, et al., 2003; Dietz and Neumayer, 2007).

In this context, the quantity as well as quality of available capital assets becomes crucial, as better presented in Equation (1), where capital (K) is comprised of the manufactured capital (K_M), the human capital (K_H) integrating all the skills and knowledge embodied in humans, the social capital (K_S) incorporating relationships between individuals, between institutions, and between institutions and individuals and ultimately the natural capital (K_N) (Pearce and Atkinson, 1998).

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$$K = K_M + K_H + K_S + K_N \quad (1)$$

Within this framework, the intertemporal condition for sustainable development emerges on the basis that every generation bequeaths a stock of productive capacity (capital assets, technology) to the next generation, which can produce more per capita utility or well-being compared to the one relished by the current generation. The environmental requirements for strong sustainability indicate that $dK/dt > 0$ and $dK_N/dt > 0$, whilst the social requirements denote that $dK/dt > 0$ and $dK_S/dt > 0$, respectively (Pearce and Atkinson, 1998).

The non-substitutability of natural capital is also exceedingly apparent if reviewed explicitly in qualitative terms. Specifically, manufactured/man-made capital is reproducible and can be destroyed, as in the case of infrastructures (e.g. roads, railways, buildings etc.), whereas natural capital destruction or depletion is irreversible and its impacts on human well-being still unknown to a great extent (Ekins et al., 2003; Dietz and Neumayer, 2007). In addition, the formation of manufactured capital is based on natural capital and cannot completely substitute the biophysical properties of natural capital, taking into account the multidimensional provision of the ecosystem services attributed to the existence of natural capital. Based on Brand (2009) it is assumed that natural capital is complementary to manufactured capital as well as human and social capital in generating human well-being, thus, rendering them unable to be complete substitutes. Any increase in future consumption, as often illustrated via the increased capacity to produce goods and services, cannot properly substitute an actual deficit in natural capital.

The notion that strong sustainability implies weak sustainability but not vice versa is predicated on the fact that based on the strong sustainability approach stocks of K_N should not decline, while other forms of capital also remain intact (non-declining) (Pearce and Atkinson, 1998). In addition, the issue of intergenerational justice and freedom for future generations in making unrestricted choices in relation to environmental constraints is also fundamental in the context of the strong sustainability approach (Toman, 1992; UNDP, 2011; Dedeurwaerdere, 2014; Pelenc, 2015).

A crucial aspect within the debate as well as the various distinctions made between the weak and strong sustainability approaches is the extent at which natural capital becomes critical for human society. The notion of the Critical Natural Capital (CNC) is closely associated with nature's ecological and economic functions and values defined as *"assets, stock levels or quality levels that are highly valued, and either essential to human health or to the efficient functioning of life-*

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support systems, or irreplaceable or not-substitutable for all practical purposes” (Tyldesley et al., 1994). Nevertheless, several other definitions have also been applied or adopted such as the *“set of environmental resources which performs important functions and for which no substitutes in terms of human, manufactured, or other NC currently exist”* (Ekins et al., 2003; Chiesura and de Groot, 2003).

Ultimately, the “criticality” of natural capital constitutes an integral part of the academic debate between weak and strong sustainability which can be traced back to certain neo-classical economic assumptions of capital theory (Turner, 1993; Beckermann, 1995; Seralgeldin and Steer, 1994; Jacobs, 1995; Ayres et al., 2001; Faucheux et al., 1997).

1.2.3 The weak vs strong sustainability debate

Advocates in favour of the weak sustainability approach argue that the global economy has proven its ability to overcome production and consumption resource restraints via the substitution of natural with manufactured capital over past decades (Pearce and Atkinson, 1993; Neumayer, 2003). Nevertheless, the substitution regarding the provision of primary life support (food, water, air purification, global climate regulation etc.) performed via the healthy functioning of natural capital is currently almost impossible (Barbier et al., 1994; Pearce and Atkinson, 1998; Dietz and Neumayer, 2007). The various ways based on which Earth’s biogeochemical cycles are performed are still not entirely comprehended on a scientific level, thus, the effects of any possible compromise inflicted due to resource depletion could be detrimental, as natural capital is irreplaceable (Atkinson et al., 1997). Human beings tend to prioritize their losses in terms of value, as far as utility is concerned, compared to potential gains (Kahnemann and Tversky, 1979). In that sense, any loss in natural capital and its associated functions, amenity services and utility provided would be most unfavourable.

As already mentioned above, one of the basic arguments of the weak sustainability approach, regarding the substitution of losses in natural capital with an increased future consumption for the generations to be, lays on precarious and highly speculative grounds. This deduction is justified due to the fact that the wishes and preferences of future generations are currently unknown, and in general, unknowable and in that context any claims about future preferences

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are subject to a lot of debate (Barry, 1977; Barry, 1990; Neumayer, 2003; Dietz and Neumayer, 2007).

Based on Pearce and Atkinson (1998) it is denoted that the strong sustainability approach does not necessarily reject the basic axioms of the weak sustainability approach, as it “implies” most of the weak sustainability’s concepts. Nevertheless, the weak sustainability approach has been strongly criticized due to the fact that it might falsely promote a trend towards the overexploitation of natural resources and misinterpreted dispensability (Barnett and Morse, 1963; Georgescu-Roegen, 1971; Victor et al., 1994; Olson, 1991; Rees, 1991). Taking into consideration the fact that the notion of sustainable development and sustainability have already been subjected numerous times to various forms of interpretation (Solow, 1986, 1992; Pezzey, 1989; Pearce et al., 1998) and different types of measurement (Bauer et al., 1966; Pearce and Atkinson, 1993; van den Bergh, 1996; World Bank, 1997; Nyman, 2003; Sharpe, 2004; Cherchye and Kuosmanen, 2006), mainly in terms of human well-being that can be sustained in conjunction with stocks in capital, monetary indicators of natural capital tend to fail. As they depend on using market prices exclusively and not properly acknowledging and integrating externalities either by applying shadow prices to marketed outputs or by using practical methods of valuation (quantitative, qualitative and hybrid methods), the valuation of capital eventually becomes inaccurate, since it is unclear on which numeric value is actually based on and prices are irrelevant (Atkinson et al., 1997; Pearce and Atkinson, 1998).

During the past decades there have been several attempts to operationalize the strong sustainability approach. One of the most prominent, proposes that the value of natural capital should be preserved, as in the case of non-renewable resources while in any extraction an offset must be applied, usually through investments in renewable resources of equivalent value that function as proper substitutes. However, based on this, the substitutability among the various forms of natural capital is considered to be unlimited in order to cope with the problem of natural capital depreciation, via investments in environmentally compensating “shadow projects” (Barbier et al., 1990; Neumayer, 2003). Another most notable approach firmly acknowledges the fact that a certain subset of the total natural capital in tangible form (physical elements) should be maintained at all times in order to preserve its functions and services. This particular subdivision is widely known as the “critical natural capital” (CNC), roughly defined as the non-substitutable natural capital that is irreplaceable, where any potential deficit can prove to be

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excessively expensive, due to its properties (ecosystem services and functions) for human welfare (de Groot et al., 2003; Dietz and Neumayer, 2007; Dedeurwaerdere, 2014).

The concept of Critical Natural Capital is closely associated with maintaining the efficient functioning of all ecological processes within certain boundaries or thresholds of deterioration, aiming at conserving the capacity of natural capital to provide the various ecosystem services, later to be called, which are essential for human survival and well-being (Noël and O'Connor, 1998; Chiesura and de Groot, 2003, de Groot et al., 2003; Dietz and Neumayer, 2007; Brand, 2009; Pelenc, 2015). However, the strong sustainability approach does indeed prioritize those ecosystem services necessary for preserving life and providing human well-being compared to the rest of the services. In that manner, these life supporting services need to be maintained intact, therefore, necessitating the formation of appropriate environmental policies (Ekins et al., 2003; Pelenc, 2015). The accurate determination of these important services, resulting in their categorization as critical, is a very arduous process, taking into consideration the existing uncertainty regarding the way in which Earth's ecosystems operate.

The most significant areas affected by natural capital and its (ecological) functions are closely related to sustainability, ecological, economic, socio-cultural and ethical factors, including the primary goal for human survival (MEA, 2005; Brand, 2009; Scheidel, 2013). As a result, the degree of natural capital's substitutability as well as the level of criticality can be disputable and very challenging as a process to properly define. Several approaches attempt to operationally define the necessary ecological criteria for environmental conservation (Safe Minimum Standards, maximum sustainable yield, ecological footprint, Biologically Crucial Levels, minimum ecosystem size etc.), though at the same time it is inevitable and essential to integrate societal values and insights along with moral beliefs and attitude to risk to fully determine the "critical" attributes of natural capital (Bishop, 1978; van den Bergh and Nijkamp, 1991; Ekins et al., 2003; de Groot et al., 2003; Chiesura and De Groot, 2003; Bithas and Nijkamp, 2006; Brand, 2009; Dedeurwaerdere, 2014; Pelenc, 2015).

Therefore, the appropriate definition of Critical Natural Capital also depends on the available data and insight regarding socio-ecological systems in addition to certain normative values, associated with the use of natural capital. In this sense, the characterization of natural capital as critical, to what extent and for whom, necessitates both factual data on the interactions of humans (human

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well-being) and natural capital, together with the proper normative basis to determine the sustainability of those interactions in order to ultimately prevent a loss of natural capital that is excessive (Dedeurwaerdere, 2014). Subsequently, it is deemed important to assimilate elements from both technical expert-based evaluations on existing ecological thresholds, as well as from public deliberation and the stakeholders' perspective to thoroughly determine the criticality of natural capital, having integrated all the appropriate parties and views on this issue (van den Hove, 2000; de Groot et al., 2003; Pelenc, 2015).

As more concisely presented in Table 1-1, the two approaches of sustainability are characterized by several fundamental differences. In particular their core ideological concept originates from the same principal ideas, spanning from beliefs regarding issues associated with environmental degradation to environmental policy formation and decision-making models. Nevertheless, the weak sustainability approach favours a more technocratic approach (instrumental rationality) in contrast to the strong sustainability approach and its more systematic and methodical applications (procedural rationality) (Pelenc, 2015).

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Table 1-1: Major weak and strong sustainability opposing views

	Weak sustainability	Strong sustainability
Main view	Extended substitutability of natural capital with other forms of manufactured capital	Extremely limited substitutability of natural capital with other forms of manufactured capital
Key concept	Optimal allocation of the planet's natural resources	Notion of Critical Natural Capital
Sustainable development	Maintenance and potential increase for future generations of the total value of the aggregate stock of capital	Conservation of the non-renewable stock of Critical Natural Capital for future generations
Environmental degradation	Technological advancements and monetary compensation can effectively counterbalance environmental deterioration	Inevitable and irreversible negative impacts on the environment by human socio-economic activities
Decision-making models	Technocratic approach for deciding/applying environmental thresholds (instrumental rationality)	Systematic scientific feedback as input for public deliberation (procedural rationality)

Source: Adapted from Pelenc, 2015.

Ultimately, the weak and strong sustainability approaches differ in relation to their assumptions regarding the substitutability of natural capital. Based on the weak sustainability approach natural capital is substitutable with man-made capital, while the strong sustainability approach declares that at least a portion of natural capital cannot be substitutable and it is necessary to preserve the Critical Natural Capital or the value of total natural capital (Dietz and Neumayer, 2007). Nevertheless, the implementation of strong sustainability's disciplines is closely related with transdisciplinary means of identifying and preserving Critical Natural Capital. In that sense, it is vital to properly acknowledge and recognize the existing ecological thresholds and planetary boundaries, based on scientific feedback and input from natural science along with data and research from social sciences in order to assess the full spectrum of research methods in a broad

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multidisciplinary network of interacting ideologies for optimal results in achieving human well-being and development (Pelenc, 2015).

1.3 Contemporary approaches to sustainability

1.3.1 Planetary boundaries

Approximately ten thousand years ago a new geological epoch called **“Holocene”** begun, leading gradually to a more stagnant human lifestyle, characterized by a transition from hunter-gatherer societies to agricultural and subsequently industrial societies and eventually the modern way of living. In this regard, it is important to denote that during their relatively 160,000 years history humans have existed mainly as hunter-gatherers, notably for approximately 90% of that time, with inconsequential environmental impacts (Steffen et al., 2011). Nevertheless, the progressive formation of complex civilizations, urbanization (large cities and megacities) and the industrial revolution led to the creation of a new geological era, the so-called **“Anthropocene”**, a term initially proposed by Paul Crutzen and Eugene Stoermer on the basis of these profound alterations on the planet (Crutzen and Stoermer, 2000; Crutzen, 2002; Zalasiewicz et al., 2010; Galaz, 2014; Castree et al., 2014; Palsen et al., 2013; Jahn et al., 2015; Biermann et al., 2012).

The repercussions of all of those highly extensive agricultural and industrial activities have been detrimental on the functions and processes of the natural environment, due to the increased atmospheric CO₂ concentration (Ruddiman 2003; Steffen et al., 2007), nitrogen fixation resulting from certain industrial processes (Galloway and Cowling, 2002), fossil fuel-based manufacturing systems (Raupach and Canadell, 2010; Richardson et al., 2011) and all the characteristics of the Great Acceleration.

The concept of the Great Acceleration (Steffen W et al., 2004) describes the exponentially increasing growth in relation to human socio-economic activities, which were spurred mainly after World War II and have affected the Earth’s system and ecosystems in general. The main variables of the Great Acceleration are closely associated with population growth, economic growth, water

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consumption and food production, global transportation, GHGs and natural resources consumption (IPCC, 2007; Steffen et al., 2015; McNeill and Engelke, 2016). The overall impact of the Great Acceleration phenomenon is effectively depicted in the IPAT equation (1), where the aggregate human impact on the natural environment (I) at a global scale is formed by the accumulation of changes occurred in relation to the population (P), affluence (A) as an indicator of consumption and technology (T) (Ehrlich and Holdren 1971, 1972a,b; Commoner et al., 1971a; Dietz and Rosa 1994, 1997, 1998; Wernick et al., 1997; Chertow, 2001).

$$\begin{array}{ccccccc} I & = & P & \times & A & \times & T \\ \text{Human Impact} & & \text{Population} & & \text{Affluence} & & \text{Technology} \end{array} \quad (1)$$

During the period 1950-2011 a huge increase regarding the volume and relative importance of every parameter of the IPAT equation took place. However, from 1950 and onward consumption and technology have become the primary factors affecting the structure and functioning of the natural environment (Kolbert, 2011; Steffen et al., 2011). Nevertheless, the increasingly growing population, and thus consumption induced massive surges in demand regarding agriculture and subsequently natural resources (Matson et al., 1997; Foley et al., 2005; FAO, 2010; Godfray et al., 2010; Sachs et al., 2010). The contemporary trajectory of human progress in relation to economic growth, examined via their essential interactions within the planet's biosphere, has shifted toward a state where the capacity of natural capital in the long-run is severely reduced, with respect to the process of sustaining the on-going rate of socio-economic growth. The need for conservation and resilience thinking regarding natural resources has become evident, taking into consideration existing and potential environmental stressors such as urbanization, migration at a global scale, emerging or financially volatile markets, diffusion on new technological and societal trends/needs and frequently occurring natural disasters, which generate abrupt and severe outcomes "sustainability-wise" (Arrow, et al., 1995; Crepin et al., 2011; Lambin and Meyfroidt, 2011; Liu et al., 2008; Ostrom, 2009, 2010; Folke et al., 2011).

The idea of sustainable development within Earth's biophysical limits on a global level produced the concept of "**planetary boundaries**", initially suggested by Rockström et al. (2009), while

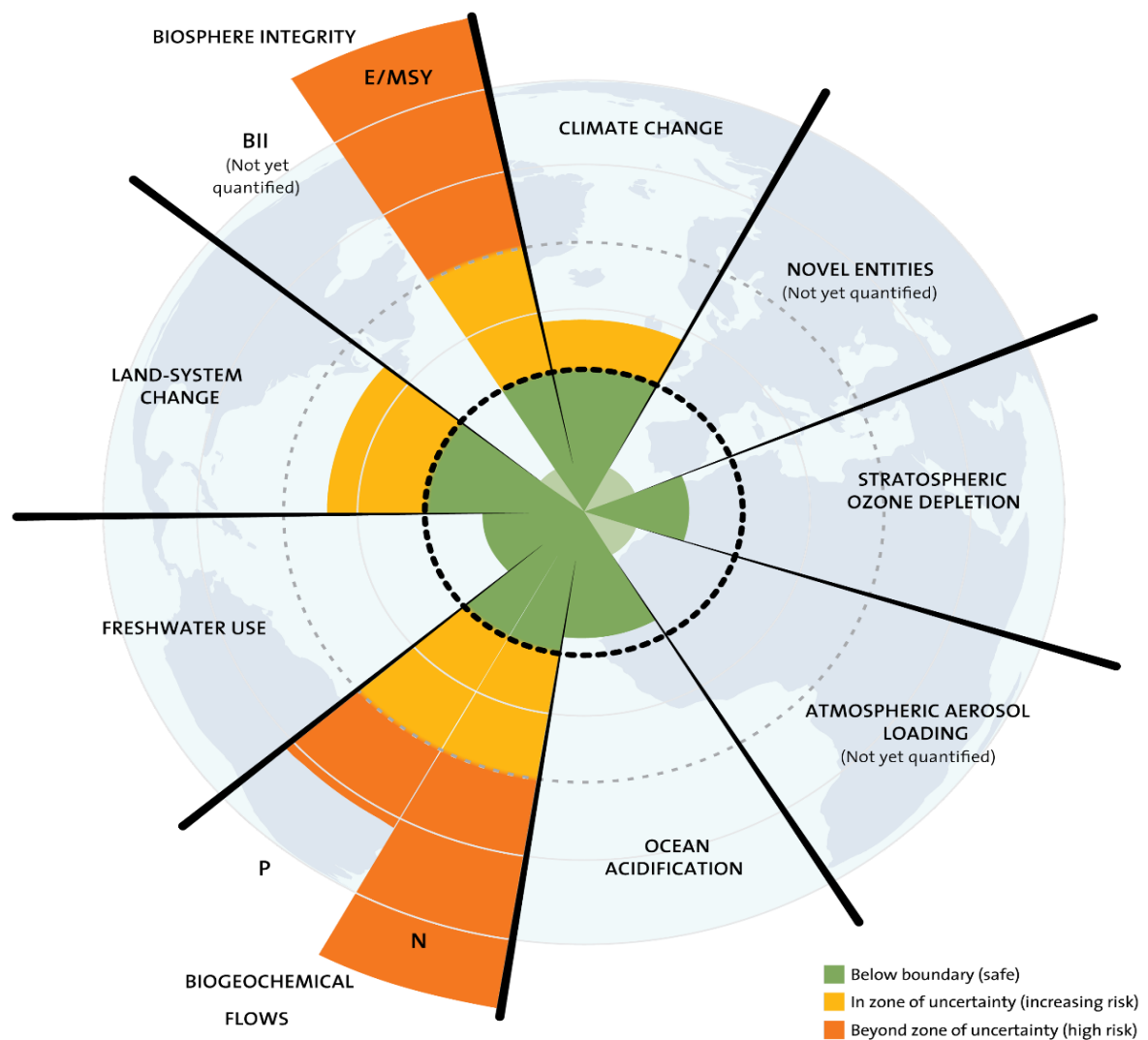
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earlier and broader elements of such a notion can be even traced back to the **Limits to growth** concept proposed by Meadows et al. (1972), thus delineating a safe operating space for human prosperity via the quantification of the aggregate human changes on the Earth system. In particular, when a boundary is crossed due to anthropogenic pressures, certain disruptions in parts of or in Earth's system as a whole occur, indicating a transition toward a different state, characterized by unforeseen and detrimental to human well-being effects (Rockström et al., 2009; Steffen et al., 2015; Biermann, 2012; Bithas, 2020; van Vuuren et al., 2016; SEI, 2017). Violation of one or more planetary boundaries can potentially be deleterious due to the non-linear and sudden environmental impacts that may take place within continental or planetary systems on. In that sense, certain tipping points exist, which ultimately indicate critical values where the state of the system is altered with regard to quality. Our collective contemporary data and information on these tipping points is preliminary, aiming at identifying early signals that will act as warning signs to avoid such pivotal transgressions regarding planetary boundaries (Zahler and Sussmann, 1977; May, 1977; Scheffer et al., 2009; Biermann, 2012; Scheffer and Carpenter, 2003; Guttal and Jayaprakash, 2008).

For this purpose, planetary boundaries propose nine thresholds for nine earth system processes respectively, as a result of preliminary scientific research. Those nine boundaries are the following: climate change, biosphere integrity, stratospheric ozone depletion, ocean acidification, biogeochemical flows (nitrogen and phosphorus cycles), land system change, global freshwater use, atmospheric aerosol loading and chemical pollution (Rockström et al., 2009; Steffen et al., 2015). Furthermore, in an effort to properly quantify these boundaries, specific parameters have been set acting as indicators which should not be transgressed, in order to help guide environmental policy. For certain boundaries, based on Rockström et al. (2009) and Steffen et al. (2015), the outer limits have been violated significantly, resulting in the transition toward a high-risk area beyond the zone of uncertainty, as more effectively depicted in Figure 1-3. In the same context, below the "high-risk" zone is the "increasing risk" zone characterized by rising levels of uncertainty, whilst at a lower stage lies the "safe" zone, thus, constituting the environmental goal for each planetary boundary. The socio-economic impacts of transgressing one or multiple planetary boundaries are intertwined with the core aspects of social-ecological resilience and the healthy functioning of human societies (Rockström et al., 2009; Steffen et al., 2015; CISL, 2019).

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Figure 1-3: The nine planetary boundaries concept



Source: Stockholm Resilience Centre, 2019.

Based on results from recent studies (Steffen et al., 2015; Häyhä et al., 2018; Stadler, et al., 2018; Li et al., 2019; CISL, 2019), it has been established that two boundaries have already been significantly transgressed, namely biosphere integrity and biogeochemical flows, bringing them in the high-risk zone and two more, that is climate change and land system change, are in the zone of increasing risk. As for atmospheric aerosol loading and chemical pollution, existing scientific

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knowledge is still insufficient for conclusive results. Nevertheless, as already mentioned, indicators correlated with specific numeric values have been suggested for all planetary boundaries, producing initial results on a global and regional level, as presented in Table 1-2. Based on these results, it is safe to say that economic growth and development are usually associated with infractions regarding planetary boundaries.

Table 1-2: Current status of the nine planetary boundaries

Planetary boundary	Control variables	Zone of uncertainty	Current status
Climate change Global temperature has risen by nearly 0.7°C since 1950, mostly due to CO ₂ emissions from fossil fuel use.	Atmospheric CO ₂ concentration, ppm Energy imbalance at top-of atmosphere, W m ⁻²	350 ppm CO ₂ (350–450 ppm) +1.0 W m ⁻² (+1.0–1.5 W m ⁻²)	398.5 ppm CO₂ 2.3 W m⁻² (1.1–3.3 W m⁻²) INCREASING RISK (In zone of uncertainty)
Loss of biosphere integrity Wild animal populations have roughly been reduced to half since 1970, and ecosystems worldwide have been negatively impacted by human activities.	<i>Genetic diversity:</i> Extinction rate <i>Functional diversity:</i> Biodiversity Intactness Index (BII)	< 10 E/MSY (10–100 E/MSY) but with an aspirational goal of ca. 1 E/MSY (the background rate of extinction loss). E/MSY = extinctions per million species-years Maintain BII at 90% (90–30%) or above, assessed geographically by biomes/large regional areas (e.g. southern Africa), major marine ecosystems (e.g. coral reefs) or	100–1000 E/MSY 84%, applied to Southern Africa only

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		by large functional groups	HIGH RISK (Beyond zone of uncertainty)
Changes to biogeochemical flows (N and P cycles) – N and P are essential nutrients for all life. Exponential rises in N and P emissions from industry and intensive agriculture eradicate marine life, cause severe air pollution and negatively affect climate patterns	<i>Global Nitrogen:</i> amount of N applied to land per year (Industrial and intentional biological fixation of N)	62 Tg N yr ⁻¹ (62–82 Tg N yr ⁻¹). Boundary acts as a global “valve” limiting introduction of new reactive N to Earth System, but regional distribution of fertilizer N is critical for impacts.	~150 Tg N yr ⁻¹
	<i>Global Phosphorus:</i> P flow from freshwater systems into the ocean	11 Tg P yr ⁻¹ (11–100 Tg P yr ⁻¹)	~22 Tg P yr ⁻¹
	<i>Regional:</i> <i>Phosphorus:</i> P flow from fertilizers to erodible soils	6.2 Tg yr ⁻¹ mined and applied to erodible (agricultural) soils (6.2–11.2 Tg yr ⁻¹). Boundary is a global average but regional distribution is critical for impacts.	~14 Tg P yr ⁻¹ HIGH RISK (Beyond zone of uncertainty)
Land-system (use) change (forest conversion to croplands, roads and cities etc.) As well as deteriorating wildlife, deforestation and urbanization affect	<i>Global:</i> Area of forested land as % of original forest cover	Global: 75% (75–54%) Values are a weighted average of the three individual biome boundaries and their uncertainty zones.	62%

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climate by altering CO ₂ flows	<i>Biome:</i> Area of forested land as % of potential forest	Biome: Tropical: 85% (85–60%) Temperate: 50% (50–30%) Boreal: 85% (85–60%)	INCREASING RISK (In zone of uncertainty)
Release of novel entities (chemical pollution) Synthetic substances – and even novel lifeforms – can radically alter Earth’s biological and physical dynamics, bringing entirely new systemic risks to human societies.	No control variable currently defined	No boundary currently identified (see boundary for stratospheric ozone for an example of a boundary related to a novel entity (CFCs))	Boundary not yet quantified
Atmospheric aerosol loading Microparticles emitted into the air cause severe local pollution problems that can cascade up to global impacts on nature and climate.	<i>Global:</i> Aerosol Optical Depth (AOD) <i>Regional:</i> Aerosol Optical Depth as a seasonal average over a region	Regional: (South Asian Monsoon as a case study): anthropogenic total (absorbing and scattering) AOD over Indian subcontinent of 0.25 (0.25–0.50); absorbing (warming) AOD less than 10% of total AOD	0.30 AOD, over South Asian region Boundary not yet properly quantified
Freshwater use (abstraction) Water use impairs/dries up rivers and aquifers, harming the environment and	<i>Global:</i> Maximum amount of consumptive blue water use (km ³ yr ⁻¹)	Global: 4000 km ³ yr ⁻¹ (4000–6000 km ³ yr ⁻¹)	~2600 km ³ yr ⁻¹

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altering the hydrological cycle and climate.	<i>Basin:</i> Amount of blue water withdrawal as % of mean monthly river flow	Basin: Maximum monthly withdrawal as a percentage of mean monthly river flow. For low-flow months: 25% (25–55%); for intermediate flow months: 30% (30–60%); for high-flow months: 55% (55–85%)	SAFE (Below boundary)
Ocean acidification Tightly coupled to climate change through ocean absorption of CO ₂ and subsequent formation of carbonic acid, the contemporary rate of ocean acidification is unprecedented in over 65 million years. Early effects on marine life are currently becoming evident	Carbonate ion concentration, average global surface ocean saturation state with respect to aragonite (Ω_{arag})	≥80% of the pre-industrial aragonite saturation state of mean surface ocean, including natural diel and seasonal variability (≥80%–≥70%)	~84% of the pre-industrial aragonite saturation state SAFE (Below boundary)
Stratospheric ozone depletion The “ozone hole” induced by ozone depletion allows greater amount of harmful UV radiation to reach Earth’s surface. The minimum ozone concentration has now been steady for ~15 years after phasing out ozone depleting substances.	Stratospheric O ₃ concentration, DU	<5% reduction from preindustrial level of 290 DU (5%–10%), assessed by latitude	Only transgressed over Antarctica in Austral spring (~200 DU) SAFE (Below boundary)

Source: Adapted from Steffen et al., 2015; CISL, 2019.

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Planetary boundaries are interconnected, resulting in the exacerbation of their negative impacts when multiple boundaries are concurrently violated. The transgression of one or more planetary boundaries can deteriorate and destabilize the Earth system to conditions unsuitable for the healthy existence of humans resulting in a seriously diminished human well-being. Furthermore, it is important to denote that certain planetary boundaries, such as biosphere integrity and climate change, which are in the high-risk zone and the zone of uncertainty respectively, are characterized as “core boundaries” due to their significance in the Earth system and their detrimental impacts, thus, ranking them higher regarding the necessity for immediate environmental action (Rockström et al., 2009; Steffen et al., 2015; CISL, 2019).

In this context, the operationalization of the planetary boundaries concept constitutes a considerable challenge, but also a critical parameter toward achieving sustainable development. Ultimately, the most preferable outcome would be to render planetary boundaries as a concept adequate and suitable for decision-making processes on an environmental policy level internationally and at a local and regional scale as well (Biermann, 2019; Nykvist et al., 2013; Whiteman et al., 2013; Hoff et al., 2014; Dao et al., 2015; Krabbe et al., 2015; Fang et al., 2015; Häyhä et al., 2016; van Vuuren et al., 2016; Ryberg et al., 2016; Fanning and O'Neill, 2016; Clift et al., 2017; O'Neill et al., 2018; Li et al., 2019).

The planetary boundaries concept is also often associated with other expressions of environmental pressures, such as the environmental footprints (Galli et al., 2012; Leach et al., 2012; Fang et al., 2015) and the ecological thresholds (Groffman et al., 2006; Andersen et al., 2009; Banks-Leite et al., 2014; Mavrommati et al., 2016), in terms of investigating environmental stressors related to certain limits with significant repercussions if transgressed. All these approaches have in common the urgent need for application of more tangible and functional policy targets and indices to preserve the Earth's capacity to efficiently sustain our current way of living.

A major challenge arising in the context of global environmental governance refers to preparing and reinforcing social-ecological systems to be able to cope with challenging situations regarding the possible violation of one or multiple planetary boundaries. Scientific knowledge, feedbacks and information at a global and regional scale are crucial during the process of forming solutions

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and pathways toward sustainable development in relation to planetary stewardship. The global nature of environmental pressures along with the increasingly persistent ecological shocks provide the rationale for developing new and more flexible forms of multilevel environmental governance to manage the negative effects of environmental degradation, and thus, remain within the safe operating space of the nine planetary boundaries. This effort requires extensive multidisciplinary research and collaboration among a vast range of scientific fields such as environmental science, earth science, ecology and social sciences. The ultimate objective is to acknowledge the existing interdependence between social-ecological systems and the Earth system within specific limits in order to ensure the viability of human existence and long-term prosperity (Folke et al., 2011; Tuomisto et al., 2012).

1.3.2 The 17 Sustainable Development Goals (SDGs)

As mentioned above in a previous section, the **SDGs** are based on decades of work and progress made by countries together with the UN. On the 25th of September 2015, the 193 countries of the UN General Assembly adopted the 2030 Agenda for Sustainable Development, which was comprised of 92 paragraphs, while paragraph 51 delineates the 17 Sustainable Development Goals and their associated 169 targets and 232 indicators. This Agenda has been adopted by all United Nations member states, both developed and developing, during the year 2015 and aims at providing *“a shared blueprint for peace and prosperity for people and the planet, now and into the future”*, characterized by a sense of global partnership. In that context, they promote human prosperity and dignity, while at the same time safeguarding Earth’s essential biophysical functions and ecosystem services (SDKPUN, 2019; ICSU, 2017).

The **SDGs** can be described as an addition to the Millennium Development Goals (**MDGs**) being their precursor, resulting from the **Rio+20 Summit** in 2012 which committed governments to set environmental, social and economic goals worldwide. Through the creation of the **SDGs** they acknowledge the great importance of certain international objectives associated with ending poverty, environmental and socio-economic deprivations, whilst aiming at spurring sustainable development and enhancing environmental resilience (Sachs, 2012; Griggs et al., 2013; McInnes, 2018). The implementation of the **SDGs** began on the 1st of January 2016, acting as essential

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guidelines for governments on a global level to mitigate contemporary and pressing environmental and socio-economic challenges which threaten human existence and well-being. The approach of the 17 **SDGs** is more comprehensive and integrated compared to the 8 **MDGs**, entrusting governments and all the associated stakeholders to establish national and regional plans for their successful implementation. Baring these principles in mind, the 17 **SDGs** are the following:

- 1) No Poverty
- 2) Zero Hunger
- 3) Good Health and Well-being
- 4) Quality Education
- 5) Gender Equality
- 6) Clean Water and Sanitation
- 7) Affordable and Clean Energy
- 8) Decent Work and Economic Growth
- 9) Industry Innovation, and Infrastructure
- 10) Reducing Inequality
- 11) Sustainable Cities and Communities
- 12) Responsible Consumption and Production
- 13) Climate Action
- 14) Life Below Water
- 15) Life on Land
- 16) Peace, Justice, and Strong Institutions
- 17) Partnerships for the Goals.

These 17 goals are characterized by specific targets, which they intend to achieve in order to fulfill the goal, and accompanied by indicators of progress for each target, though the number of targets and indicators usually differs between each goal. As a result, the operationalization of these targets within a viable policy framework has become an issue of outmost importance. In that sense, the majority of the targets should be properly evaluated by experts, as it may be necessary to further prioritize them or even reduce their overall number. To this end, concepts such as the “SMART” (specific, measurable, ambitious, realistic, timebound) criteria have been proposed (Maxwell et al., 2015), though the most significant aspect which has been indicated relates to the

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essential scientific assistance and confirmation needed to substantiate these targets. The final format of these targets will undoubtedly be a matter of policy formation, which could prove efficient predicated on the assumption that it has been based on scientific knowledge and evidence (Hák et al., 2016).

Furthermore, the practical application and translation of the **SDGs** and its targets is required for “real world scenarios”, as is the case of the private sector and business organizations in order to operate in an environmentally, economically and socially viable and acceptable manner. The **SDGs** require the re-evaluation of certain outdated and currently applied rules, procedures and values on behalf of the private business sector to reach the desired outcomes, while simultaneously overcoming shortcomings in terms of organizational matters and business practices (Fleming et al., 2017). Taking into account the fact that the **SDGs** currently retain governmental acceptance at a global scale, normative frameworks, such as the “Gap Frame”, have been formed as an expert-consultation approach characterized by five main steps to successfully translate the **SDGs** into actions for all nations and tools for business practices (Muff et al., 2017). In addition, in an effort to further help businesses to understand and integrate the **SDGs**, the UN Global Compact along with the Global Reporting Initiative (GRI) and World Business Council for Sustainable Development (WBCSD) developed the **SDG Compass**, a guide which aids businesses in aligning their corporate goal setting and sustainability strategies with the principles of the **SDGs**.

The agenda of the 17 **SDGs** is extensive and requires the adoption of interdisciplinary approaches along with collaborative relationships, which is actually the main objective of the last goal (SDG 17: Partnerships for the Goals). Education for sustainable development expressed via acknowledging all the different perspectives of sustainability in various sectors and disciplines. The importance of applying interdisciplinary approaches with regard to education for sustainable development has already been demonstrated in several studies (Eagan et al., 2002; Dale and Newman, 2005; Summers et al., 2005; Luppi, 2011; Jain et al., 2013; Annan-Diab and Molinari, 2017). In this sense, the interrelatedness of the 17 **SDGs** toward mitigating multifaceted matters, varying from clean energy and climate change to poverty alleviation and human rights protection, necessitates scientific input and skills from different disciplines integrated in a common framework, as better depicted in Figure 1-4, where the **SDGs** are shown within the three concentric circles model within a safe operating space for humanity (UNESCAP, 2015; SRC, 2017; Crossman et al., 2018).

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Figure 1-4: The 17 SDGs within the safe operating space concept



Source: Adapted from Azote Images for Stockholm Resilience Centre, 2016.

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1.3.3 Doughnut economics

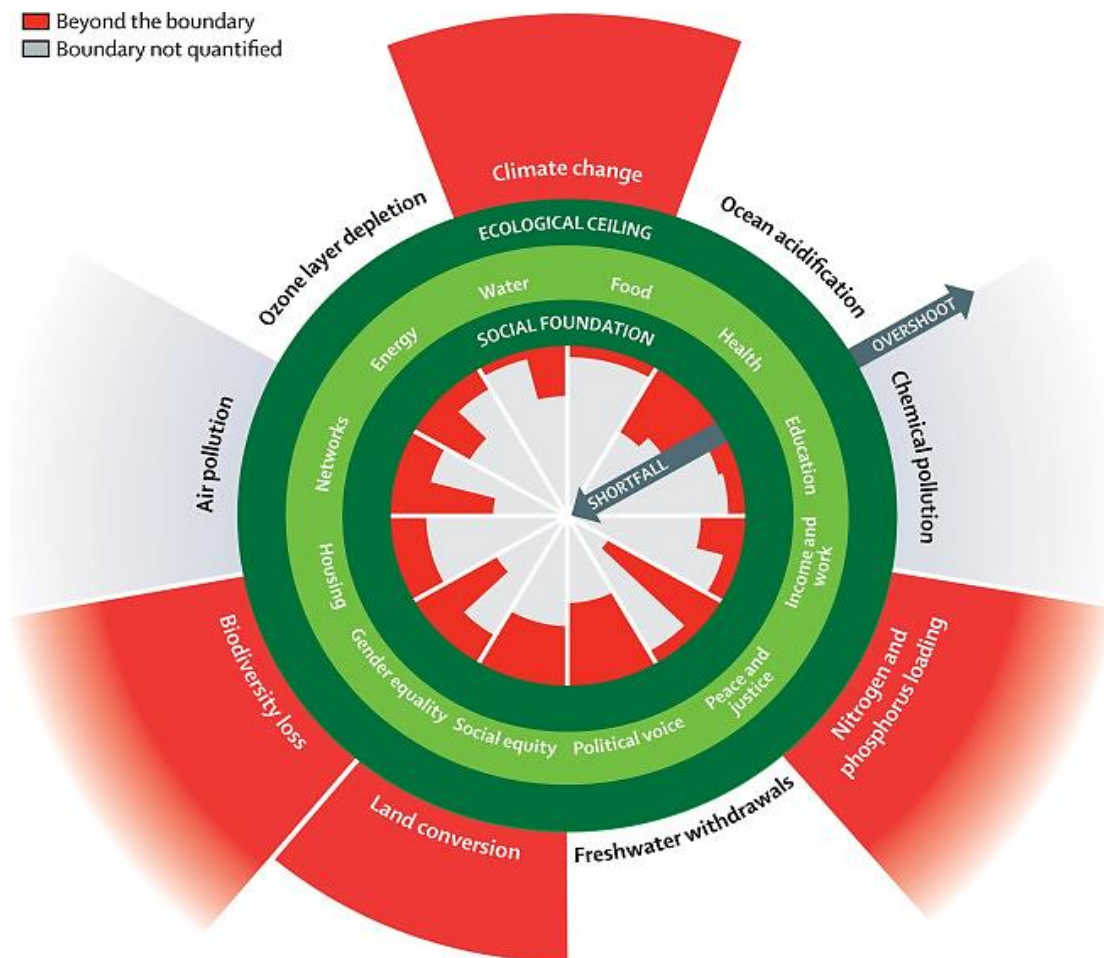
The combination of elements from both the concept of the nine planetary boundaries and the SDGs led to the formation of interesting approaches and ideas as in the case of the so-called **“Doughnut economics”** approach by Kate Raworth (Raworth, 2017a). Based on this contemporary approach, the basic argument refers to the consideration of both planetary boundaries and fulfilling the most vital social rights and needs, often expressed via the SDGs.

The central ideas promoted by this approach are characterized by trends of reorienting the goals of modern economics resulting from urgent environmental problems, expressed through transgressions regarding the nine planetary boundaries and social inefficiencies. The fixation on constant GDP growth to the point that it can be characterized as an end in itself has created extreme inequalities in income and wealth on a global level (OECD, 2019; FAO, 2019; World Bank, 2019). The Doughnut economics concept promotes the integration of the Circular Flow diagram as a more realistic depiction of modern economy, where the economy is embedded within society and both of them are enclosed within the natural environment, thus, revising concepts already stated decades ago by René Passet (Passet, 1979). Furthermore, the Doughnut economics approach consents toward a global economy more distributive and regenerative by design, taking into account ecological degradation, in order to create a circular type of economy and abolish the former linear type economy (Raworth, 2017a).

As mentioned above, the connection to the SDGs is made via the integration of the 11 government priorities of Rio+20, which in turn are associated with natural resources. These 11 dimensions of economic and social rights form the social foundation for the “Doughnut” concept of a safe and just operating space for humanity integrated within the context of sustainable development. In particular, these 11 dimensions refer to the following: food, water, health, education, income and work, peace and justice, political voice, social equity, gender equality, housing, networks and energy. In turn, the nine planetary boundaries form the environmental ceiling for achieving human well-being. These principles are better depicted in Figure 1-5, where the concept of the Doughnut shaped economy is evident along with the 11 dimensions of the social foundation and the nine planetary boundaries and their current condition (Raworth, 2017b).

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Figure 1-5: The Doughnut economics concept



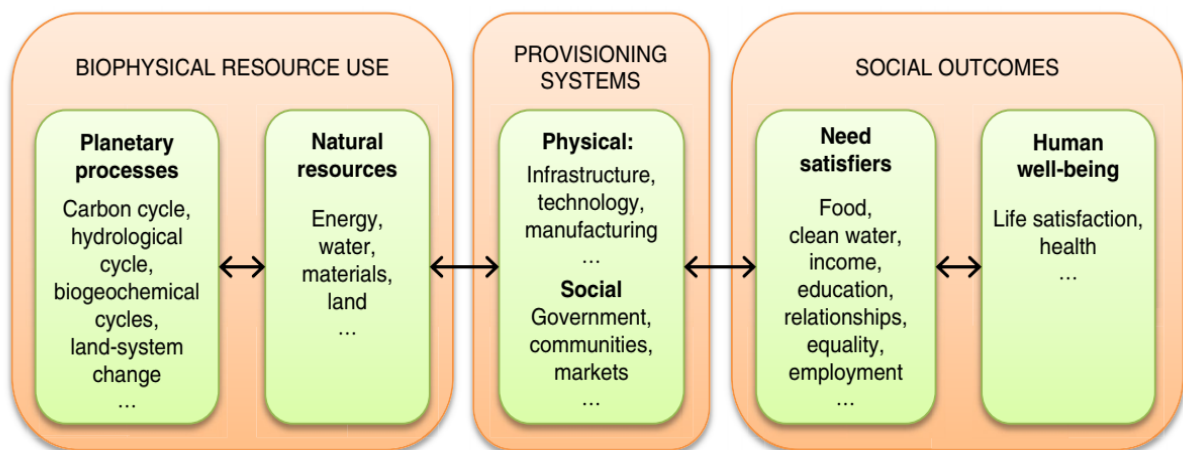
Source: Raworth, 2017b.

Based on this framework, environmental policy priorities have to be reconsidered and further reassessed. Environmental stress/shocks and poverty are interconnected in the sense that infractions in one can exacerbate the other. For example, climate change is associated with harsh environmental impacts such as increasing droughts and floods, which dramatically diminish people's ability to ensure food security, clean water and, ultimately undermining their health. On the other hand, rising poverty leads to environmentally unsustainable ways of living, as billions of people heavily rely on the use of traditional biomass or coal for cooking and heating, producing CO₂ emissions, and thus, further exacerbate deforestation and biodiversity loss (Raworth, 2012).

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In that sense, viable and effective environmental policies should aim at mitigating the negative effects of poverty and environmental degradation concurrently within an integrated framework, considering the intertwined nature of environmental sustainability and poverty. Biophysical resource use, which includes natural resources and all the vital planetary functions and processes, is closely connected and interdependent with the physical and social dimensions of the provisioning systems as well as social outcomes in terms of basic need satisfiers and human well-being, better expressed by O'Neil et al. (2018) in Figure 1-6, though their analytic framework depicting the link between planetary processes and human well-being.

Figure 1-6: The framework of the relationship between planetary processes and human well-being



Source: O'Neil et al., 2018.

The relationship between human well-being and the use of natural resources is also evident and equally important when examined on a regional level. The safe and just operating space proposed in the context of the “Doughnut” is directly affected by changes occurring within the context of regional use and sustainable management of natural resources and the associated impacts on planetary boundaries in light of the existing social conditions with regard to particular regions. The integration of scientific data and information with reference to regional socio-economic activities and the natural environment is indeed necessary in order to form and effectively apply policy measures for mitigating environmental threats at a national and global scale (Nykqvist et al., 2013; Dearing et al., 2014). The establishment of regional-scale boundaries would be a crucial

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step toward the efficient application of the planetary boundaries concept in relation to the aforementioned social foundation within the context of a more dynamic model of modern economy, characterized by multidisciplinary scientific co-operation (Raworth, 2017a; O'Neil et al., 2018).

In an effort to properly operationalize the safe and just operating space proposed via the nine planetary boundaries concept prior to the Doughnut economics approach for ultimately achieving sustainable and equitable social-ecological systems, certain modelling approaches have been made. To this end, driver interactions are incorporated along with feedbacks to create a versatile framework which investigates the social-ecological interactions and feedbacks that directly affect sustainable development on a regional level. The interactions of the underlying external trajectories with the internal drivers are closely examined, whilst attempting to design a tool for proactive system governance via the identification of certain ecological signals or warnings, thus, delineating sustainable limits and further contribute to properly assessing alternative approaches regarding environmental governance. The future of social-ecological systems can be uncertain, bearing in mind all the conceivable trajectories of environmental degradation, decision-making processes and socio-economic development, hence, acting proactively from local, regional, national to global is necessary in order to minimize any potential risks and maximize the efficiency of environmental policy measures to be implemented (Cooper and Dearing, 2019).

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Chapter 2: The Concept and Importance of Ecosystem Services

2. The concept and importance of ecosystem services

2.1 The origins

The perception of what an ecosystem consists of, its functions and benefits to human society is quite old, though, one of the most prominent first approaches toward the scientific conceptualization of the ecosystem services, later to be called, was made by Arthur Tansley in 1935, integrating the term “system” to include the majority of living organisms as well as physical factors, which ultimately form biomes, taking into account both organic and inorganic factors and their interactions in terms of an “ecosystem” (Tansley, 1935). Shortly after, Raymond Laurel Lindeman delineated the “ecosystem” in quantitative terms (Lindeman, 1942) and eventually Eugene Odum wrote the first textbook in 1953 (Odum, 1953).

During the late 1970s the term “ecosystem services”, in the form of functions performed by ecosystems, arose in order to trigger public interest regarding the conservation of biodiversity (Westman, 1977; Ehrlich and Ehrlich, 1981; de Groot, 1987; Gómez-Baggethun et al., 2010). However, a few years before during the early 1970s the akin term “environmental services” was incorporated by Wilson and Matthews (1970). Ecosystem services, as mentioned earlier, first appeared within a context of terminology in Ehrlich and Ehrlich (1981) and more systematically in Ehrlich and Mooney (1983), but it was based on previous literature, which denoted the benefits and values provided by certain functions performed on the basis of the natural environment (King, 1966; Helliwell, 1969; Hueting, 1970; Odum and Odum, 1972; Braat et al., 1979; Gómez-Baggethun et al., 2010). In this sense, ecosystem services were derived from broader concepts, as in the case of Schumacher (1973) who possibly first used the notion of natural capital, thus, paving the way for other scientists to utilize terms such as “nature’s services” and “ecological services” (Westman, 1977; Pimentel, 1980; Ehrlich and Ehrlich, 1981; Thibodeau and Ostro, 1981; Kellert, 1984; de Groot, 1987 Gómez-Baggethun et al., 2010).

Gradually the constant depletion of the planet’s natural capital became more apparent, aided by a global growing interest in ecology, which encompassed ecosystems and the notion of the non - market valuation of nature’s commodities (Boulding, 1966; Daly, 1968; Ayres and Kneese, 1969; Odum, 1971; Freeman et al., 1973). Two major communities were formed, the first can be

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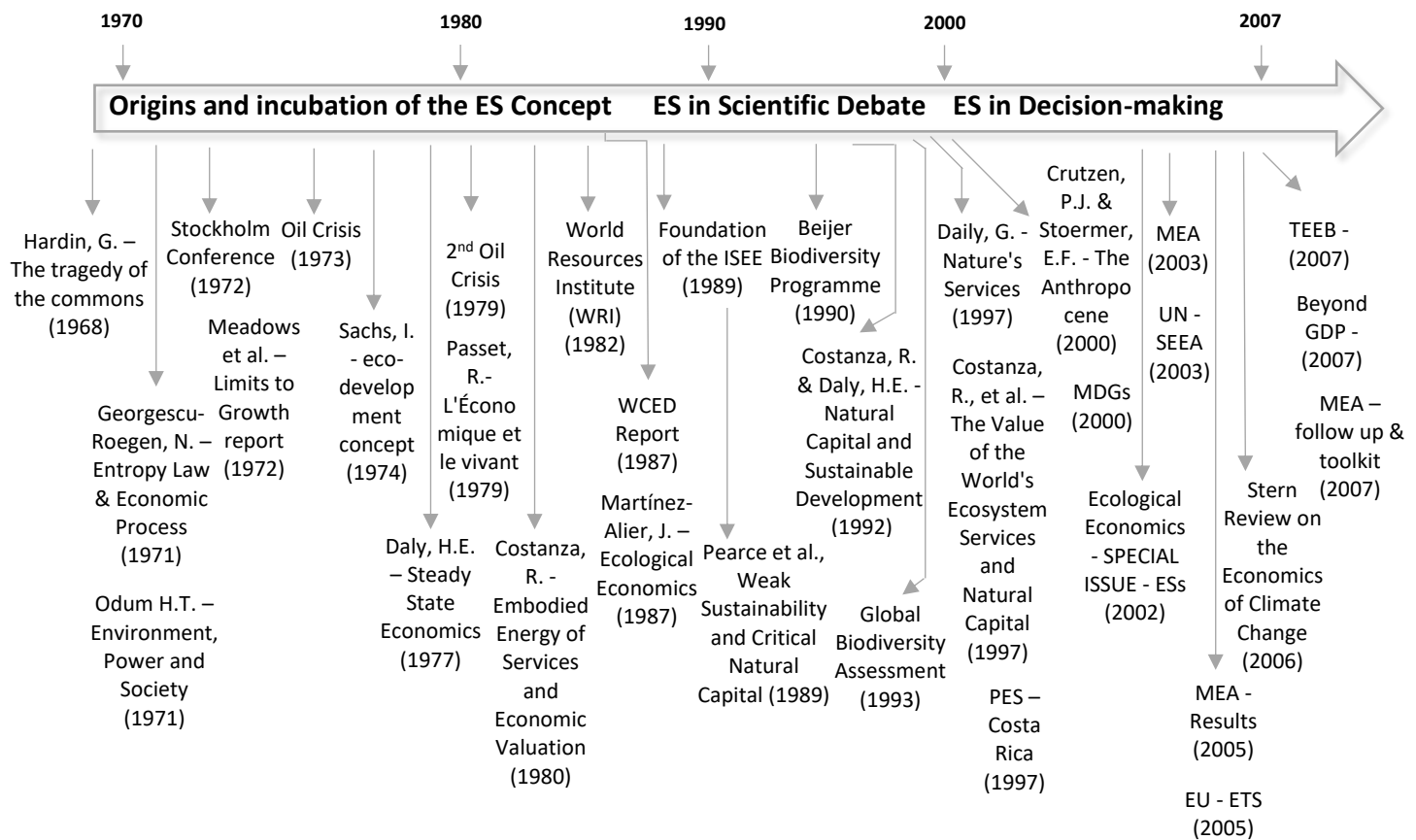
characterized as an ecosystem ecology community, while the other as the environmental economics community, paving the way for the transdisciplinary field of "ecological economics", which appeared during the 1980s. This innovative scientific field combined elements from both communities along with parts and scientific research from fields such as political science, earth system science and psychology, efficiently integrating them toward a more pluralistic and thorough approach (Jansson, 1984; Costanza, 1989; de Groot 1987; Costanza et al., 1991 Braat 1992; de Groot 1992).

During the 1990s, ecosystem services became mainstream in terms of literature produced, as comprehensively depicted in Figure 2-1, and were associated with increased interest on methodologies for conducting economic valuation (Costanza and Daly, 1992; Perrings et al., 1992; Daily, 1997; Costanza et al., 1997). The Beijer Institute's Biodiversity Program and Costanza's highly cited paper (Costanza et al., 1997) presenting the value of the global natural capital, are considered milestones in mainstreaming ecosystem services. The impact of those figures was significant with regard to the policy making procedure and sparked further interest in producing research on the monetary valuation of natural capital and ecosystem services. Subsequently, during the year 1995 the Global Biodiversity Assessment was produced whilst during the early 2000s the UNEP-CBD adopted the so-called "Ecosystem Approach" (Gómez-Baggethun et al., 2010).

Furthermore, the Millennium Ecosystem Assessment (MEA) of 2003 was rather successful in promoting ecosystem services as a crucial topic in the policy agenda, while providing a more anthropocentric approach, expressing interest on the functions of ecosystems, biodiversity and all the related ecological processes which directly contribute to the maximization of human well-being, thus, paving the way for a plethora of studies and systematic research on this issue (Fisher et al., 2009; Gómez-Baggethun et al., 2010; Lele et al., 2013). As a result, some of the most crucial steps in the history of the ecosystem services concept were taken, as cumulatively presented in Figure 2-1, as in the cases of the Stern Review on the Economics of Climate Change, the Potsdam Initiative-Biological Diversity 2010, the project Economics of Ecosystems and Biodiversity (TEEB) aiming at estimating the costs of ecosystem services degradation as well as global biodiversity loss, and the MEA Synthesis report of 2007 (Stern 2016; TEEB, 2009; MEA, 2007; Gómez-Baggethun et al., 2010).

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Figure 2-1: The evolution of ecosystem services



Source: Adapted from Gómez-Baggethun et al., 2010.

2.2 Definition and categorization

In the interest of properly defining the term ecosystem services, it is essential to first delineate the concept of an ecosystem. Based on the most commonly used definition provided by the MEA of 2003, “An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the nonliving environment interacting as a functional unit”. The size of an ecosystem may vary from something relatively small as a pond in a garden to an ocean basin when examined as a whole body. In that sense, human-beings constitute a fundamental component of ecosystems, taking into consideration our physiology along with our extensive daily activities (MEA, 2003).

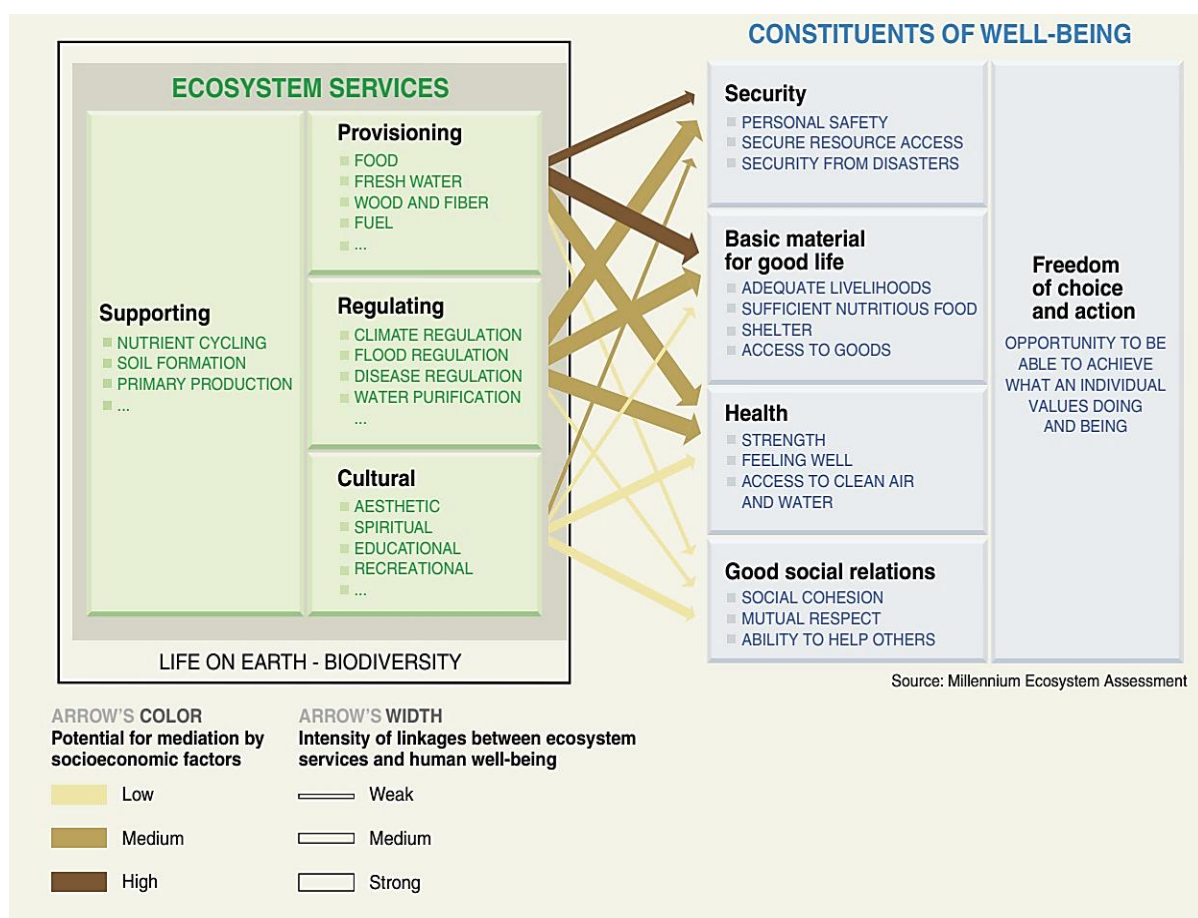
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Therefore, ecosystem services are described as the benefits that humans obtain from our planet's ecosystems which are subsequently assorted in four major categories. The supporting services, often referred as intermediate services as well, are essential for the production of all other ecosystem services and are comprised of soil formation, nutrient cycling and primary production, whilst pollination is usually also included in this category. The provisioning services, refer to the provision of necessary products such as food, fresh water, raw materials, biochemicals, genetic resources, medicinal and ornamental resources. The third category is the regulating services, which is described as the "*benefits obtained from regulation of the ecosystem processes*", most prominent of which are climate, water and air quality regulation, water purification and water flow regulation, moderation of disturbance, waste treatment, erosion prevention and biological control (MEA, 2003). The final category relates to the cultural services, consisting of non-material benefits provided by the ecosystems in the form of services such as spiritual, religious, recreational, aesthetic, inspirational and educational benefits, ecotourism, cultural heritage, sense of place and cognitive development.

On more contemporary studies an additional category has been formed, the "habital services", which includes the nursery services and gene pool protection provide by ecosystems (de Groot et al., 2012). The healthy functioning of the planet's ecosystems enables the seamless provision of all these benefits to humans which constitute integral parts of the basic components of well-being, including basic material for a good living, security, health, good relations, freedom and choice (Figure 2-2) (MEA, 2003; 2005).

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Figure 2-2: Ecosystem services categorization and human well-being



Source: MEA, 2005.

In addition, ecosystem services refer to several functions performed on the basis of a certain biophysical structure, which are further configured as services and ultimately benefits for human beings, in the sense that they generate wealth and increase utility (MEA, 2005). As a result, a plethora of studies has tried and still attempts to measure and assess the various aspects of society's dependence on the natural environment and the associated services provided. These efforts have culminated in redetermining policy targets in accordance with economic valuation predicated on how the healthy functioning of numerous ecosystem services or the potential partial/total loss of them can induce losses in human welfare (TEEB, 2008), thus, resulting in the formation of major intergovernmental bodies, as in the case of the Inter-governmental Platform on Biodiversity and Ecosystem Services (IPBES) in 2012.

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Based on these efforts to appropriately value ecosystem services, major steps have been made in further classifying and categorizing ecosystem services according to the biome they represent with multiple categories such as the following presented in Table 2-1 (de Groot et al., 2012; MEA, 2005):

Table 2-1: Classification of ecosystem services per biome

Ecosystem services	Biome	Characteristics
Marine	Open ocean	Deep sea (water and sea floor below 200 m) excluding coral reefs, shelf sea, ocean islands and atolls that are included in coastal biomes
	Seas and marginal seas	Marine areas where the sea is deeper than 50 meters
Coastal	Estuaries	Area between 50 meters below mean sea level and 50 meters above the high tide level or extending landward to a distance 100 kilometers from shore
	Seagrass beds	
	Coral reefs	
	Shelf areas	
	Coastal wetlands (tidal marshes and mangroves, coastal watersheds)	
	Sand beaches	
	Dunes	
	Oyster reefs	
	Shallow seas of continental shelves, rocky shores and beaches	
	Saline lakes	

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Forest	Tropical (moist- or rainforests, deciduous/semi-deciduous broadleaf forest and tropical mountain forests)	A canopy covering at least 40% of an area made of woody plants taller than 5 meters. A crown cover more than 10%. It includes temporarily cut-over forests and plantations, but excludes orchards and agroforests used as food crops
	Temperate (temperate deciduous forest, temperate broadleaf and mixed forest, temperate coniferous forest, temperate rainforests)	
	Boreal (Taiga, snow forests)	
Woodlands	Open canopy forests	Transition zones between different ecosystems (e.g. grasslands, true forests, and deserts) including a large variety of vegetation types interleaved with one another. They are located along the western coasts of North and South America, areas around the Mediterranean Sea, South Africa, and Australia, covering approximately 5% of the planet's surface
	Savannas	
	Shrublands	
	Scrublands	
	Chaparral	
Grasslands	Tropical grasslands (savannas)	Plant communities, characterized by grass as the dominant vegetation occurring in a wide variety of environments
	Temperate grasslands (including the European and Central Asian steppe and North American prairie)	
	Boreal grasslands (tundra)	
	Mountainous grasslands (e.g. Latin American Paramo highlands)	

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Inland Wetlands	Freshwater floodplains	Excluding coastal wetlands, rivers and lakes
	Swamps/marshes	
	Peat lands	
Fresh water lakes/rivers	Lakes	Freshwater rivers and lakes excluding saline lakes, wetlands and floodplains
	Rivers	
Dryland	Temperate grassland	Lands where annual precipitation is less than two thirds of potential evaporation, from dry subhumid areas (ratio ranges 0.50–0.65), through semiarid, arid, and hyper-arid (ratio <0.05). They exclude polar areas, but include semi-deserts and true deserts
	Mediterranean	
	Tropical grassland and savanna	
	Desert	
Tundra	Arctic	A vast area of treeless level or rolling ground located in cold regions (arctic) or above the timberline on high mountains (alpine). Characterized by large zones of bare ground and rock, mosses, herbs, lichens, small shrubs
	Alpine	
	Antarctic	
Polar	Polar barrens	Located at high latitude on land surfaces not covered by perpetual ice and snow. They comprise more than 10% of the planet's land surface, excluding high-altitude cold systems in low latitudes
	Tundra	
	Ice caps	
	Permafrost	
	Polar deserts	
	Polar coastal areas	
Island	Continental	Land areas smaller than a continent and entirely surrounded by water. The oceanic islands rise to the surface from the floors of

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	Oceanic	the ocean basins. The continental islands are unsubmerged parts of the continental shelf entirely surrounded by water
	Archipelago	
Mountain	Hills and landforms rising prominently above its surroundings, steep slopes, summit area	Typically defined on the basis of elevation alone, and at lower elevation, on a combination of elevation, slope, and local elevation range. Higher altitudes are characterized by treeless alpine vegetation, while lower slopes are covered by montane forests

Source: Adapted from de Groot et al., 2012; MEA, 2003; 2005.

Furthermore, ecosystem services are examined and evaluated for efficiency purposes on three different scales: global, regional and local for both short-term and long-term time periods. Cross-scale examination based either on geographic or temporal orientation is deemed important and effective due to existing interactions between direct and indirect drivers of change and ecosystem services. For example, changes in the population size or technology can influence or alter factors that in turn affect ecosystems. Subsequently, changes in ecosystem services affect human well-being from a global level to a regional one and consequently local, through different time periods, as thoroughly presented in Figure 2-3 (MEA, 2005).

The basic categories within the MEA (2003) framework for reporting results and assessments at a global scale are 10, and though they do not constitute ecosystems themselves they have integrated the crucial aspects of all types of ecosystems. However, they are often associated with boundaries which tend to overlap, resulting in several reporting categories to be included in more than one type of classification. These categories, as already mentioned above, have been further organized for assessment purposes on the basis of their central concept as well as their content as follows (MEA, 2003):

- 1) Marine (oceans with major drivers such as fishing activities etc.),
- 2) Coastal (interface between an ocean and land),

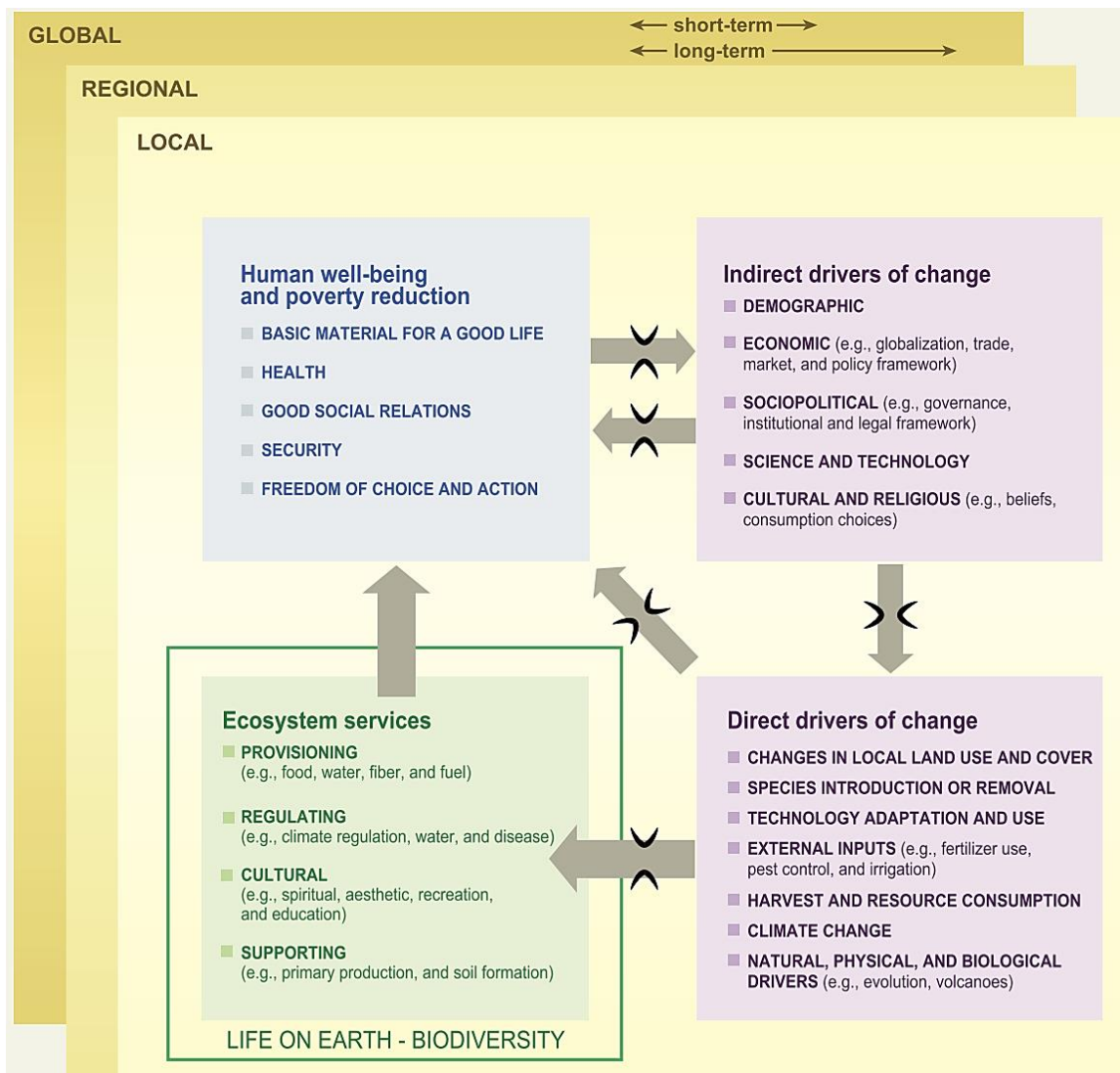
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- 3) Inland water (permanent water bodies inland from the coastal zone and areas whose ecology/exploitation is affected by the permanent, seasonal and intermittent occurrence of flooded conditions),
- 4) Forest (lands thoroughly surrounded by trees, used as providers of timber, fuelwood as well as and non-timber forest products),
- 5) Dryland (lands with limited plant production due to water unavailability, usually exploited through livestock grazing and cultivation),
- 6) Island (lands isolated by surrounding water characterized by a high proportion of coast to hinterland),
- 7) Mountain (lands defined by high elevation, slopes and isolated inner basins/plateaus less than 25 km² extent surrounded by mountains),
- 8) Polar (frozen for most of the year lands of high latitude, ice caps, areas dominated by permafrost, polar deserts, tundra and polar coastal areas),
- 9) Cultivated (lands characterized by domesticated plant species, used for farming activities, agroforestry and aquaculture production),
- 10) Urban (man-made built environments and human settlements with a population of 5,000 or more and high human density).

The process of investigating and evaluating the planet's ecosystem services in total is likely to be more successful and efficient when performed under a conceptual framework which integrates biodiversity, human well-being, the direct and indirect drivers of change, while also taking into consideration their interactive relationship with ecosystem services intertemporally on a global, regional and local level, as better depicted in Figure 2-3.

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Figure 2-3: The MEA conceptual framework of the interactive relationship among biodiversity, ecosystem services, human well-being, and drivers of change



Source: MEA, 2005.

The most prominent efforts to properly describe how ecosystem services, together with their related functions and processes, contribute to human well-being, have resulted in certain classification systems, which attempt to integrate all the associated assessments along with aspects of valuation and modelling techniques. In that sense, the most frequently applied classifications systems of ecosystem services (in terms of economic assessment and environmental policy) are the MEA, The Economics of Ecosystems and Biodiversity project (TEEB),

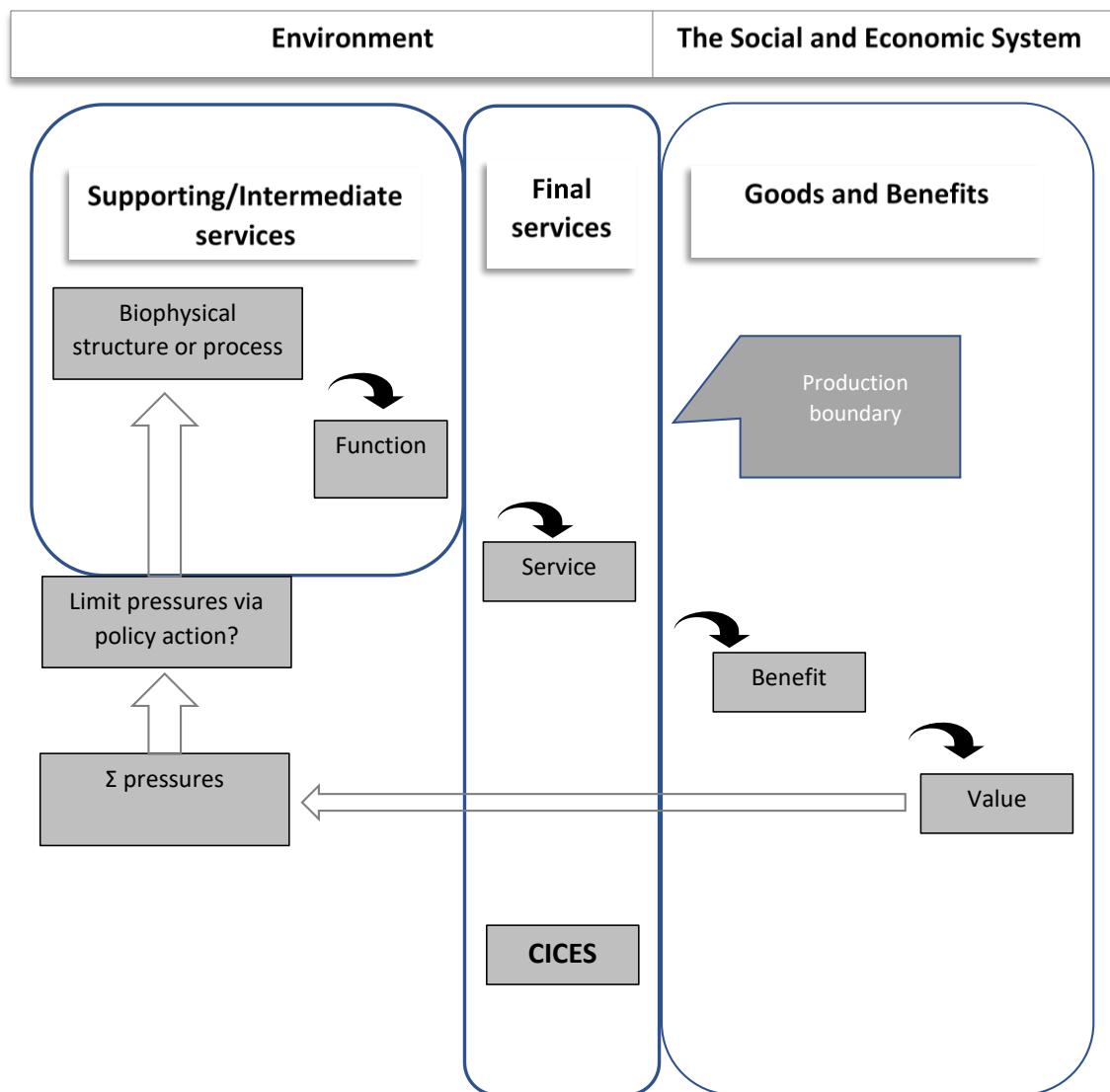
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the Common International Classification of Ecosystem Services (CICES), the Final Ecosystem Goods and Services Classification System (FEGS-CS) and the National Ecosystem Services Classification System (NESCO) classifications (MEA, 2005; Haines-Young and Potschin, 2013; Landers and Nahlik, 2013; US Environmental Protection Agency, 2015). The latter (FEGS and NESCO) have been developed by the U.S. Environmental Protection Agency as classification systems for final ecosystem services, though they are generally similar to the CICES system. The CICES was formed as a scientifically accurate classification system, which is hierarchically consistent and can be applied for natural capital accounting objectives, as better depicted in Figure 2-4.

These classification systems are based on theoretical frameworks represented via the process of graphic design for efficiency reasons, while they usually try to compensate for possible shortcomings or weaknesses on behalf of others. In this regard, the cascade framework (Haines-Young and Potschin, 2013) denotes supporting services as a “function”, while the novel at the time “habitat services” category was introduced within the concept of the TEEB classification system. Furthermore, in order to avoid double counting during the valuation process, the FEGS-CS and NESCO systems require clear separation between intermediate and final services, focusing for the most part on benefits and beneficiaries. Therefore, the suitability and probable efficiency of these classification systems should be based on their “fit-for-purpose”, the purpose and needs of the ecosystem services analysis, and thus policy-making at hand and the existing limitations of each classification system (Heink et al., 2015, Spangenberg and Settele, 2010; La Notte et al., 2017).

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Figure 2-4: The ecological structure and processes through the cascade model



Source: Adapted from Potschin and Haines-Young, 2016.

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2.3 Ecosystem services and sustainable development

Investigating ecosystem services within the context of an academic field can be a quite contemporary and multidisciplinary process, integrating normative aspects with strong associations toward the notion of sustainability and sustainable development. Nevertheless, the majority of research on ecosystem services, especially during the period 1997-2011, can be characterized as splintered, mostly prioritizing the thorough description of the existing interactions between humans and the natural environment (Abson et al., 2014). However, ecosystem services offer alternative approaches to prosperity in terms of improving human well-being without constant economic growth (Fioramonti, 2013; 2017a).

In this sense, the ecosystem services concept provides a description on the interdependency of human well-being and nature, while at the same time emphasizes on the dangers arising from failure to incorporate all the necessary types of values (both use and non-use) and their associated costs and benefits (Jax et al., 2013). Thus, the concept of ecosystem services in relation to sustainable development has become crucial for both biological conservation purposes as well as environmental policy and natural resources management.

The need for a holistic approach through transdisciplinarity is derived from the existing human dependence on ecosystems at an overall scale. In many cases, ethical issues and problems tend to arise from conceptualizing and subsequently applying the concept of ecosystem services, though potential trade-offs do exist, when forming a clearly defined environmental policy. As a result, an effective policy should properly balance all the related scientific disciplines incorporated along with the specific stakeholders involved, creatively combining them while aspiring to fulfill different goals and purposes (Jax et al., 2013).

During the process of mainstreaming the concept of ecosystem services from the perspective of decision-making procedures as well, the sustainable use of natural resources has emerged as a major issue which further highlights the importance of three parameters: (i) the co-production of ecosystem services by social-ecological systems, (ii) the benefits/beneficiaries from the provision of ecosystem services, and (iii) the proper and most efficient practices regarding the governance of ecosystem services. These parameters are interconnected, thus, reinforcing the need for more integrative collaboration through the field of natural and social sciences. In addition, the effective governance of ecosystem services demands intensive collaboration between the decision-makers

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and policy-makers together with the associated users of ecosystem services, based on intertemporal and numerous spatial scales (Bennett et al., 2015).

Many approaches have arisen in an effort to provide operational frameworks for ecosystem services and sustainable development in a decision-making context. Through these approaches certain crucial steps can be pinpointed associated with: (a) the connection of ecosystem services with sustainable development criteria, (b) the adoption of multi-criteria analysis to assess ecosystem services based on weights corresponding to stakeholder preferences' and opinions', and (c) the application of temporal and spatial discount rates (Vatn, 2009; Zagonari, 2016). In that sense, this type of frameworks can contribute to identifying critical features based on which decisions are made. However, the reliability of the various ecosystem services approaches as well as several proposed frameworks depends on successfully combining them with multi-criteria analysis assessments. The application of multi-criteria analysis assessments in an ecosystem services approach during the decision-making process for sustainable development, tends to draw special attention to fundamental issues to be discussed and settled by stakeholders. Thus, the addition of experts with specific scientific expertise from different disciplines, who are essentially needed in this process, provides accuracy and objectivity toward achieving mutual understanding among the stakeholders and decision-makers involved (Vatn, 2009; Oikonomou et al., 2011; Lele and Srinivasan, 2013; Zagonari, 2016).

Contemporary frameworks, such as the ESPA (Ecosystem Services for Poverty Alleviation), incorporate aspects from existing frameworks based on social-ecological systems science and sustainable development through sustainable ecosystem management on an international level (Fisher et al., 2014). Among the basic components of this framework is multidisciplinary in relation to research themes, integrated thinking, poverty alleviation and human well-being. Social differentiation is also very important regarding the access to ecosystem services as well as indirect anthropogenic drivers and the ecosystem services impacts with regard to global consumption. The ESPA framework aims toward field applicability taking into account that several of its components can be quantifiable, while other aspects are for the most part qualitative. In this sense, it is often described by virtue of a normative disposition advocating toward social equity and environmental sustainability based on both qualitative and quantitative methodologies with apparent policy applications, though a mixture of socio-ecological and political directions, pertaining to ecosystem services and the improvement of human well-being (Fisher et al., 2014).

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It may well be argued that sustainable development based on the efficient management of ecosystems acts as a guide for environmental policy and the decision-making process, but the omission of power relations, which regulate access and use of ecosystems, and therefore ecosystem services to a great extent, could have deleterious effects. As a result, it would be effective to properly investigate and analyze the various ways based on which power relations establish governance as well as the associated formal and informal institutions which manage and control the access to ecosystem services. In addition, it is vital to determine how labour relations in relation to ecosystem services co-production affect human well-being, whilst acknowledging the importance of the historical co-evolution of power relations and environmental change in the process of forming ecosystem services values. The IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) framework aspires to combine transdisciplinarity along with integrating power relations and dynamics in ecosystem services' assessments, intertemporally at a regional and global scale (Berbes-Blazquez et al., 2016). Power relations and dynamics form, but they are also formed by institutions (both formal and informal), thus, the integration of institutional assessment in the ecosystem assessment procedure contributes to the more efficient comprehension regarding the drivers of ecosystem services change and their respected effects on human well-being.

Taking into consideration the fact that human well-being is strongly associated with the well-functioning of ecosystems for providing ecosystem services, any alterations on the ecological functioning of the ecosystems could result in negative direct or indirect impacts on human welfare. Both the transgression of certain planetary boundaries along with the overexploitation of natural resources have intensified the strain on the natural environment, impairing both the structural components of biodiversity as well as the healthy functioning and consistent provision of ecosystem services. In this context, a conceptual framework would advocate toward incorporating the existing interactions among biodiversity, ecosystem functioning and human well-being into the decision-making procedure for the conservation of healthy ecosystems (Pinto et al., 2014).

Furthermore, in the context of an adequate and dynamic framework the utilization of research results can be an integral part during the process of outlining and implementing sustainable management activities, whilst transdisciplinary approaches would greatly aid in the successful interpretation of the existing interactions between ecosystems and the surrounding socio-

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economic activities. Nevertheless, the need for new approaches in relation to data collection (remote sensing data, decentralized data at multiple scales) is urgent in order to integrate changes in real-time and further involve citizens when necessary (Fioramonti, 2017b). These new techniques can accommodate the contemporary novel forms of communication, thus, improving public awareness and environmental policy regarding ecosystem services (Costanza et al., 2014a; Costanza et al., 2017). The link between data systems and evaluation methodologies with the formation of environmental policy and governance has become more apparent nowadays, taking into account the currently increasing need for improved measures and indices of economic development (e.g. Genuine Progress Indicator (GPI), World Bank's adjusted net savings, UN's Inclusive Wealth Index (IWI), OECD's Better Life Index), which encompass the crucial aspects of ecosystems and natural resources (Kubiszewski et al., 2013; Costanza et al., 2014; Costanza et al., 2017).

These relatively new approaches demonstrate the necessity for implementing better types of assessment regarding economic development which has proven very important in terms of sustainable development and the concept of ecosystem services. The traditional linear approach based primarily on Input-Output tables (I-O or IOTs) in relation to national accounts cannot fully assimilate the process based on which economic activities are embedded in society along with the natural environment (Costanza et al., 2016). The SDGs represent a good example of this specific need for a dynamic, non-linear system which integrates both natural and human systems in the process of achieving human welfare and well-being (Fioramonti, 2017a; Costanza et al., 2017). The integration of ecosystem services into mainstream economic policy together with more extensive citizen involvement and awareness is essential for the so-called "well-being economy" of the 21st century and its current global goals, as in the case of the SDGs.

After all, a crucial aspect within the context of the SDGs, as mentioned before, is the maximization of human well-being on the premise that the natural environment is preserved in order to properly support human existence for the future. The integration of ecosystem services into strategies for achieving the 17 SDGs can contribute toward this major objective. Comprehending the various ways based on which ecosystem services support multiple targets in the framework of the SDGs is essential for an adequately planned and cost-effective environmental policy based on synergies for better results (Wood et al., 2018). Ecosystem services as in the cases of the provision of food and water, the maintenance of habitat and biodiversity along with carbon

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storage and sequestration have been identified as key services based on Wood et al. (2018), as they tend to contribute to the fulfillment of targets regarding seven or more SDGs. In addition, certain modelling tools are already in existence potentially aiding decision-makers toward integrating ecosystem services approaches during the process of policy-planning, thus, optimizing their chances for improved efficiency. For these efforts, experts' perceptions of ecosystem service contribution to SDG targets and proper ecosystem services management on a local and national level are deemed critical.

Nevertheless, as far as the European Union (EU) is concerned, though ecosystem services are indirectly embedded in certain policies regarding environmental issues, such as the Biodiversity Strategy 2020 and the Invasive Alien Species Regulation, currently there is an absence of particular policy or agenda specified to governing ecosystem services. Based on Bouwma et al. (2018), after having reviewed twelve EU policies they reached the conclusion that there is moderate consistency among the existing policies and the ecosystem services concept. However, methods for improving and integrating ecosystem services in the implementation of currently active EU policies both on regional and national levels do exist, as is the development of specifically designated financing mechanisms, common monitoring methods for evaluating ecosystem services, as well as implementing certain tools for achieving cross-sectoral synergies and trade-offs among various ecosystem services (Bouwma et al., 2018).

Furthermore, on an EU basis the Blue Growth Agenda in the Maritime Affairs framework is associated with maritime economic activities supported by ecosystem services, specifically marine ecosystem services, and often abiotic outputs offered by marine natural capital. Several multi-sectoral economic activities such as coastal and cruise tourism, blue biotechnology, aquaculture and blue energy are provided and supported via the healthy functioning of marine ecosystem services. The use of specific indicators based on socio-economic factors, representing the demand for ecosystem services in connection to the various sectoral needs and interests, can assist in achieving sustainable use regarding natural resources and the associated ecosystem services (Lillebø et al., 2017). In any case, the existence of trade-offs between socio-economic and environmental aspects is evident, as the demand for ecosystem services is, for the most part, driven by social and economic factors. However, the unhindered provision of all these necessary ecosystem services requires certain legislative actions (protection) as well, in order to be sustainable and promote human well-being for forthcoming generations.

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Chapter 3: An Overview on the Economic Valuation of Ecosystem Services

3. An overview on the economic valuation of ecosystem services

3.1 The need for ecosystem services valuation

The economic valuation of nature in general, and ecosystem services in particular, can be traced back from environmental to ecological economics via a plethora of studies and vast literature, incorporating aspects of natural and social sciences through an economic point of view (de Groot et al., 2002; Turner et al., 2003; Liu et al., 2010; Seppelt et al., 2011; La Notte et al., 2012). The economic valuation process is useful and indeed necessary when biophysical parameters require “conversion” in monetary units through the application of various ecological models combined with the appropriate economic models. In this regard, environmental values represent specific values and uses of the natural environment, and thus they are crucial for the conservation and protection of these environmental assets, as they delineate their significance and public benefits they provide (Dietz et al., 2005). Ecosystem values denote the importance of ecosystem services, as well as their merit in monetary terms, for human beings based on estimations and appraisals regarding the amount individuals are willing to pay to conserve or enhance these services (Liekens et al., 2013). In this context, the economic valuation of the natural environment is typically conducted via market price information or eliciting consumer preferences through a wide range of non-market valuation methods (Varian and Hal, 1992).

Therefore, it is essential to first comprehend the meaning of valuation, as it is associated with actions related to specific objectives and conditions. This process of assigning values to specific objects or functions is characterized by user-oriented goals and purposes in order to eventually provide scientific measurement (Costanza, 2000; Farber, Costanza and Wilson, 2002). On certain occasions, the valuation of ecosystem services is considered by some as unnecessary or even improper on the basis that it relies on very anthropocentric notions (Heal, 2000; Limburg et al., 2002). In particular, despite the fact that human beings have partially altered ecosystem structures and may continue to do so, these ecosystems retain their functionality and will in all likelihood persevere in the future as well, in one way or another. Ecosystem services are invaluable as they are essential for human survival and cannot be delineated by societal values.

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Nevertheless, certain attempts have been made toward determining the existing interactions between the natural environment and human beings on the basis of specific parameters within ecological systems and ecosystem dynamics (Limburg et al., 2002).

Nevertheless, the need for ecosystem services and functions valuation can be identified on the basis of three concepts of value: the ecological, economic and socio-cultural value (Farber et al., 2002; Limburg et al., 2002; Howarth and Farber, 2002; Wilson and Howarth, 2002; de Groot et al., 2002). The ecological value is associated with the conservation of ecosystems' capacity to properly operate along with safeguarding the intactness of their integrity. Bearing in mind that the majority of ecosystem processes and functions are interlinked, the levels which ultimately determine their sustainable use should be assessed via the careful consideration of the underlying and complicated system conditions as well as the dynamic interactions among the functions, processes and associated values (de Groot et al., 2000; Limburg et al., 2002; Boumans et al., 2002).

There is a plethora of traditional and modern economic valuation methods attempting to delineate economic values often organized in certain categories based on their methodological approaches such as direct market valuation, indirect market valuation, contingent valuation, group valuation etc., which will be described further on the next Section (see chapter 3.2). Ecosystems, as an integral part of natural systems, are a vital source of non-material well-being, while socio-cultural reasons are frequently associated with identifying crucial environmental functions, physical and mental health, cultural diversity, education, cultural identity/heritage, spiritual values and freedom (Norton, 1987; English Nature, 1994). In this context, the socio-cultural value is primarily related to the *information functions* of ecosystems which provide opportunities for cognitive development (aesthetic information, recreation, cultural and artistic information, spiritual and historic information, science and education) (de Groot et al., 2002).

However, there are several reasons which could be described as more "tangible" in justifying the need for ecosystem service valuation. An essential part of the decision-making process for every government environmental agency on a global level is the need to decide on the best and more efficient ways of allocation regarding public investments for the protection/conservation of the natural environment. Thus, the justification for this kind of important decisions needs to be made in terms of fiscal accountability, ergo economic benefits in addition to environmental benefits.

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There are often cases where it is impractical or even unfeasible to assess benefits in monetary terms, but nevertheless the provision of information justifying the proper management of environmental investments can be sufficient. In that sense, estimates of ecosystem services' benefits are crucial as they contribute to the decision-making process on issues related to comparing the benefits among different projects/programs, prioritizing conservation and restoration programs as well as taking into consideration public values and promote citizen participation in supporting environmental initiatives. The maximization of the environmental benefits per monetary unit spent is vital in order to defend and ultimately vindicate decisions made by government agencies, and thus government spending considering the lack of adequate resources (King et al., 2000).

In addition, valuing ecosystem services for both current and future generations, is important in order to accurately delineate the correlation between environmental benefits and human well-being together with society's great dependency on natural resources. Hence, the natural environment is often delineated in terms of infinite value due to the apparent capacity of supporting human existence. Nevertheless, the valuation of marginal changes in ecosystem services may very well facilitate the policy-making procedure in determining when a policy intervention can irrevocably change ecosystem conditions, therefore, generating negative effects on human well-being. In an effort toward prioritizing funding and making decisions based on "value for money", the adoption of an ecosystem services assessment framework may contribute to creating market for services, given that valuation eventually provides the necessary information to support policy instruments of this type (Defra, 2007). Furthermore, through the valuation of ecosystem services a more realistic representation regarding environmental impacts is likely to occur, as it can properly illustrate the connection between ecological effects and changes in human welfare in a more systematic way.

It is often an arduous process to effectively integrate the various impacts occurring on ecosystems, as the value of these impacts may not be properly interpreted or even be disregarded during the decision-making process. However, the extensive use of market-based instruments for conservation, which is currently extensively taking place worldwide, has incorporated ecosystem services valuation into economic decision-making. In particular, among the most prominent instruments are the markets for ecosystem services as well as the payments for ecosystem

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services schemes (Bayon, 2004; Landell-Mills and Porras, 2002; Wunder, 2005; Pagiola and Platais, 2007; Engel et al., 2008; Pagiola, 2008; Lele et al., 2013). The ecosystem services concept has integrated a large number of ecosystem functions as services to be valued in monetary terms and subsequently be incorporated into markets or payment instruments, thus, facilitating governmental policy purposes as well as private and financial sectors (Bayon, 2004; EC, 2008; Lele et al., 2013).

On the other hand, this process of mainstreaming ecosystem services on a large scale has produced negative results regarding the original environmental purposes of raising public awareness on environmental conservation issues or threats. In this sense, the focus has often shifted toward strictly utilitarian objectives for utilizing various ecosystem services as commodities on potential markets or parts of market strategies, therefore, ultimately neglecting the environmental aspects whilst also contributing to environmental degradation (Rees, 1998; Martínez-Alier, 2002; Robertson, 2004; McCauley, 2006; Spash, 2008; Soma, 2006; Redford and Adams, 2009; Peterson et al., 2010; Kosoy and Corbera, 2010; Lele et al., 2013).

The need for ecosystem services valuation can be justified for both the utilitarian and intrinsic values derived from them. Without ecosystem services human life cannot be properly sustained, taking into consideration the limited substitutability of natural capital. During the 1980s, ecological economists argued on the basis of this specific limitation of substitutability and the widespread use of valuation methods which are preference-based. On the other side, environmental economists would commonly employ monetary valuation methods to non-market assets of the natural environment (Gomez-Baggethun et al., 2010; Neumayer, 2010; Ekins et al., 2003). These two opposing approaches are usually referred to as the “incommensurability debate” and is essentially the main argument between the weak and strong sustainability schools of thought (Aldred, 2006; Salles, 2011).

The valuation and quantification of ecosystem services is clearly linked to human well-being, as it is the ultimate goal, but taking into account the so-called “resource curse”, it is apparent that an abundance in natural resources does not guarantee success regarding this goal (Sachs and Warner, 2001; Brunnschweiler and Bulte, 2008). In this respect, the contribution of ecosystem services to human well-being relies on society’s ability to accurately value these services. The

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complicated relationship between ecosystems and human well-being has been thoroughly described in the case of Salles (2011) in three phases: (a) identifying the ecosystem functions, (b) outlining the benefits for society derived from the ecosystems, and (c) analyzing the economic value of these services based on available alternatives. However, several crucial parameters during the phases of observation and analysis do exist, such as technological availability, cultural preferences, and freedom of choice, directly affecting human well-being in association with ecosystem services.

When aspects of public goods are involved in the context of public policies based on efficiency maximization, the valuation of ecosystem services can provide valuable information, during the decision-making procedure, on technical issues regarding cost-effective, minimum-cost, and efficient conservation policies (Bingham et al., 1995; Ando et al., 1998; Polasky, Camm, Garber-Yonts, 2001; Heal et al., 2005; Wätzold and Schwerdtner, 2005; Murdoch et al., 2007; Underwood et al., 2008; Daily et al., 2009; TEEB, 2009). In virtue of the quantity and quality of studies associated with the valuation of ecosystem services, it would be prudent to denote the usefulness of several indicators of values provided by them for the economic assessment of various projects and programs. However the increased frequency of ecosystem services valuation, especially in monetary terms, may inadvertently contribute to a more extensive commercialization of the natural environment (Salles, 2011).

As mentioned earlier, ecosystem services build on a foundation of natural capital stocks vital for the planet's life-support system, contributing directly and indirectly to human welfare, thus, acquiring economic value. In the case of Costanza et al. (1997), the aggregate economic value for 17 ecosystem services representing 16 biomes, was approximately estimated between the range of US\$ 16–54 trillion annually, characterized by an average of US\$ 33 trillion per year. These values are associated with the entire biosphere, the majority of which exists outside markets, and at the time were characterized as a “minimum estimate”, taking into consideration that the gross national product in total globally was approximated at US\$ 18 trillion on an annual basis (Costanza et al., 1997).

In addition, de Groot et al. (2012) examined 320 publications and over 300 case study locations representing 10 major biomes regarding the monetary value of ecosystem services. Their results

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indicated a total value within the range of 490 int\$/year generated by an average hectare of open oceans to 350,000 int\$/year generated by an average hectare of coral reefs. Furthermore, these values are for the most part non-marketable, often deemed as non-tradeable “public benefits”. In this sense, the necessity for ecosystem services valuation is most evident by virtue of their importance and contribution to the total human welfare for both current and future generations at a global scale as well as for efficient sustainable ecosystem management and better decision-making (de Groot et al., 2012).

Taking into account the fact that many ecosystem services are irreplaceable, any potential effort to replace the existing ecosystem services would not actually increase welfare, but on the contrary may possibly affect the global price system. The value contribution of these services to the global economy is tremendous, hence, if it were incorporated in indicators such as the GDP (Gross Domestic Product) or GNP (Gross National Product) it would drastically alter their structure and magnitude. As already stated, ecosystem services are often non-marketable, and thus tend to be disregarded or underestimated when aspects of social costs are calculated for certain projects and initiatives. As a result, total benefits might be overvalued, therefore, undermining the decision-making process, leading to ill-suited policy recommendations. The value of natural capital and ecosystem services is inextricably linked to their abundance, ergo considering their current levels of consumption it would be logical to deduce that their value could increase exponentially in the foreseeable future (Costanza et al., 2014; Kubiszewski et al., 2017; Costanza, 2020).

Based on this evidence, the need for proper ecosystem service valuation is imperative in spite of any existing uncertainties surrounding their value. Bearing in mind that ecosystem services are irreplaceable, their thresholds are pre-determined and absolute, so any potential violation would ultimately lead to overwhelming increases in their value. In this context, the ecosystem services valuation process can provide crucial information and data, emphasizing on the contribution of ecosystem services to human welfare as well as the multiple potential negative impacts to come from any further deterioration (Costanza et al., 1997; 2014; 2020).

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3.2 Methods and techniques

3.2.1 The Total Economic Value (TEV) framework

Ecosystem services are associated with both market and non-market values. Market values refer to prices, the monetary units, consumers must pay to acquire goods and services available for purchase as commodities in their respective markets. On the other hand, non-market values cannot be traded directly in markets, as markets prices do not exist for them and are usually further subcategorized into use and non-use values. During the valuation process of ecosystem services both use values (based on actual or planned use) and non-use values are taken into account. The non-use values are, for the most part, comprised of the existence value, the bequest value, the altruistic value and on certain occasions the option value (Carson and Bergstrom, 2003).

These types of value are integral parts of the framework of Total Economic Value (TEV), which is extensively applied as means of valuation for natural resources worldwide and ecosystem services as well. The TEV assesses the gain in total regarding human well-being from certain applied policy measures by the net sum of the willingness to pay (WTP) or willingness to accept (WTA) respectively. At this point it is important to denote that WTP and WTA represent value in monetary terms with regard to receiving/forgoing environmental benefits (gains) or alternatively evading/accepting losses (DEFRA, 2007). In the case of ecosystem services the total value of marginal changes is very important for properly and adequately appraising them.

At this point, it would be useful to briefly describe the different types of use and non-use values for a more comprehensive depiction of the methods and techniques used during the valuation of ecosystem services. As mentioned above, the use value category includes direct-use, indirect-use and option value. Direct-use value refers to the actual or planned use of ecosystem service(s) by individuals. Among the most prominent examples are consumptive use or ecosystem extracted resources (i.e. food, water, timber etc.) as well as non-consumptive use, which is the case of services provided by ecosystems (e.g. regulating, cultural services). Amenities such as these can be traded on markets (e.g. food), but they can also be non-marketable (e.g. inspiration resulting from recreational ecosystem services). The indirect-use values are related to ecosystem services supporting human beings through vital functions, such as climate and water regulation, soil

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retention and provision, pollination, pollution filtering and waste decomposition. These services and several others equally important in sustaining human existence are often unnoticed by people until they are lost or impaired. Thus, the measurement of indirect-use values can be substantially more complicated in comparison with direct-use values, as changes occurring in their quality or quantity can be misunderstood or improperly measured (Braden and Kolstad, 1991; Freeman, 2003; Champ et al., 2003).

Within the context of use value, the option value refers to the value individuals give for the option to use resources, though they might not be currently using them, or maintain ecosystem services for the future. Respectively, future uses can be direct or indirect. Option value is related to ecosystems' components, which are often unknown, and serves as a form of insurance, as in the case of diverse species performing ecological "tasks" unbeknownst to them (blending of species in habitats that sustain ecosystem functions under ever changing conditions) (DEFRA, 2007).

As we mentioned earlier, non-use value, which is sometimes referred to as passive use as well, is derived from knowing that the natural environment is maintained, and thus it is consisted primarily of the existence value, the bequest value and the altruistic value. The existence value is associated with individuals' values arising from the knowledge that certain aspects of the natural environment (ecosystem resources) exist, even though they may never utilize them (e.g. preservation of different species of animals through donations by individuals though they might never see them up-close). In the case of the bequest value, people attach value based on the fact that ecosystem services will be conserved through preservation, and therefore "passed" on to future generations. For example, even if a person is indifferent about rainforests or their preservation, he/she might strongly desire to preserve it for his/her descendants (future generations) (Carson and Bergstrom, 2003; DEFRA, 2007).

The altruistic value is a type of non-use value people place on ecosystem services and their availability for others to enjoy/utilize in the current generation. A good example would be the case of national parks, as someone might attach value to them because they acknowledge the fact that they offer recreational pleasure to other people and for this reason they wish to preserve them. Hence, non-use value cannot be easily assessed as it is quite challenging for individuals to appraise this kind of values. Nevertheless, non-use values can often be equally if not more

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important compared to use-values, as was the case with the Natura 2000 sites in Scotland where 99% of the total value of this type of sites was characterized non-use value (Gibson et al., 2004; DEFRA, 2007).

Another lesser-known type of value is the quasi-option value, which is especially applicable in the case of ecosystems, as there is great uncertainty and most often circumstances can be irreversible, offering space for further scientific research (and progress) on ecosystem's processes and behaviour (OECD, 2006). The quasi-option value is related to the value of information which can be secured by postponing decisions associated with uncertain outcomes, benefits or costs, hence, more information can be potentially acquired on the grounds of reluctance in making a decision whilst subsequently committing natural resources (DEFRA, 2007; Traeger, 2014). Though the quasi-option value is not integrated in the TEV framework certain examples do exist, taking into account certain situations of land-system change. In particular, when forest land is converted for agricultural use, benefits such as crops with market values arise, but the foregone benefits from preserving that particular piece of land remain unknown. If this decision for land conversion was to be delayed, more information could be available regarding these foregone benefits (i.e. vital ecosystem services which exist unbeknownst to people, such as habitat protection for important/threatened species) (DEFRA, 2007).

3.2.2 Methods for appraising values

The most widely applied methods for assessing values regarding ecosystem services can be categorized in two basic types of approaches: the use-value and the non-use value. In the context of the economic valuation approaches the main goal refers to the elicitation of public preferences regarding changes in the state of ecosystem services estimated in monetary terms. The two most prominent methods of this type of economic valuation are the Revealed Preference (RP) and Stated Preference (SP) approaches. The RV method relies on information and data on people's preferences regarding marketable goods or services which integrate environmental/ecological attributes. In that sense, the RV method is based on the existence of actual markets, thus,

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including techniques such as market pricing, random utility modelling, travel cost, hedonic pricing and averting behaviour. In the case of market prices and averting behaviour these “pricing approaches” utilize observed market prices as direct measures of economic value for an ecosystem service (i.e. the actual market prices, damage costs avoided and averted expenditure) or as proxies for the specific value at hand (cost-based approaches) (Carson et al., 1996; Bockstael and McConnell, 2007; Boyle, 2003; Sousa, 2018).

The Stated Preference (SP) methodology is based on the use of specifically structured questionnaires for eliciting public preferences in relation to changes in ecosystem services. As a result, SP surveys are often applied in a wide thematic and research spectrum for evaluating non-use values with contingent valuation and choice modelling being their main approaches (Mitchell and Carson, 1989; Adamowicz et al., 1998; Bateman et al., 2002; Brouwer, 2006; Kanninen, 2007). In the context of the TEV framework the RP and SP approaches are both used to evaluate use value, while in the case of non-use value only the SP approach is applied, as better depicted in Figure 3-1.

As part of the TEV framework, the dose response/production function approach often appears and though it does not constitute a valuation technique, valuation is usually applied to quantified results via this approach, as in the case of assessing the link between air pollution and harmful health effects. The production function emphasizes the potential relationship between an ecosystem service and the production of marketed goods. This technique is usually applied for appraising indirect-use value, since ecosystem services are regarded as inputs in the production process, while their value is deduced based on changes within the production process of marketed goods resulting from ecological changes (Adams and Crocker, 1982; Raj, & Lal, 2012; Chiputwa et al., 2019).

As depicted in Figure 3-1, both use and non-use value methods of economic valuation are applied in benefits transfer. In particular, this process is used in order to estimate economic values (benefits/damages) of ecosystem services via transferring useful information acquired by means of published research and studies (study sites) regarding other locations or even context (policy site). In this sense, further surveys can be “avoided” in addition to the time/cost associated with them, based on results from other similar surveys conducted in other locations (King et al., 2000;

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DEFRA, 2007). In the context of the TEV framework, another type of classification can be made on in terms of price and cost. That is, some approaches use market prices as direct estimations of economic value regarding an ecosystem service, as in the case of market prices, damage costs avoided and averting expenditure, or as proxies for the value (cost-based approaches). The cost-based approaches are based on the costs associated with the provision of certain ecosystem services obtained from actual markets, such as replacement costs, opportunity cost and cost of alternatives. Nevertheless, techniques, such as those based exclusively on costs often do not accurately estimate utility, as they are considered “non-demand” curve methods and should be applied on specific occasions (DEFRA, 2007).

Within the non-economic evaluation sphere there are certain approaches characterized as deliberative and participatory. This type of approaches relies on the premise that opinions and preferences are formed and expressed in other units other than money. Within the context of deliberative and participatory approaches a mixture of economic or non-economic valuation techniques is often applied, focusing on qualitative aspects. Values are elicited via direct questions to individuals regarding their behaviour or views/opinions on certain issues pertaining to ecosystem services. The primary goal is to better comprehend people’s preferences as well as the whole decision-making process, which ultimately affects policy choices, as they usually depict societal values (Efteci, 2006; Stagl, 2007; Gasparatos and Scolobig, 2012).

The most frequently applied types of deliberative and participatory approaches are:

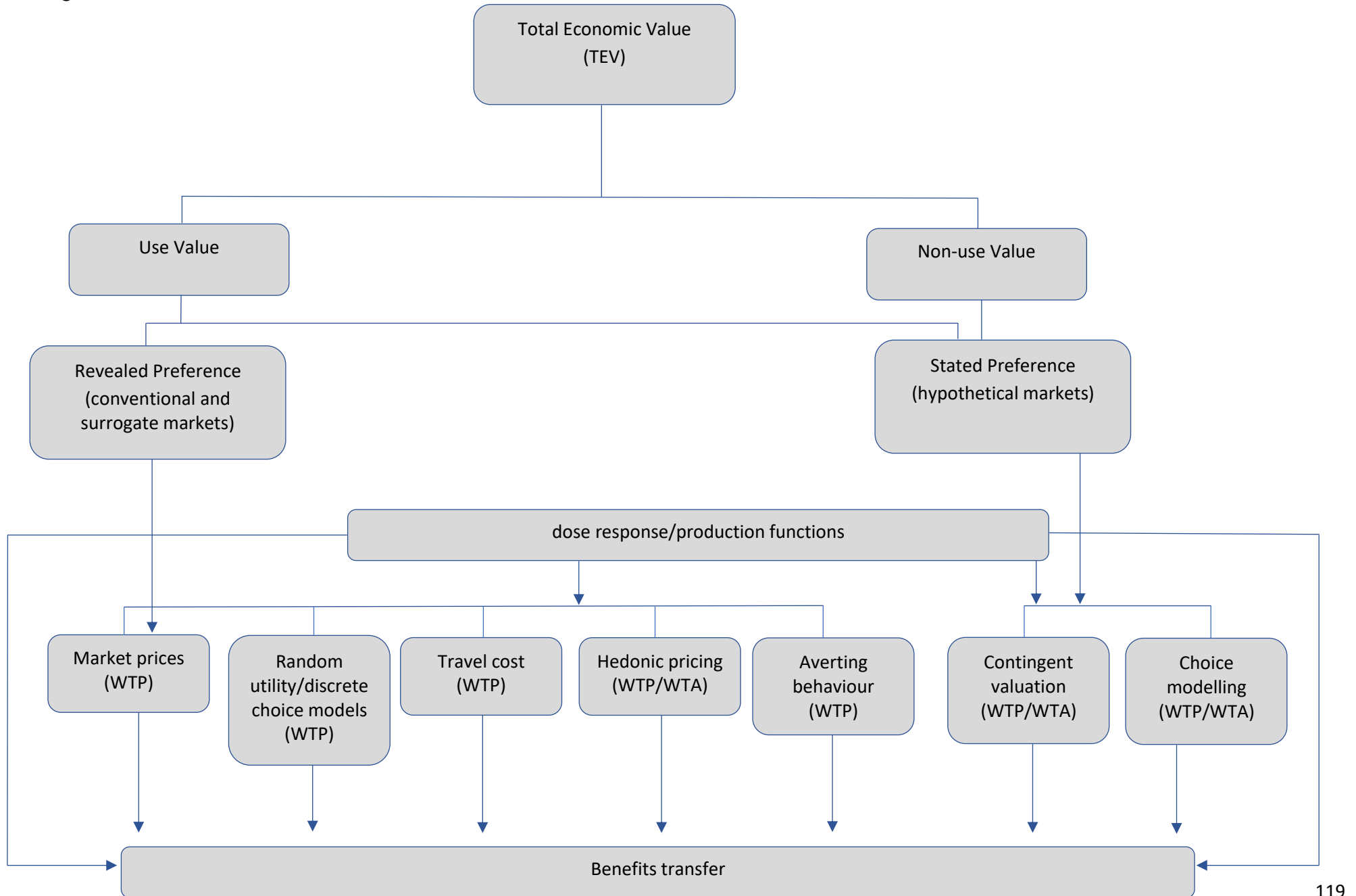
- (a) citizen’s juries where the participants are called to give informed opinions after proper deliberation and based on evidence provided by experts and/or stakeholders,
- (b) deliberative discussion focus groups either consisted of experts and stakeholders or the general public, in an effort of shaping a collective view after adequate consideration of the opinions of all parts included,
- (c) semi-structured surveys for qualitative purposes, conducted face-to-face or via telephone in order to investigate opinions/views on specific issues,
- (d) various types of health-based approaches, such as health year equivalents (HYE) and quality-adjusted life year (QALY) where value can be measured in terms of health-base impacts,

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(e) the Q methodology approach, often applied in social sciences, aiming at determining conventional ways based on which individuals form opinions on environmental issues (ecosystem services). The focus lies on patterns of behaviour/attitude and common social perceptions, whilst creating sets of views, which ultimately might not truly represent the opinion/views of a particular person (DEFRA, 2007; DEFRA, 2011; Chilvers, 2009).

Another course of action regarding ecosystem service valuation is the group valuation approach, involving group deliberation as well, and is primarily based on a socio-political background. In accordance with the group valuation principles decision-making is most efficient when performed via open public debate (Jacobs, 1997; Wilson and Howarth, 2002; Sagoff, 1998; de Groot et al., 2002).

Figure 3-1: Methods of economic valuation



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One of the most contemporary techniques applied for obtaining values during the ecosystem services valuation process is the meta-analysis. Through this method, estimates on values from pre-existing studies and generally legitimate research are further analyzed to reach more concrete and tangible conclusions. The overall procedure can be organized in four basic stages (Chung, Burns and Kim, 2006; Cheung and Vijayakumar, 2016; Seidler et al., 2019):

- Collection of all the available empirical information/data on the issue under examination via the use of search engines such as Scopus, Web of Science and Google Scholar,
- Conversion of the outcomes of the selected studies to a common metric for further comparison among studies, coding along with study characteristics, and insertion into databases,
- Gathering any additional study attributes together with areas of expertise regarding the selected values from external resources. In the case of non-market valuation, population density of the targeted area, income of the targeted population, land use of the targeted area and information on the quantity (supply) and quality of the ecosystem service(s) under examination are included,
- Analysis of the acquired data via the application of a variety of statistical and econometric techniques to further comprehend all the relevant sources of variation regarding the ecosystem service values.

Meta-analysis research is based on datasets from several countries regarding different time periods, therefore, improving the representativeness and generalization capacity when compared to a single study. In addition, since the Geographical Information Systems (GIS) are growing and becoming more widespread, more spatial-sensitive information is collected, resulting in the formation of more specific case datasets (Mimis, 2012; Koetse, Brouwer and van Beukering, 2015). On the other hand, meta-analysis studies demand a considerable amount of time while they are also highly dependent on data availability. In addition, during the meta-analysis features or attributes characterized as case study “specific” (explicitly applied for each study) are usually excluded, since the study characteristics and outcomes need to be comparable for the final model specification to be effective (Smith and Huang, 1993; Brouwer et al.,

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1999; Boyle et al., 1994; Bateman and Jones, 2003; Woodward and Wui, 2001; Brander et al., 2006; Johnston et al., 2006; Brander and Koetse, 2011; Quintas-Soriano et al., 2016; Reynaud and Lanza, 2017; Lara-Pulido et al., 2018).

Stated preference methods

As previously mentioned, the most prominent types of methods within the Stated Preference framework are the Contingent Valuation Method (CVM) and the Choice modelling or Choice Experiment (CE). These particular techniques have been applied within the context of our case studies, described in detail in one of the following chapter of this dissertation (see Chapter 7). In contrast to Revealed Preference (PR) techniques, these methods can potentially capture actual as well as possible future changes in ecosystem services, while at the same time assessing non-use values (Hanley et al., 1997; Koetse, Brouwer and van Beukering, 2015).

The CVM method can be applied to every type of ecosystem service and is predicated upon conditionality, as denoted by the characterization “contingent”. In that sense, hypothetical scenarios are being made in relation to issues regarding ecosystem services. The most common course of action relates to directly asking individuals about their maximum WTP or alternatively minimum WTA for positive and negative environmental/ecological changes respectively with regard to ecosystem services. This method is based on the premise that a hypothetical market is formed, which is reasonably accurate compared to actual markets, for the use and/or preservation of ecosystem services. This procedure is carefully described to the respondents (participants) of the survey via a series of questions related to potential changes in the quality and quantity of the good/service under examination. Hence, the responses are further analyzed and aggregated to obtain certain values and statistics (Boxall et al., 1996; Bateman and Willis, 2001; Grafton et al., 2008; Latinopoulos, 2015).

The most fundamental stages toward this effort are the following:

- Identification of the ecosystem service(s) to be valued as well as the targeted population,
- Designing the survey, including the type of survey (via e-mail, telephone, postal mailing, web-based), payment vehicle, question format, WTP/WTA questions, and conducting the pilot-survey,

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- Implementation of the survey, including the selection of the survey sample (usually random) from the targeted population,
- Analysis of the results via the application of various techniques (statistical, econometric etc.), including survey data quality, data cleaning, handling non-responses.

In addition, certain practical guidelines exist, aiming at optimizing the efficiency of a CV survey, and thus they are briefly outlined as follows (Arrow et al., 1993):

- Sample type and size: guidance from a professional sampling statistician is frequently required to choose the proper sample specific design and size. In the case of damage assessment probability sampling is necessary.
- Minimization of non-responses: a high non-response rate negatively affects the results as they become unreliable.
- Personal Interview: face-to-face interviews significantly contribute toward eliciting more reliable answers, especially when compared to mail surveys, though telephone interviews may offer centralized supervision at lower cost.
- Conducting pretests for potential interviewer effects: it is crucial to conduct experiments aiming at assessing interviewer effects in order to maximize the credibility of a CV survey, as interviewers may contribute (inadvertently or not) to social desirability bias, based on the fact that the preservation of the environment is generally regarded favourable.
- Extensive reporting: thorough and comprehensive provision of information on the population sampled, the sampling frame incorporated, the size of the sample, the total non-response rate of the sample along with its components (e.g. refusals), and lastly the item non-response with regard to every question of importance. In this sense, it is critical to replicate the questionnaire used or any other form of communication based on the exact wording and sequence applied, while all data collected within the context of the CV study must be archived and available to interested parties.

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- Meticulous pretests for the applied CV questionnaire: conducting proper pilot tests in order to validate the efficiency of the questionnaire on the basis of the derived evidence. For this reason, it is necessary to demonstrate that respondents have understood and accepted the main description and questioning well enough.

As far as the structure of CVM surveys is concerned, they may be conducted via face-to-face interviews, web-based surveys, mailed questionnaires and group gathering, while the use of telephone is becoming less preferable (Ellis and Krosnick, 1999; Alreck and Settle, 2004; Duffy et al., 2005; Chang and Krosnick, 2009; Blasius and Brandt, 2010; Lindhjem and Navrud, 2011). Regarding the question formats for eliciting respondents' opinions/views and their associated WTP/WTa, the most frequently applied formats are the dichotomous choice, the closed-ended choice card, and the open-ended choice card. In the case of the dichotomous choice respondents are asked whether they are willing or not to pay (or accept for WTa) a certain "bid amount", while in the "double bounded" dichotomous choice design respondents are given a secondary bid amount and asked once more whether they are willing to pay/accept, in order to determine the range for the WTP/WTa (Brown, 2003; Koetse, Brouwer and van Beukering, 2015).

In the closed-ended choice card several bids are presented to the respondents who are subsequently asked to choose the best bid based on their opinion which closely represents their maximum WTP or their minimum WTa, respectively. By contrast, in the open-ended choice card no bids are given to the respondents, but they are asked nonetheless to state the amount they are willing to pay or accept. A potential disadvantage of the CVM method is the fact that all the responses are on the basis of hypotheses, and thus might not represent actual behaviour. In addition, failure to accurately describe the hypothetical scenario on behalf of the interviewer can result in biased responses. Furthermore, potential biases during the phases of the survey design, choosing the payment instrument as well as the bid amount starting point, may also downgrade the results of a survey. Nevertheless, as mentioned above, CV surveys can be applied for an almost unlimited number of cases with respect to ecosystem services, appraising both use and non-use values (Mitchell and Carson, 1989; Mogas et al., 2006; Brander and Koetse, 2011).

The second most notable approach from the SP methodology is the Choice experiment (CE) method or choice modelling. This approach is similar to the CVM, as it can be applied for the estimation of a copious

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number of ecosystem services and is also based on hypothetical scenarios and the subsequent choices on behalf of the participants/respondents. The focal point of the CE method is the notion that any good or service(s) associated with ecosystems can be described in terms of their attributes and characteristics. In this context, any potential change occurring and altering these attribute levels can basically result in a different outcome (good/service), characterized by different values regarding their attributes. The values are deduced from the hypothetical choices and trade-offs participants make among the various combinations of attributes presented to them. In particular, during a CE survey participants are asked to choose among a set of alternatives, associated with values and in accordance with the selected payment vehicle, which represents the price for the ecosystem good/service at hand as a part of the choice characteristics (Hanley et al., 1998; Adamowicz et al., 1998; Mogas et al., 2009; Koetse, Brouwer and van Beukering, 2015).

Within the framework of the CE method, participants are asked repeatedly to choose among complicated, multi-attribute options (choice cards), as they are usually presented with a series of choices each one consisting of two or more choice options. Subsequently, the choice options are described through the use of the same set of attributes that outlines the most important parameters of these options including the status quo option as one of them. As a result, the respondent evaluates each choice and its associated choice options and selects the most preferred one according to him/her. A major advantage for the CE method is the trade-offs taking place among the alternatives with different features, thus, making it a suitable approach for policymaking where there are various sets of potential actions with different impacts on ecosystem services. The basic steps while conducting a CE are the following (Hensher et al., 1998; Louviere et al., 2000):

- (i) Similarly to the CVM, the first step is the identification of the ecosystem service(s) to be valued and the targeted population,
- (ii) Designing the survey, including selecting the type of survey (via e-mail, telephone, postal mailing, web-based), choosing the choice attributes and their associated attribute levels, selection of the payment vehicle, and launching a pilot survey in order to test the relevant levels of the selected choice attributes,
- (iii) Implementation of the survey, including the selection of the survey sample (most frequently random) from the targeted population,

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- (iv) Analysis of the survey results with the use of specific statistical analysis choice models in order to infer the WTP values from the trade-offs which were made by the participants.

In the context of the CE method, economic values are inferred on the basis of the trade-offs occurring between the monetary and non-monetary attributes. In that way, and due to the evaluation of the multi-attribute profiles as part of the choice cards, a large amount of information is eventually collected. Furthermore, the WTP values and information collected are less likely to be biased as a result of “strategic response” behaviour. CE models can be effective as policy tools as well aiming at further investigating hypothetical or proposed scenarios/options during the decision-making process. This “advantage” can be attributed to the fact that CEs are not primarily or exclusively predicated on pre-existing market conditions, but on a preferably realistic range of values (da Costa and Hernandez, 2009; Koetse et al., 2015). In the case of the CE, participants are able to evaluate non-market benefits eloquently presented to them without the necessity to directly assign monetary values to non-material benefits associated with ecosystem services. However, the choices made are hypothetical, and thus they might not represent true preferences or they may be biased. In that sense, it is vital to thoroughly design, check and pre-test CE questionnaires to prevent problematic situations such as these. In addition, CE surveys can often be extensive requiring substantial data collection and analysis which can ultimately prove to be rather costly (Chaikaew et al., 2017; Khan et al., 2019).

3.2.3 Selecting a valuation method

Every valuation method is characterized by advantages and disadvantages, whereas it can be applied for the valuation of more than one ecosystem service and function. Nevertheless, it has been well documented that within the context of the evaluation process of a specific function/service the choice of method is based on the general type of function/service that is being evaluated and the benefits (direct or indirect) provided to certain individuals as well as if the economic value is associated with the use or non-use values of the ecosystem under consideration (Wilson and Howarth, 2002; Farber et al., 2002; Costanza et al., 1997). In particular, regulating services are for the most part valued via the use of indirect

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market valuation techniques, such as replacement cost and avoided cost, while in the case of habitat services the direct market valuation method is preferred. Provisioning services are usually appraised via the use of direct market valuation, but also factor income methods on the basis of their impact on yields and income provided from marketed products (Dixon et al., 1994; Shelley et al., 2014). The cultural or “information” services can be evaluated via the use of a variation of techniques, taking into account that services, such as cultural and spiritual information are often assessed through the CVM, recreational activities and tourism via market pricing and travel cost and aesthetic information through hedonic pricing (de Groot et al., 2002). The supporting services are mainly valued through direct market methods, but there can also be variations based on certain specific characteristics for each case.

As shown in Table 3-1, ecosystem services are grouped and categorized on the basis of their relevant attributes as well as the most applied methods of valuation for each case, taking into consideration certain crucial aspects. Notably, the type of ecosystem service under examination, the type of the economic value to be appraised (i.e. non-use values are estimated exclusively by SP methods), the main objective of the valuation process (e.g. there can be based on the TEV framework or on estimating marginal values), the data/information availability, and the degree of accuracy for the final results (i.e. in pre-assessment cost-benefit analysis the level of uncertainty can be intensified compared to studies which aspire to establish the appropriate user’s fee for an ecosystem service in accordance with the estimated levels of cost recovery (Koetse et al., 2015).

Table 3-1: Selection of valuation methods for estimating different ecosystem services

Method of valuation	Type of value	Ecosystems service(s) valued	Benefits	Limitations
Market prices	Direct and indirect use	The ones that contribute to marketed products. Examples: timber, fish, genetic information etc.	Availability and robustness of market data	Only for those ecosystem services with markets

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Cost-based approaches	Direct and indirect use	Determined by the existence of the appropriate markets for the ecosystem service(s) under consideration. Examples: expenses on water filtration as proxy for value of water pollution damages, man-made defenses used as proxy for wetlands storm protection.	Availability and robustness of market data	Actual value can potentially be overestimated
Production function method	Indirect use	Ecosystem services serving as input to market products. Examples: effects of air/water quality on agricultural production and forestry output	Availability and robustness of market data	Data-intensive, lack of data regarding changes in services and impact on production
Travel cost	Direct and indirect use	Ecosystems services contributing to recreational activities	Based on observed behaviour	Usually limited to recreational benefits. Difficulties with trips to multiple destinations
Hedonic pricing	Direct and indirect use	Ecosystem services contributing to air quality, visual amenities, landscape.	Based on market data. Relative robustness.	Highly data-intensive, limited for the most part to services related to property.

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Random utility method	Direct and indirect use	Ecosystems services contributing to recreational activities	Based on observed behaviour	Only for use - values
Contingent valuation	Use and non-use	All ecosystem services	Ability to assess both use and non-use values	Resource-intensive method, biases in responses, disadvantages of hypothetical market(s)
Choice modelling	Use and non-use	All ecosystem services	Ability to assess both use and non-use values	Resource-intensive method, biases in responses, disadvantages of hypothetical market(s)

Source: Adapted from DEFRA, 2007.

It may well be argued that every valuation method is characterized by both advantages and disadvantages, hence, during the process of choosing the most appropriate method experience and good judgment on the part of the analyst are both equally essential. On some occasions, more than one valuation technique is utilized, and subsequently their results are compared (Ready et al., 1997; Carson et al., 1996; Hanley et al., 1998; Adamowicz et al., 1998; Stevens et al., 2000; Alberini et al., 2007; Mogas et al., 2009; Koetse, Brouwer and van Beukering, 2015). In addition, certain trends exist since the travel cost method is generally used for valuing recreational areas, while hedonic pricing for the valuation of specific features with environmental quality regarding specific locations. The CVM is most useful for public goods, mainly due to the fact that the respondent (participant) is usually presented with different scenarios for valuation, while the travel cost and hedonic pricing methods are most effective for the valuation of private goods/services (Wilson and Carpenter, 1999; Carson et al., 2003; Mimis et al., 2013; Latinopoulos, 2020).

Regarding the Revealed and Stated Preference methods it is vital to make a distinction between willingness to pay (WTP) and willingness to accept (WTA). As already mentioned, the willingness to pay refers to the maximum amount of money a person is willing to give for the proposed improvements in

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environmental quality and is, therefore, liable to income restrictions. On the other hand, the willingness to accept has no income limitations, taking into consideration the fact it indicates the minimum amount of money an individual would accept for lowering the environmental quality in each case (Field, 2002; Carson et al., 2003). Nevertheless, each of these methods can prove to be inadequate when presented with “practical difficulties”, as most of the people do not fully comprehend or acknowledge several of the services they are ultimately asked to place economic values on. In addition, the underlying market along with various ecosystem conditions can profoundly affect the value of ecosystem services, therefore, altering estimates of value when these conditions change. In that sense, the scale of an effective and operational study in ecosystem services valuation should be determined on the basis of meticulous policymaking. Any assessment regarding value should be placed in context, as ecosystem conditions and human behaviour may vary from case to case. Furthermore, it has been shown that through the extensive collaboration between economists and ecologists, and thus interdisciplinarity “in practice”, the valuation process can prove to be more effective as well as a fundamental part of a genuinely comprehensive environmental analysis (NRC, 2005).

3.3 The current and future challenges of ecosystem services valuation

Over the years the process of valuing ecosystem services has evolved integrating modern techniques, such as utilizing advanced software programs and satellite functions to cover vast land areas which are subsequently logged and analyzed. The use of GIS along with innovative approaches such as measuring the economic value of an ecosystem via the use of light emitting energy or certain models as in the case of the Global Unified Metamodel of the Biosphere (GUMBO), for modeling the dynamics of an ecosystem and the value of their services, indicate the strong connection between social welfare and ecosystem services. In other terms, the interlinked connection between socio-economic and ecological changes, incorporating aspects from every form of capital (human, natural, built) together with the existing interactions with the natural environment (Konarska, 2002; Sutton and Costanza, 2002; Boumans et al, 2002; Carson et al., 2003).

Taking into consideration the plethora of documented losses and degradation regarding global ecosystem services, contemporary environmental management should be flexible, based on multidisciplinary whilst

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including multiple perspectives. In that context, it is crucial to further disaggregate ecosystem service values and priorities on the basis of factors such as wealth, age and education in order to gain a broader perspective regarding the state of awareness, opinions and needs of different stakeholder groups. The need for effective investigation on how each socio-economic group prioritizes and values ecosystem services is imperative in terms of successful ecosystem services management as well as environmental and social justice (Adams, 2016; Lau et al., 2018).

Ecosystem services are often associated with non-material benefits or corresponding market values. Nevertheless, in the course of an appropriate and effective valuation process all forms of value emerging from interactions with the natural environment should be included along with non-financial motivations or commitments on behalf of the beneficiaries regarding ecosystem services. In this context, certain patterns have been observed in relation to ecosystem services frameworks for incorporating these elements. The various ways, based on which ecosystem services are provided to each beneficiary, are determined by both social and environmental drivers of change within very complicated and dynamic socio-ecological systems. The application of appropriate landscape-ecosystem models integrated within GIS systems can significantly contribute to achieving the effective valuation of ecosystem services (Mulder et al., 2015; Balvanera et al., 2015; Durance et al., 2016). Nowadays, more than ever, the need for joint collaboration in systematically assembling and aligning social and environmental databases is crucial, especially in relation to ecosystem services with non-material benefits. The creation and maintenance of this type of data observatories has been described as of paramount importance and would greatly facilitate any decision-making process in the long run (Small et al., 2017).

The ecosystem services concept has been criticized for predominantly relating to anthropocentric notions regarding environmental conservation. However, beyond purely utilitarian factors and elements, human welfare is consisted of intrinsic values as well (Jax et al., 2013; Schröter et al., 2014; Schröter and van Oudenhoven, 2016). In this sense, a contemporary ecosystem services concept should creatively combine both utilitarian as well as non-material benefits provided via ecosystems to humanity in order to properly direct all relevant policy measures for environmental, in general, and specifically ecosystem services conservation. Toward this effort, several frameworks and approaches have appeared during the last few years. Within the framework of MAES (Mapping and Assessment of Ecosystems and their Services), an innovative ecosystem assessment approach is proposed on the basis of an extensive set of important

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policy questions, collaboration between stakeholders and experts on different scales and governance levels, and existing data to effectively assess the current state of several ecosystem services. This endeavour has resulted in the production of various indicators, which can be applied along with the proper typology (e.g. CICES) to adequately map ecosystem services and ecosystem condition, as already partially attempted in the case of various EU policies (marine, water, agricultural, forest). Nevertheless, significant efforts remain to be made in order to cover the existing data gaps for this approach to ultimately become completely integrative, applicable and successful (Maes et al., 2016).

Another innovative approach currently gaining momentum is based on natural capital accounting, aiming at estimating changes regarding the stock of natural capital (i.e. air, water, soil, living organisms) and subsequently integrating the value of ecosystem services into accounting systems. At the EU level, the currently applied international accounting framework is the System of Environmental Economic Accounting-Experimental Ecosystem Accounting (SEEA EEA), proposing a specific methodological framework. In this context, ecosystem services accounts operate as a practical tool in providing data and information on the role of ecosystems regarding the provision of essential services for the benefit of society (Mäler et al., 2008; Vallecillo et al., 2019). However, in an effort for this tool to be successful the necessary workflow involves the integration of different biophysical and socio-economic models, thus, progressing from biophysical to economic evaluation and eventually formation of the relevant accounting tables. For this purpose, ecosystem service potential, demand and actual flow are crucial concepts in terms of appropriately assessing any ecosystem services utilized.

Ecosystems have been associated with a total value of approximately €50 billion, taking into account the nature-based recreation accounts for the year 2012 denoting *“40 million potential visits to high-quality areas for daily recreation”* (Vallecillo et al., 2019). As a result, a proper representation of all the different components with regard to ecosystem services along with identifying all the drivers of change in reference to the actual service flow derived from these ecosystems, the socio-economic systems and their spatial relationship is fundamental in accurately appraising natural capital, in general, and especially ecosystem services. In that sense, it is also imperative to properly determine ecosystem services generation and delivery in biophysical terms as part of the economic valuation procedure in an attempt to appropriately set the ecological foundation for the decision-making process (TEEB, 2010; Gomez-Baggethun et al., 2014; Pandeya et al., 2016). Therefore, the accurate distinction among ecosystem functions, services and

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benefits is crucial in terms of effective economic valuation. Furthermore, the use of the so-called “scenario analysis” on the basis of alternative plausible scenarios, which acknowledge and integrate the total value along with the total cost of human intervention, can prove to be helpful during the cross-examination and elimination of invalid information.

For the economic valuation process to be successful, certain aspects ought to be thoroughly considered. Namely, the overall contribution of ecosystem services to human well-being, the incentives of policymakers and stakeholders regarding ecosystem management and conservation, the repercussions of facilitating alternative agendas/courses of action as well as the specific requirements and necessities existing on a local level. In the interest of efficiency, in terms of environmental policy within the framework of any modelling scale, it is crucial to recognize that economic values are, for the most part, context-sensitive, subjective, anthropocentric and time relevant. As a result, the utilization of novel approaches such as participatory monitoring of ecosystem services, particularly at a local scale or in cases of data scarcity, can greatly contribute to assimilating local knowledge/information and preferences for a more policy-oriented valuation process (Buytaert et al., 2014; Pandeya et al., 2016).

Over the last few years Ecosystem Services economic Valuation (ESV) has often been promoted as a decisive tool toward the adequate and efficient economic valuation of ecosystem services, taking into account the fact that it incorporates aspects from the perspective of both costs and benefits in relation to ecosystem services degradation. ESV, as a method, embodies a more utilitarian view regarding the environment, presumably responding on the needs of decision-makers for better and more efficient conservation of ecosystem services. On that premise, both positive economic effects generated from the proper management of ecosystem services together with the negative effects resulting from their degradation are explored. ESV is mainly oriented toward the provision of information for awareness raising purposes or general influence, utilized by decision-makers within the context of proper economic valuation. Nevertheless, it has been criticized as it is often associated with ambiguous content, not being contextualized or expressed clearly and without adequate exemplification. As a result, further research is recommended for ESV’s merits as well as for other emerging, and thus not yet proven approaches, for their value to be inarguably determined and, therefore, integrate them in the economic valuation of ecosystem services and subsequently the decision-making process (Laurans et al., 2013).

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Part II: Operational criteria

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4. Marine and coastal ecosystem services

4.1 Crucial parameters pertaining to marine/coastal ecosystem services

Marine and coastal environments extend from coasts to the open ocean, initiating from up to 100 km inland extending to the continental shelf, covering open ocean systems characterized by waters of up to 6.000m depth (Small and Nicholls, 2003). In the context of these marine environments, several types of distinctions exist such as the coastal and estuarine wetlands, most prominent of which are mangroves, marshes, dunes, sand beaches, seagrass beds and oyster as well as coral reefs. Marine and coastal environments are linked to human well-being, being among the most exploited ecosystems worldwide. In particular, on a local level they provide communities with food, as is the case of small-scale artisanal fisheries, whilst their regulating services generate benefits to mankind at a global scale (e.g. coastal erosion protection, climate regulation etc.). Coastal zones represent approximately 4% of the planet's aggregate land area and 11% of the oceans worldwide. In addition, they accommodate more than a third of the global population, accounting for 90% of the catch associated with marine fisheries (Holmlund and Hammer 1999; Worm et al., 2006; Barbier, 2017; Drakou et al., 2017a).

Nevertheless, due to the constant intensification of human intervention through various socio-economic activities on a daily basis, marine and coastal ecosystems have been and continue to be severely deteriorated, therefore, generating adverse effects on their healthy functioning and subsequently regarding the associated benefits they provide. Excessive coastal development, fishing and aquaculture, population growth, oil extraction, marine transport, coastal land use and tourism, urban infrastructure, ocean acidification, pollution from land-based sources, declining water quality resulting from the increasing occurrence of harmful algal blooms (HAB), oxygen depletion (hypoxia) and sea level rise are among the most important "stressors" to marine and coastal ecosystems. These unfavourable drivers are known to heavily contribute to polluting and altering the structural integrity of marine and coastal ecosystems, ultimately diminishing human well-being, taking into account the fact that 50% of salt marshes, 30% of coral reefs, 35% of mangroves and 29% of seagrasses have already been either lost or degraded on a global level during the last decades (Costanza, 2008; van Beukering et al., 2007; Allsopp et

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al., 2009; Butchart et al., 2010; Beharry-Borg and Scarpa, 2010; Secretariat of the Convention on Biological Diversity, 2010; Cinner et al., 2012; Barbier, 2017; Drakou et al., 2017a).

The significance of marine and coastal ecosystems to human existence and well-being as well as the deleterious anthropogenic impacts to marine and coastal ecosystems have been observed since Ancient Greece (Daily, 1998; Morton, 2001; Papanastasis et al., 2010) and onwards (Wilkinson and Buddemeier, 1994; Souter and Linden, 2000; Spalding et al., 2001; Wilkinson, 2008; Jackson, 2008). It is worth mentioning that according to Spalding et al. (2001) approximately 25% of the planet's fish species reside within coral reefs, though almost 89% of the planet's oyster reefs have been destroyed by human intervention (Barbier, 2017). Critical habitats such as these (coastal/marine ecosystems) are highly interconnected from land to ocean being associated with significant economic benefits for mankind. For this reason and based on the current trends regarding the rapid degradation of marine and coastal ecosystems, it may well be argued that the foregone economic benefits and values associated with these ecosystems can be immense.

4.1.1 Marine/coastal ecosystems and human well-being

The overexploitation of marine and coastal resources along with the subsequent degradation of their associated ecosystems, an apparent attribute of the Anthropocene era (Ellis, 2015), has significantly diminished human welfare, and thus human well-being (Jameson et al., 1995; Moberg and Folke, 1999; Corbett and Koehler, 2003; Wilkinson, 2004; MEA, 2005; van Beukering et al., 2007; Butchart et al., 2010; Fabinyi et al., 2014; He, 2015; Osterblom et al., 2015). The recreational value provided by oceans and coastal areas, both on a local level as well as globally on account of tourism, is substantial, while according to Cesar et al. (2003) the total revenue from reef-based tourism and recreation market at a global scale is estimated at approximately US\$9.6 billion on an annual basis (Rees et al., 2010; Willemen et al., 2015). In addition, failure to properly or/and in due time acknowledge the benefits provided by marine and coastal ecosystem services has strongly contributed to accelerating the degradation of marine and coastal ecosystems (Daily, 1997; Costanza et al., 1997; Secretariat of the Convention on Biological Diversity, 2000; MA, 2005; Sachs et al., 2009; TEEB, 2010).

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Marine and coastal ecosystems sustain human populations on the basis of the various ecosystem services they provide on a global level, such as food provision, protection from natural disasters, cultural heritage, climate regulation and several others, all of them serving in the best interest of human beings (Adger et al., 2005; Martinez et al., 2007; Pendleton et al., 2012; Fletcher et al., 2014). Furthermore, multiple cultural and non-material benefits are also associated with the Cultural Ecosystem Services (CES) provided within the context of marine and coastal environments and are closely related to recreational and aesthetic experiences, spiritual enrichment, cultural identity and heritage, art and religion (Costanza et al., 1997; MEA, 2005; Chan et al., 2012). There is an abundance of studies exploring the connection between marine and coastal ecosystems and their immense influence on cultural practices (Creason, 2004; Patterson et al., 2008; CAFF, 2013), thus, validating the notion that environmental degradation induces irreversible and generally negative cultural changes, as was the case of north Atlantic regarding the collapse of the herring fisheries and cod stocks (Hamilton and Haedrich, 1999; Chapin et al., 2000; Turner et al., 2003; Hamilton et al., 2004; Gowdy et al., 2010; Gee and Burkhard, 2010).

Marine and coastal CESs along with their elements often tend to be neglected in the context of ecosystem services assessments frameworks, as they are usually deemed highly subjective and they are, therefore, often inadequately evaluated or incorrectly assessed during the decision-making process. In this sense, they frequently tend to be omitted, undervalued or misrepresented resulting in detrimental effects in terms of efficient environmental management and conservation regarding marine and coastal ecosystem services (Brady, 1998; Fisher et al., 2009; TEEB, 2009; Chan et al., 2012; Fletcher et al., 2014). Furthermore, based on the results of Garcia Rodrigues et al. (2017) and their systematic review of 72 peer-reviewed publications, scientific research regarding marine and coastal CESs is insufficient when compared to other ecosystem service categories. In particular, certain deficiencies exist with regard to identifying the importance of open ocean and deep-sea areas in providing CESs as well as appreciating the significance of non-natural capital in the co-production of marine and coastal CESs. There is also an urgent need of additional integrated valuation assessments, taking into account their currently insufficient number, regarding CECs and their contribution to human well-being (Garcia Rodrigues et al., 2017).

At present, there is sufficient evidence that culture and marine/coastal ecosystem services are linked, and thus it would be practical to appropriately recognize their contribution to human well-being and integrate them in economic assessments relating to environmental issues. Consequently, certain trade-offs often take place during the environmental policy making, and that is why it is crucial to properly understand

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and not underestimate the cultural values associated with CESs and marine/coastal ecosystems in order to prevent potential significant losses regarding human welfare (Beaumont et al., 2007; Chan and Ruckelshaus, 2010; Liu et al., 2010; Chan et al., 2012; Laband, 2013). Moreover, marine and coastal CESs can contribute to providing necessary information and knowledge for promoting and further supporting marine and coastal sustainability, capitalizing upon the significance of local knowledge and experiences (Fletcher et al., 2014).

4.1.2 Strategies and interventions associated with marine/coastal ecosystems

The proper acknowledgement of the value and importance of marine and coastal ecosystem services, whilst integrating them in the decision-making process has been deemed essential toward achieving efficiency in terms of cost efficiency regarding sustainable conservation policies (TEEB, 2011a, b; Waite et al., 2014). There has been a plethora of studies exploring and demonstrating the variety of socio-economic benefits for human beings derived from the healthy functioning of marine and coastal ecosystems and the necessity for implementing marine/coastal conservation programs, aiming at the maximization of the aforementioned societal benefits (van Beukering et al., 2007; TEEB, 2010; TEEB, 2011a,b; Schuhmann, 2012; Waite et al., 2014; Schumann and Mahon, 2014; Christie et al., 2015). In addition, several international agreements and policy instruments have been signed and enacted, both on a local and global level, to protect and sustain marine and coastal ecosystems, thus, acknowledging their importance for human well-being. Among the most prominent are the Convention on the High Seas, the United Nations Convention on the Law of the Sea (UNCLOS), the EU Marine Strategy Framework Directive (MSFD) as well as Directive 2014/89/EU, which established a framework for Maritime Spatial Planning.

Hence, achieving ecological sustainability along with economic viability with regard to marine and coastal ecosystems has been deemed essential, requiring the implementation of science-based environmental policies. In this context, spatial information can prove to be very helpful in providing crucial data during the design of realistic ocean policies, whilst generating useful policy instruments such as maritime spatial planning (MSP) and the marine protected areas (MPAs) for the optimal distribution of marine resources both on a local and national scale (Young et al., 2007; Chaigneau and Brown, 2016). Effective marine

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spatial planning depends on acknowledging the benefits provided by marine ecosystem services, aiming at managing the negative impacts of human socio-economic activities via the application of certain boundaries, while at the same time defining areas of sustainable human intervention. In the current era, it is imperative to integrate instruments such as these (MSP, MPAs) into ecosystem services assessments approaches, as the existing interactions between humans and marine/coastal ecosystems occur across temporal and spatial scales (Drakou et al., 2017b).

In this sense, it is vital to properly identify the associated beneficiaries of marine and coastal ecosystem services as well as those responsible for any social drivers of ecosystem change. In the case of MES, the benefits and costs generated by the services or “disservices” (negative impacts) of marine and coastal ecosystems do not always occur within the context of the same ecosystem, resulting in problematic situations which in turn require thorough research and further investigation (Richards and Stokes, 2004; Conchedda et al., 2011; Katsanevakis et al., 2011; White et al., 2012; Pendleton et al., 2012; Pacific Possible - The World Bank, 2016; Drakou et al., 2017b).

Taking into consideration all the aforementioned factors, it is deduced that marine and coastal ecosystems are threatened and continue to deteriorate at an alarming rate. Most of the benefits provided via marine and coastal ecosystem services are undervalued, thus, the overall importance regarding the conservation of these ecosystem services is severely underestimated. It is crucial, in terms of future research, to emphasize on investigating the multiple benefits emerging from marine and coastal ecosystems, their interconnectivity along with the spatial variability of marine ecosystem services. Furthermore, it would be conducive, in an attempt to improve marine and coastal management/policy, to explore the lesser known marine and coastal ecosystem services (e.g. protection from sea-level rise, wind damage reduction etc.), aiming at improving the valuation and assessment process regarding the benefits provided by these ecosystems, and hence appropriately influence decision and policy-making in relation to the management and conservation of these environments (Barbier, 2012; 2017; McLeod and Leslie, 2009; Spalding et al., 2014).

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4.2 On the classification and typology of marine/coastal ecosystem services

There are several ecosystem services classification systems in existence, mainly based on the most common classification of ecosystem services (see chapter 2.2), which have often been further modified to be applicable to the specific type of ecosystem under investigation, and thus better serve the research purposes of each study. In the case of marine and coastal ecosystems, it is deemed efficient and important to integrate all the related ecosystem functions and benefits provided by these ecosystems via the four main categories of ecosystem services. Namely, there refer to the provisioning, regulating, habitat, and cultural ecosystem services.

In that regard, it would be helpful to elucidate once more on certain aspects regarding ecosystem services. In particular, marine and coastal ecosystem services are perceived as the direct and indirect benefits/contributions of marine/coastal ecosystems to human well-being. These ecosystem benefits, which humans derive from marine and coastal ecosystem services, are transformed into useful products and experiences. In every marine/coastal ecosystem there are certain ecosystem functions in existence, identified as the ecological processes regulating and controlling the flows and fluxes of energy, organic matter and nutrients through each ecosystem (TEEB, 2010; Cardinale et al., 2012; Haines-Young and Potschin, 2013).

Within the context of this dissertation and based on Liqueste et al. (2013), Kandziora et al. (2013), Böhnke-Henrichs et al. (2013) and Hattam et al. (2015), a particular classification and typology of marine and coastal ecosystem services has been developed, as presented in Table 4-1, aiming at displaying all the categories of marine and coastal ecosystem services along with a brief description and their most familiar and useful applications. In summary, the provisioning services are consisted of three main categories: (i) food provision (further subcategorized in wild capture seafood and farmed sea food), (ii) water provision and storage, and (iii) biotic raw materials and biofuels (further subcategorized in genetic resources, medicinal resources, ornamental resources and biochemicals).

Furthermore, the regulating services are comprised of nine major categories in the interest of integrating and incorporating all the related aspects of regulatory purposes regarding regulating marine and coastal ecosystem services. In particular, these nine categories are associated with: (i) air purification/air quality regulation, (ii) climate regulation (atmospheric/gas regulation, weather regulation), (iii) disturbance prevention or moderation (natural hazard protection), (iv) water flow regulation, (v) water purification,

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(vi) waste treatment and assimilation, (vii) coastal protection, (viii) ocean nourishment, and (ix) biological control. The habitat services are characterized by two main categories, the lifecycle maintenance and the gene pool protection. Finally, the cultural and amenity services referring to marine and coastal ecosystem services are consisted of seven categories. These are the following: (i) recreation, leisure and tourism, (ii) aesthetic experience and information, (iii) inspiration for culture, art and design, (iv) cultural heritage and identity, (v) cultural diversity, (vi) spiritual and religious experience, and (vii) information for cognitive development (knowledge systems).

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Table 4-1: Classification and typology of marine and coastal ecosystem services

Categories	Ecosystem services	Description	Applications
Provisioning Services	Food provision		
	Wild capture sea food	All available marine fauna & flora extracted from unmanaged coastal/marine environments for human consumption	Fish, shellfish, seaweed, seafood, marine plant & animal, edible algae, fish oil
	Farmed sea food	Food from aquaculture for human consumption	Cultivated fish, crustaceans, aquatic plants, mollusks, edible algae, fish oil and other edible organisms
	Water provision & storage	Marine water in oceans, seas and inland seas extracted for human use in industries and other economic activities	Seawater used in shipping, industrial cooling, desalinization
	Biotic raw materials & biofuels	The extraction of any material from marine/coastal environments	Algae (non-food), sand, salt and other renewable biotic resources (e.g. sand eels harvest for animal feed & fertilizers)
	Genetic resources	The provision/extraction of genetic material from marine flora and fauna for use in non-marine and non-medicinal contexts	The use of marine genetic material derived from flora/fauna to improve crop resistance to saline conditions

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	▪ Medicinal resources ▪ Ornamental resources ▪ Biochemicals	Any material extracted from or used in the marine environment for its ability to provide medicinal benefits Any material extracted for use in decoration, fashion, handicrafts, souvenirs, etc. Renewable biofuels	Pharmaceuticals derived from the marine environment, marine/coastal salt-water for health purposes, natural marine products used as medicine Seashells, aquarium fish, pearls, coral, collection of natural ornaments (e.g. leaves and twigs for ornamental or religious purposes) Natural products used as biochemicals and/or cosmetics

Regulating Services	Air purification/air quality regulation	Influence on the concentration of pollutants from the atmosphere	Removal of pollutants such as fine dust, particular matter, sulphur dioxide, carbon dioxide, etc. from the air; Capturing/filtering of chemicals and gases; Dilution and sequestration of wastes
	Climate regulation (atmospheric/gas regulation, weather regulation)	Contribution of the biotic elements of marine/coastal ecosystems to the maintenance of a favourable climate through influences on the temperature regulation, hydrological cycle, and their contribution to climate-influencing substances in the atmosphere	Production, consumption and use by marine organisms of gases such as CO ₂ , nitrous oxides, methane, water vapour and dimethyl sulphide; Long-term storage of greenhouse gases in ecosystems; Changes in basic components of local climate such as wind, temperature, precipitation, radiation due to ecosystem properties
	Disturbance prevention or moderation (natural hazard protection)	Contribution of marine ecosystem structures to the dampening of the intensity of environmental disturbances as in the case of storm floods, tsunamis, typhoons and hurricanes	Protection from natural hazards, reduction in the intensity of and/or damage caused by environmental disturbances directly resulting from existing marine ecosystem structures such as sea grass beds, salt marshes and mangroves
	Water flow regulation	Contribution to the maintenance of localized coastal current structures	Maintenance of water cycle features such as water storage and buffer, irrigation and drought prevention, natural drainage; The effects of macro algae on localized current intensity; Maintenance of deep channels by coastal currents used for shipping

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	Water purification	The capacity of ecosystems to purify water from harmful substances such as pesticides, disease-causing microbes and pathogens and sediments	Water quality regulation, bioremediation
	Waste treatment and assimilation	The capacity of marine/coastal ecosystems to filter, decompose and remove contaminants, organic nutrient inputs and other pollutants added to marine/ coastal environments as a result of human processes such as storage, burial and biochemical recycling	Breakdown of chemical pollutants by marine microorganisms; Filtering of coastal water by shellfish
	Coastal protection	Contribution to coastal erosion prevention, natural hazard regulation, erosion regulation, moderation of extreme events	Coastal dunes maintenance via coastal vegetation; Reduction in scouring potential resulting from near-shore macro-algae forests
	Ocean nourishment	The capacity of an ecosystem to recycle nutrients, such as Nitrogen and Phosphorus. Soil formation	Nutrient cycling, maintenance of soil fertility, pedogenesis and soil quality regulation
	Biological control	Contribution to the maintenance of population dynamics, resilience through maintaining food web structure and flows, disease and pest control	Support toward reef ecosystems by herbivorous fish which keep algae populations in check; Existence of top predators and contribution to limiting the population sizes of opportunistic species, such as jelly fish and squid

Habitat Services	Lifecycle maintenance	Contribution of a particular marine habitat to migratory species' populations via the provision of essential habitat for feeding, reproduction and juvenile maturation (migratory and nursery habitat)	Reproduction habitat of commercially valuable species harvested elsewhere; Biologically mediated habitat; Maintenance of life cycles of migratory species
	Gene pool protection	Contribution of marine habitats to the maintenance of viable gene pools via natural selection/evolutionary processes which enhance adaptability of species to environmental changes along with the resilience of the ecosystem	Inter-specific/Intra-specific genetic diversity supported by marine ecosystems which enhances the adaptability of species to environmental changes; Maintenance of genetic diversity

Cultural & Amenity Services	Recreation, leisure and tourism	The provision of opportunities for recreation, leisure and tourism which highly depend on the particular (healthy) state of marine/coastal ecosystems. Recreation and community activities (social relations); Ecotourism	Outdoor activities and tourism related to the marine and coastal environment including several forms of sports, leisure and outdoor pursuit (e.g. beachcombing, bird/whale watching, recreational fishing, sailing, SCUBA diving, etc.)
	Aesthetic experience & information	Contributions from marine/coastal ecosystems to the existence of surface or subsurface landscapes which generate noticeable emotional responses within the individual observer, including informal spiritual experiences. Landscape aesthetic amenity and inspiration	The particular visual facets of a seascape (as in the case of open blue water), a reef-scape with abundant and colourful marine life, a beachscape with open sand, etc. which emotionally resonate with individual observers; Visual quality of the landscape of marine/coastal ecosystems or parts of them which influence human well-being and the need to create something (e.g. art, music and literature); The sense of beauty individuals obtain via the observation of landscapes of marine/ coastal ecosystems
	Inspiration for culture, art and design	Contributions via the existence of environmental features which inspire elements of culture, art, and/or design	Utilization of marine landscapes as motifs in paintings; Use of marine environmental features (such as waves) in jewellery; Construction of buildings based on marine inspired themes; Use of marine organisms or marine ecosystems in cinematography (e.g. "Jaws", "Finding Nemo"); Source of inspiration for art, national symbols, folklore, advertising, architecture, technology

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	Cultural heritage & identity	Contribution to the maintenance of cultural heritage and identity, whilst providing a “sense of place” (excluding aesthetic and formal religious experiences). This service also includes the significance of marine/ coastal ecosystems with regard to cultural traditions and folklore, both on a local level (e.g. in the case of a particular coastline or cliff formation) as well as at a global scale (e.g. regarding a particular marine landscape)	Values individuals place on the maintenance of historically important landscapes and forms of land use (e.g. the Wadden Sea is listed as an UNESCO World Heritage site)
	Cultural diversity	Contribution to social and cultural values and adaptations pertaining to living at coasts and exploiting marine resources	Variety of cultures, human societies, choices, skills, human values and worldviews, providing wisdom from the past for future benefits in specific regions or/and worldwide
	Spiritual and religious experience	Contribution to formal and informal collective religious experiences (excluding services covered by Aesthetic experience & information or/and Inspiration for culture, art and design)	Spiritual and emotional values individuals or religions attach to local environments/landscapes resulting from religious and/or spiritual experiences (i.e. various Greek and Roman deities were connected to the sea such as Poseidon, Neptune, etc.); In the case of Christianity fish is regarded as a prominent spiritual symbol; Marine organisms (e.g. whales, salmon, etc.)

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	Information for cognitive development (knowledge systems)	Contribution to education, research, individual as well as collective cognitive development; Environmental education based on existing marine and coastal ecosystems/landscapes	are significant spiritual symbols in various indigenous communities Contributions to bionic design, biomimetics, research on applications of marine genetic resources and pharmaceuticals; The development of surfaces to reduce marine biological fouling based on similar surfaces discovered in marine environments; The environmental education of children and adults; Utilization of marine animal swimming mechanisms/techniques in engineering design; The application of hydrodynamic flow analysis to marine animals for ship design; Environmental education and information (beyond formal schooling), based on traditional knowledge and specialist expertise, resulting from living in this particular marine/ coastal environment

Source: Adapted from Liqueste et al., 2013; Kandziora et al., 2013; Böhnke-Henrichs et al., 2013; Hattam et al., 2015.

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Several conceptual frameworks, as in the case of the cascade model (de Groot et al., 2010; Haines-Young and Potschin, 2010; Viehman et al., 2009; Pereira et al., 2010; Maes et al., 2013; Liqueste et al., 2013), have been utilized in order to effectively contextualize specific biophysical structures and processes to human values and benefits in regard to marine and coastal ecosystem services. However, certain categories of ecosystem services have been investigated progressively more compared to others. In particular, food provision is considered the most evaluated ecosystem service from the provisioning services category (Sagoff, 2008; Liqueste et al., 2013), while water purification is the most frequently analyzed in reference to the regulating services category (Hyytiainen et al., 2009; Plutchak et al., 2010; Souza et al., 2011; Liqueste et al., 2013). In addition, coastal protection and climate regulation is also among the most addressed and analyzed regulating services, whilst recreation, leisure and tourism is the most prominent (in terms of published research studies) ES from the category of cultural and amenity services (Liqueste et al., 2013). The least analyzed or assessed marine and coastal ecosystem services are usually those included within the cultural and amenity services category along with water provision, air quality regulation, biological regulation and weather regulation (Liqueste et al., 2013).

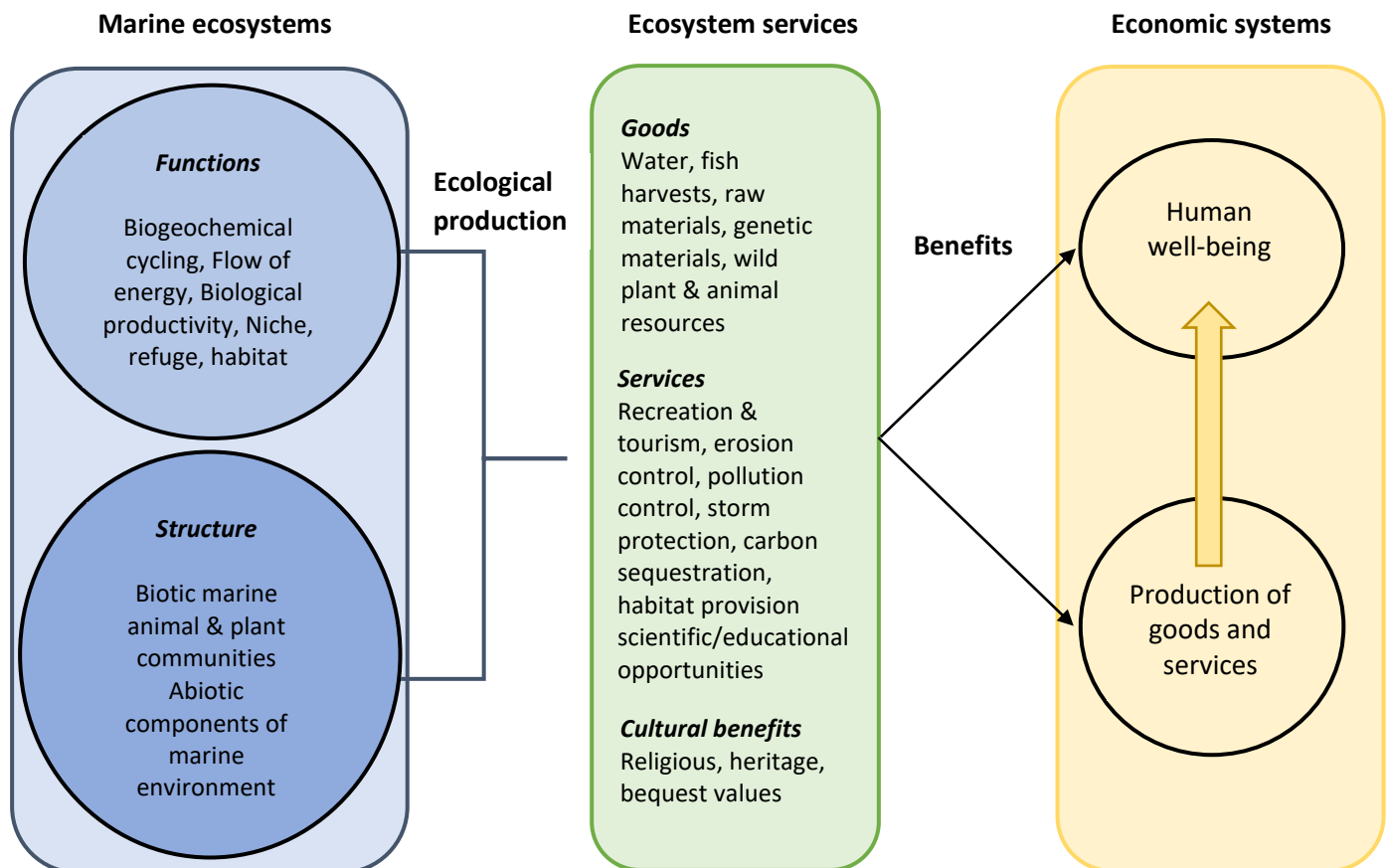
4.3 Economic valuation and policy priorities in the case of marine/coastal ecosystem services

Marine and coastal ecosystem services are considered to be among the most significant resources for coastal communities regionally, but also on a national level and in terms of international trade as well (Lau et al., 2010). In that sense, it is essential to properly understand and acknowledge all the benefits provided by marine and coastal ecosystems, which are ultimately characterized as very important for human well-being within the context of sustainable development from an economic point of view (Lopes and Videira, 2013). Similarly to other ecosystems, marine and coastal ecosystems are based on a certain structure and functions, progressively leading to the ecological production of their associated ecosystem services, thus, generating a variety of goods, services and cultural benefits which either have direct (positive) effects on human well-being or

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indirectly affect human welfare via the protection or conservation of valuable economic assets, as better illustrated in Figure 4-1.

Figure 4-1: Economic benefits generated by marine ecosystems



Source: Adapted from Barbier, 2017.

As previously mentioned (see chapter 4.2), marine and coastal ecosystems deliver these benefits via their associated ecosystem services, therefore, generating a “significant” amount of money. In particular, the provision of seafood and other raw materials by means of fish harvests has been estimated to amount to trillions of dollars on an annual basis, along with other benefits from prominent marine/coastal ecosystem services, such as maintaining good water quality, regulating Earth's climate, the modulation of global biogeochemical cycles together with supporting a large

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variety of cultural and aesthetic uses (Holmlund and Hammer, 1999; Worm et al., 2006; UNEP, 2011; Börger et al., 2014). In addition to providing critical services, as in the case of transportation, recreation and tourism, scientific and educational opportunities, marine and coastal ecosystems are closely associated with cultural benefits, in reference to religious and spiritual significance and altruistic values (bequest for future generations).

However, the majority of these marine and coastal ecosystem services have been and still are subjected to degradation due to anthropogenic pressures and “stressors” including climate change, ocean acidification, chemical pollution, over-fishing, habitat degradation and deoxygenation, most of which constitute transgressed planetary boundaries (Lotze et al., 2006; Halpern et al., 2012; National Geographic Society, 2013). Combined with large-scale economic activities as in the case of shipping, fisheries, aquaculture, renewable energy generation, recreation and tourism, and oil or gas extraction, the biodiversity loss and overall impact on marine and coastal ecosystems are at the moment considered detrimental (MEA, 2005; UNEP, 2006; EEA, 2010). As a result, these actions have an adverse impact on the supply of all the necessary goods and services, urging for the implementation of further policy measures to address uncertainties and mitigate threats, while acknowledging important parameters such as the aggregate benefits and costs of conservation and degradation respectively (Lopes and Videira, 2013).

In this context, marine/ coastal ecosystem services valuation is necessary as means of properly measuring the associated costs and benefits regarding a certain policy to be implemented during the process of decision-making as well as in order to improve society’s awareness with regard to the value of benefits human beings obtain from healthy marine and coastal ecosystems. In addition, effective ecosystem valuation directly contributes to a variety of other relevant and important tasks such as environmental policy, project or program appraisal, guidance in the case of national development plans, ranking priorities within business sectors, green accounting, specifying liability or compensation with respect to environmental litigation, while forming the framework for establishing market-based tools as in the case of taxes, fees, charges, penalties, fines, tradable permits, subsidies and incentives (UNEP-WCMC, 2011). However, when unnecessary changes or alterations occur within the framework marine and coastal ecosystems, the delivery of their intermediate and final ecosystem services is impaired. In particular,

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unfavourable changes associated with natural resources (resource change) affect the intermediate services, which in turn affect the final services, thus, reducing human welfare.

The applicability of any method of ecosystem services valuation to marine and coastal ecosystems is mainly based on their suitability to acknowledge and assess any occurring changes in relation to marine/ coastal ecosystem services. In that sense, it is crucial to avoid and prevent risks such as double counting via acknowledging the value of intermediate services through their impacts on final services. As depicted in Table 4-2, based on the principles of TEV along with policy purposes, certain valuation methods are usually utilized or preferred for each category regarding marine and coastal ecosystem services.

Table 4-2: Selection of valuation method for marine/coastal ecosystem services on the basis of their applicability

Method of valuation	Type of value	Important parameters	Ecosystems services valued

Market based approaches (market prices and other economic variables)

Market prices	Direct use values	Requires adjustments for costs, subsidies, taxes	Provisioning services (when marketed) as in the cases of fisheries, aquaculture, renewable energy, fossil fuels
Market proxies	Direct use values	Requires adjustments for costs, subsidies, taxes	If an ecosystem service is not marketed, proxy market value can sometimes be applied: e.g. valuation of subsistence fishing at the market value of fish
Production function method	Use values	Data-intensive	i.e. nursery habitats for fisheries are usually valued via a production function

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Avoided costs	Cost	On the premise that replacement would be appropriate	i.e. the cost of recreating coastal wetlands in order to compensate for losses
Cost of illness	Depending on how health impact is valued	Production function linking change to health impact	Any ecosystem changes affecting human health or mortality (for example: wastewater treatment)

Revealed preference methods (actual/observed behaviour)

Travel cost	Use values (for recreational purposes)	On the premise that visits are made to a specific site	Ecosystem services associated with or contributing to recreational purposes
Hedonic pricing	Use values within property (houses, homes)	Based on awareness of impacts	General environmental quality, amenities, seascapes, peace and quiet
Random utility model	Use values (for recreational purposes)	Depends on choice among sites	Ecosystem services associated with or contributing to recreational purposes

Stated preference methods (hypothetical behaviour)

Contingent valuation	Use and non-use values	On the basis of pricing single option	All services due to the ability of estimating both use and non-use values (e.g. biodiversity, cultural values, heritage values etc.)
Choice modelling	Use and non-use values	On the basis of forming choice(s)	All services due to the ability of assessing both use and non-use

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		from available options	values (e.g. recreational values, biodiversity, spiritual values etc.)

Source: Adapted from UNEP-WCMC, 2011.

4.3.1 On the value of marine and coastal ecosystem services

The marine environment contributed approximately \$20 trillion USD on an annual basis regarding the valuation of ecosystem services at a global scale (\$33 trillion in total) in 1997, based on Costanza et al. (1997), bearing also in mind all the implied positive effects on human well-being. In light of new data, a re-estimation tool place acknowledging changes within the aerial extent of certain ecosystems as well, regarding the 1997-2011 time period, eventually yielding significant results due to the fact that the first evaluation (during 1997) underestimated the total global value of ecosystem services by almost int\$100 trillion (van der Ploeg et al., 2010; Costanza et al., 2014; de Groot et al., 2012; Pendleton et al., 2016). However, due to the constant deterioration and degradation of marine ecosystems, the quality of their associated ecosystem services has been severely diminished. This value can be further translated as an approximate loss in global value to the extent of int\$20.2 trillion regarding the aforementioned 1997-2011 time period (Pendleton et al., 2016). This decrease can partially be contributed to acknowledging and integrating the global value of marine and coastal ecosystem services on the basis of new estimates made in relation to them.

The value of marine and coastal ecosystem services, with the inclusion of wetlands, is estimated to have been originally undervalued by int\$62.3 trillion (Costanza et al., 2014). Coupled with the increasingly growing rates of degradation and loss regarding coral reefs and coastal wetland areas, the total value of marine and coastal ecosystem services at a global scale is estimated to have declined by approximately int\$19.1 trillion (Pendleton et al., 2016) , accounting for almost 95% of the estimated change in reference to the value of global ecosystem services.

Undervaluing or never even acknowledging in the first place the significance and contribution of marine and coastal ecosystems services in terms of financial value can lead to further “misfortunes” regarding human well-being. The effectiveness and quality of marine and coastal

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functions and ecosystem services in monetary terms is closely associated with their proper evaluation, as daily business and political decisions are based for the most part on financial returns. On some occasions, markets have been formed globally for marine ecosystem services in the interest of regulating important sectors such as commercial fisheries, while markets have also been proposed for other noteworthy aspects, as in the case of carbon sequestration and marine biodiversity offsets (Ten Kate et al., 2004; Nellemann et al., 2009; Lau et al., 2010).

In addition, in the case of PES (payments for ecosystem services) deals investments are often made in order to restore or conserve specific marine ecosystems and their associated ecosystem services. The main focus is the preservation of specific ecosystem services, as for example the biodiversity habitat conservation or the shoreline protection in return for some form of economic value. If successfully performed, these “payments” assist or may even produce the highly beneficial results generated by marine/ coastal ecosystems, taking into consideration that every transaction of this sort requires regular verification of the sellers’ actions and their resulting impact on natural resources. In that sense, sellers ought to preserve or enhance the selected ecological functions of a certain structure on a greater level than what would occur in the absence of payment, whilst bearing accountability to independent verifiers in case a buyer requires to check or ensure that the service for which he/she is being paid for is in fact being delivered. The PES approach may also incorporate multi-level governance along with bundling or shared values for ecosystem services and while it is mainly considered environmentally effective, they (PES) may ultimately prove to be unfair (Lau et al., 2010; Schomers and Matzdorf, 2013; Calvet-Mir et al., 2015; Reed et al., 2017; Wang and Wolf, 2019).

Nevertheless, published research on the total value of ecosystem services at a global scale or in particular regarding specific ecosystems has contributed to a large extent toward recognizing the importance of ecosystems to human well-being, as to that effect monetary valuation is usually a prerequisite. In this context and based on current trends within this specific area of expertise, it can be inferred that additional data is required in order to raise awareness and accomplish positive results in terms of environmental policy. The lack of aggregate global data, especially in relation to marine and coastal ecosystems, may lead to less than accurate results regarding valuation. Current trends, as mentioned above, strongly indicate that marine and coastal ecosystem services have declined (in terms of value) during the last thirty years, though public

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awareness has to certain extent grown, often due to extensive awareness campaigns regularly conducted. In any case, further research is required on the valuation of marine and coastal ecosystem services as additional challenges exist, taking into consideration the relatively small number of value estimates and case studies, the extensive variability and heterogeneity regarding value estimates along with the fact that a lot of them (published studies) have already become outdated (Pendleton et al., 2016).

4.3.2 Priority targets in terms of environmental policy

It is deemed essential, in terms of efficiency, to appropriately balance the increasingly competing demand regarding the exploitation of marine and coastal ecosystems, therefore, preventing further deterioration whilst conserving these ecosystems through the utilization and implementation of adequate environmental policies on a global level. Since the 1960s, the deterioration process of marine and coastal ecosystems has been greatly intensified, mainly due to factors related to the increased inputs of certain materials, as in the case of organic matter, nutrients, sediments and pollutants, the physical disturbance through shoreline and offshore constructions as well as trawling fisheries, thus, urging for ecosystem recovery and restoration (Duarte et al., 2015). Within this context, efficient environmental policies should be based on the meticulous and accurate specification of these recovery targets in an effort to promote and establish more effective methods of stewardship regarding marine and coastal ecosystems.

During the policy-making procedure, the main goal should be oriented toward the overall improvement of the current status and conditions regarding the selected marine and coastal ecosystems. A variety of policy initiatives such as these has been utilized worldwide on a national, European as well as international level. Most prominent examples of which are the following (Calado et al., 2010; Duarte et al., 2013; Börger et al., 2014; Knezevic et al., 2015):

- i. the United Nations Convention on Sea Law (UNCLOS) in 1982 (UN, 1982),
- ii. the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) in 1992 (OSPAR, 1992),
- iii. the UN Convention on Biodiversity (CBD) in 1992 (CBD, 1992),

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- iv. the European Water Framework Directive (WFD) in 2000 (Directive, 2000/60/EC),
- v. the IMO Convention on Ballast Water Management in 2004 (BWM Convention, 2004),
- vi. the Integrated Maritime Policy (IMP) in 2007 (CEC, 2007),
- vii. the Marine Strategy Framework Directive (MSFD) in 2008 (Directive, 2008/56/EC),
- viii. the UK Marine and Coastal Access Act (MCAA) in 2009 (HM Government, 2009),
- ix. the National Estuary Program (NEP), the Clean Water Act (CWA) and the US National Ocean Policy in the case of the USA,
- x. the UN Oceans Compact in 2012 (UN, 2012),
- xi. the EU Integrated Maritime Policy (IMP) in 2012 (European Commission, 2012)
- xii. the Communication from the Commission to the European parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A European Strategy for more Growth and Jobs in Coastal and Maritime Tourism in 2014 (European Commission, 2014)
- xiii. the Maritime Spatial Planning Directive in 2014 (Directive, 2014/89/EU)
- xiv. the Commission Directive (EU) 2017/845 in 2017 (European Commission, 2017)
- xv. the Commission Decision (EU) 2017/848 in 2017 (European Commission, 2017)
- xvi. the EU biodiversity strategy for 2030 (European Commission, 2020)
- xvii. the various National Strategies for Integrated Coastal Zone Management formed based on recommendations of the EU for the good preservation and management of coastal zones.

Based on these initiatives and agreements, it can be said with confidence that the participation and collaboration (when possible) of all the related and interested parties and stakeholders is essential and can prove to be effective, while further assessments are required regarding marine and coastal ecosystems for more informed decisions to be made on an environmental policy level (Bingham et al., 1995; Ledoux and Turner, 2002; Lopes and Videira, 2013).

From the perspective of one the most important initiatives with regard to the marine environment, the Marine Strategy Framework Directive (MSFD), the main goal is to achieve Good Environmental Status (GES) of EU marine waters by the year 2020, where GES is defined as *“The environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive”* based on Article 3 of the Directive

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(MSFD, 2008/56/EC). As a result, the sustainable use of the marine environment is highly promoted in an effort to safeguard the potential activities, and utilization in general, for future generations. Consequently, marine and coastal ecosystem services ought to be adequately delivered as part of attaining GES (Atkins et al., 2011; Borja et al., 2013). In addition, a plethora of studies currently exists regarding the estimation of the values derived from marine and coastal ecosystem services, properly delivered when GES is achieved (Pendleton, 1995; Beaumont et al., 2008; UNEP-WCMC, 2011; Barbier et al., 2011; Ressurreição et al., 2011; Lique et al., 2013; Ghermandi and Nunes, 2013).

On a similar level, the EU Blue Growth Agenda constitutes a long term strategy targeting maritime economic activities, whilst considering the oceans coasts as drivers which together with the marine and coastal ecosystem services support these multi-sectoral economic activities (coastal recreational activities, cruise tourism etc.). However, this particular capacity of marine and coastal ecosystems to efficiently supply all the required services in a sustainable manner is based on their healthy functioning, combined with aspects of abiotic regulation and maintenance, provided within the framework of the various physical structures and processes with regard to the respective marine and coastal environments. In this sense, certain legislative actions are required to protect and ensure this capacity, as the GES of these ecosystems is evidently linked to human well-being and prosperity (Lillebø et al., 2017).

As in the case of the WFD, initiatives regarding marine management governance are often characterized as highly complicated due to the fact that they in turn have to cope with the complexity of the various marine and adjoining systems (Hering et al., 2010; Borja et al., 2013). In this context, the need for more simplistic and operational definitions capable of integrating all the related criteria and descriptors, on the basis of available information and data, is urgent. As accurately illustrated in initiatives such as the MSFD together with the Maritime Spatial Planning and Integrated Coastal Management Directive, it is imperative to adequately protect and preserve marine and coastal environments to ensure their sustainability, and thus carry on delivering their ecosystem services and associated societal benefits for human beings (Borja et al., 2013).

Nevertheless, policies such as the aforementioned have often been described as mere legislative measures, operating under the premise of evaluating if the current status of the system under examination is as expected or requires proper management aiming at restoration (Mee et al.,

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2008; Duarte et al., 2015). In that sense, the process of recovery is based on certain targets which have to be fulfilled through the application of certain regulatory measures, under a well-defined framework of precision regarding the selected trajectories of recovery, along with the characteristics and features which will ultimately determine when the selected ecosystems have indeed recovered (Elliott et al., 2007; Borja et al., 2012; Duarte et al., 2015). Nevertheless, during the process of policy-making it is essential to incorporate every aspect or factor (economic, social, environmental) involved in order to accurately illustrate the societal benefits provided by marine and coastal ecosystem to human beings.

Furthermore, within the context of marine planning ecosystem services are often incorporated in accordance with the Ecosystem service valuation (ESV) or patterns, models and technical tools such as Marine InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs), MIDAS (Marine Integrated Decision Analysis System), MIMES (Multiscale Integrated Models of Ecosystem Services), EAR (Ecosystem Assessment and Reporting) and ARIES (ARtificial Intelligence for Ecosystem Services) in order to make predictions on how policy intervention can potentially alter certain integrated marine ecosystem service values (Turner and Schaafsma, 2015; Luisetti et al., 2014). As far as marine planning is concerned, the use of ESV can substantially contribute to crucial areas such as discovering hidden ecosystem benefits/costs, which have been ignored due to predominantly acknowledging commercial revenues/costs, or providing useful information on the economic trade-offs between different marine plans and ecosystem services (Börger et al., 2014).

In addition, in reference to CES (Cultural ecosystem services), the risk of mis- or under-representation may lead to biased or erroneous decisions during the decision-making process, taking into account the fact that CES often tend to be highly valued on account of the recreational and cultural benefits they provide (Chan et al., 2012; MEA, 2005; Tielborger et al., 2010; Martin et al., 2016). However, as far as marine and coastal ecosystems are concerned in connection with CES, there is still limited information available (Liquete et al., 2013; Lopes and Videira, 2013; Martin et al., 2016). Bearing in mind that trade-offs among different ecosystem services frequently occur, responsible management based on solid information is critical during the decision or policy-making in an effort to choose the most favourable from a wide variety of competing options (Brown et al., 2001; Environmental Law Institute, 2009). Policy formation on the basis of integrating aspects of CES contributions could prove to be beneficial, as it may shorten

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the gap between monetary and non-monetary values with regard to ecosystem services within the framework of the decision-making process, while promoting a more holistic approach to sustainable development integrating economic, non-monetary and environmental values as well (Chan et al., 2012; Martin et al., 2016).

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Chapter 5: Plastic Pollution in the Marine Environment

5. Plastic pollution in the marine environment

5.1 Marine plastic pollution

Plastic pollution in the marine environment is a contemporary problem of gargantuan proportions taking into consideration the ongoing survey results on a global level. Marine litter originate from both land and sea-based sources, while based on evidence it has been established that man-made litter can be found approximately in every marine environment, including existing ice and sediment cores (Derraik, 2002; Barnes et al., 2009; Ryan et al., 2009; Browne et al., 2011; Jambeck et al., 2015; Maes et al., 2018). Marine litter is an amalgamation, mainly consisting of certain types of plastic materials together with lower quantities of other materials, such as metal and glass. The most common plastic items to be considered marine litter are plastic bags, bottles, and fishing gear, therefore, indicating the anthropogenic source of the problem (UNEP, 2009, 2011).

Marine plastic pollution is usually identified as the accumulation of anthropogenic litter in the marine environment, characterized by high concentrations of up to 580,000 pieces per km² at a global scale, induced and distributed as a result of an increasingly growing production worldwide (Wilcox et al, 2015). Marine debris is defined as *“any persistent, manufactured or processed solid material discarded, disposed of or abandoned in the marine and coastal environment”* based on UNEP (2009), whilst it has been shown that plastics, for the most part, constitute the most common items of marine debris and litter (UNEP, 2009; Galgani et al., 2015; Kroon et al., 2018).

As mentioned above, marine litter is present in every marine habitat, being very pervasive and has been discovered in marine organisms, habitats and ecosystems worldwide including secluded beaches located in the most remote areas in the ocean as well as the seafloor, seamounts, submarine canyons, banks, mounds, continental shelves and ocean ridges (Thompson et al., 2004; Barnes et al., 2009; Gall and Thompson, 2015). In the case of the seafloor, plastic has been found to accumulate at a very high rate, even in the deepest areas or secluded locations, as for example the Charlie-Gibbs Fracture Zone across the Mid-Atlantic Ridge (Pham et al., 2014). In addition, plastics are the most prevalent items among marine litter, especially on the seafloor, while the most common types of plastic debris discovered in the ocean relate to plastic bags (usually

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fragmented), cigarette filters and cigar tips, food wrappers, derelict fishing lines, ropes and nets, buoys, balloons, boat hulls, six-pack rings, baby nappies and diapers, disposable syringes, lids, beverage bottles and bottle caps, plastic films from agriculture, and pre-production resin pellets (Sheavly and Register, 2007; Löhr et al., 2017). All of these items have a common anthropogenic place of origin, characterized as an adverse consequence of improper use and disposal, either deliberately or impulsively.

In reference to the Mediterranean Sea, plastic waste and litter accumulate on the seafloor of both Western and Eastern basins based on inputs of water masses originating from the Atlantic Ocean as well as the Eastern Mediterranean Sea (Ioakeimidis et al., 2017). Information on floating plastic debris is harder to obtain compared to seafloor plastic waste, though plastic waste and debris are characterized by their tendency to travel and accumulate across seas and oceans via surface currents either wind-driven or non-wind-driven. The multitude of plastic litter in the Mediterranean Sea is immense, directly comparable to similar ones with regard to the five subtropical gyres of the planet (Cózar et al., 2014; 2015; Ioakeimidis et al., 2017).

5.1.1 Briefing on plastic waste

Plastic debris and waste, being created by humans, is correlated with a plethora of socio-economic activities performed either on land or at sea. Nevertheless, the origins of plastic as a material are detected during the 20th century in the creation of synthetic polymers. Inventors such as John Wesley Hyatt were among the first to experiment with natural substances in order to produce new materials, as in the case of celluloid. During 1907, bakelite was commercially produced, being the first fully synthetic polymer, by the inventor Leo Baekeland who was the first one to apply the term “plastics” on the basis of the Hellenic word “plastikos”, denoting something flexible or moldable (Worm et al., 2017). At later stages, the mixture of phenol and formaldehyde along with heat and pressure resulted in the formation of the bakelite resin, thus, introducing the

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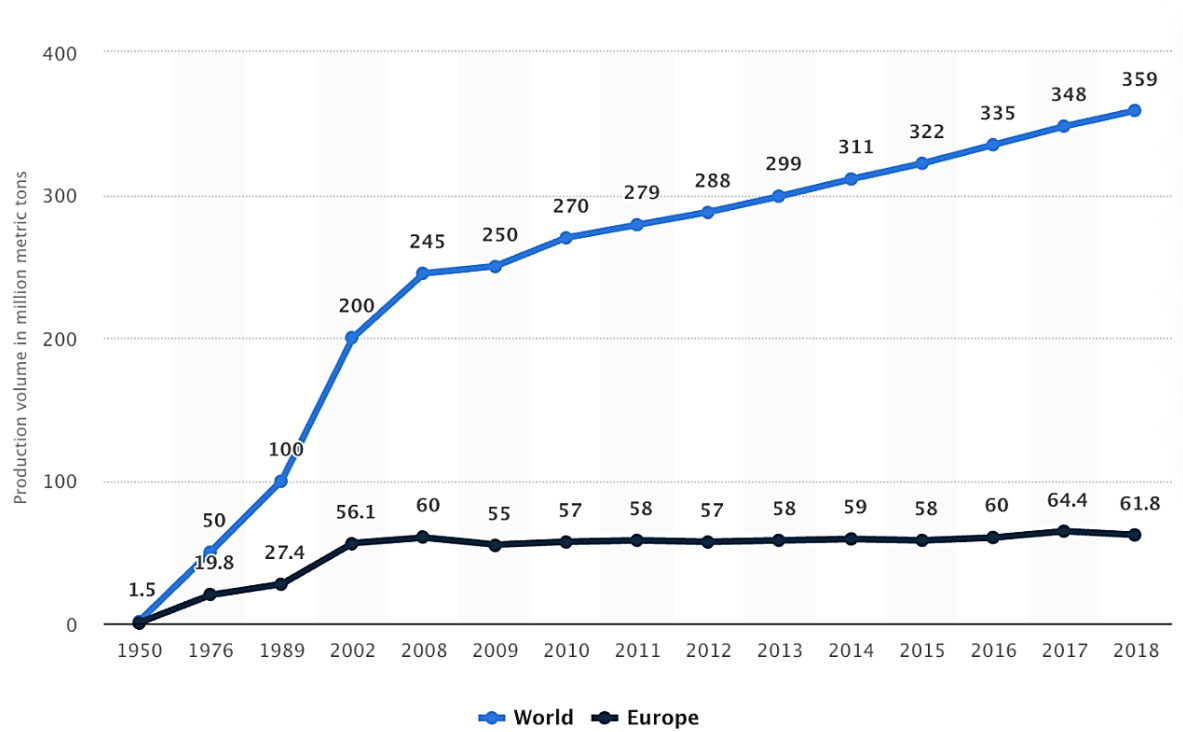
new era of commercialized plastics, a multi-billion dollar industry around the world highly associated with human material use and consumption.

During the current era, there are numerous different types of plastic produced, though the most common types of plastic litter discovered in the marine environment is associated with polyethylene (PE), polypropylene (PP), polyvinylchloride (PVC), polyterephthalate (PET), polyurethane (PUR), and polystyrene (PS). Among these categories, single-use plastic items, usually made from low-density plastic polymers and not easily recycled, are more likely to enter the marine and coastal environment (Addamo et al., 2017; Almroth and Eggert, 2019). However, early speculations on the potential harmful effects of plastics on marine environment have been made since 1972, based on Carpenter and Smith (1972) as well as Colton et al. (1974), who theorized that the so-called “plasticizers”, which refer to toxic non-polymeric compounds in plastics, can be passed on to marine organisms.

Plastic production reached approximately 348 million tons at a global scale during the year 2017, while in 2018 global plastics production roughly approached 360 million tons (PlasticsEurope, 2019). In particular, as far as Europe is concerned plastic production resulted in 62 million tons and a total turnover of up to 360 billion euros during 2018 within the context of the European plastics industry (PlasticsEurope, 2019). It has been estimated that 8300 million metric tons (Mt) of virgin plastics have been produced to date, a figure closely associated with the generation of 6300 Mt of plastic waste as of 2015 (Geyer et al., 2017). As better illustrated in Figure 5-1 and Figure 5-2, global plastic production has demonstrated rapid growth since the 1950s and is inclined to increase at an alarming rate for the future on a global level, though concerning Europe plastic production continues at a steady rate. Furthermore, in consideration of the aggregate plastic waste generation and dipodal and its current and future trends (Figure 5-3), it can be said with confidence that by the year 2050 approximately 12,000 Mt of plastic waste will end up in landfills or in the natural environment (Geyer et al., 2017).

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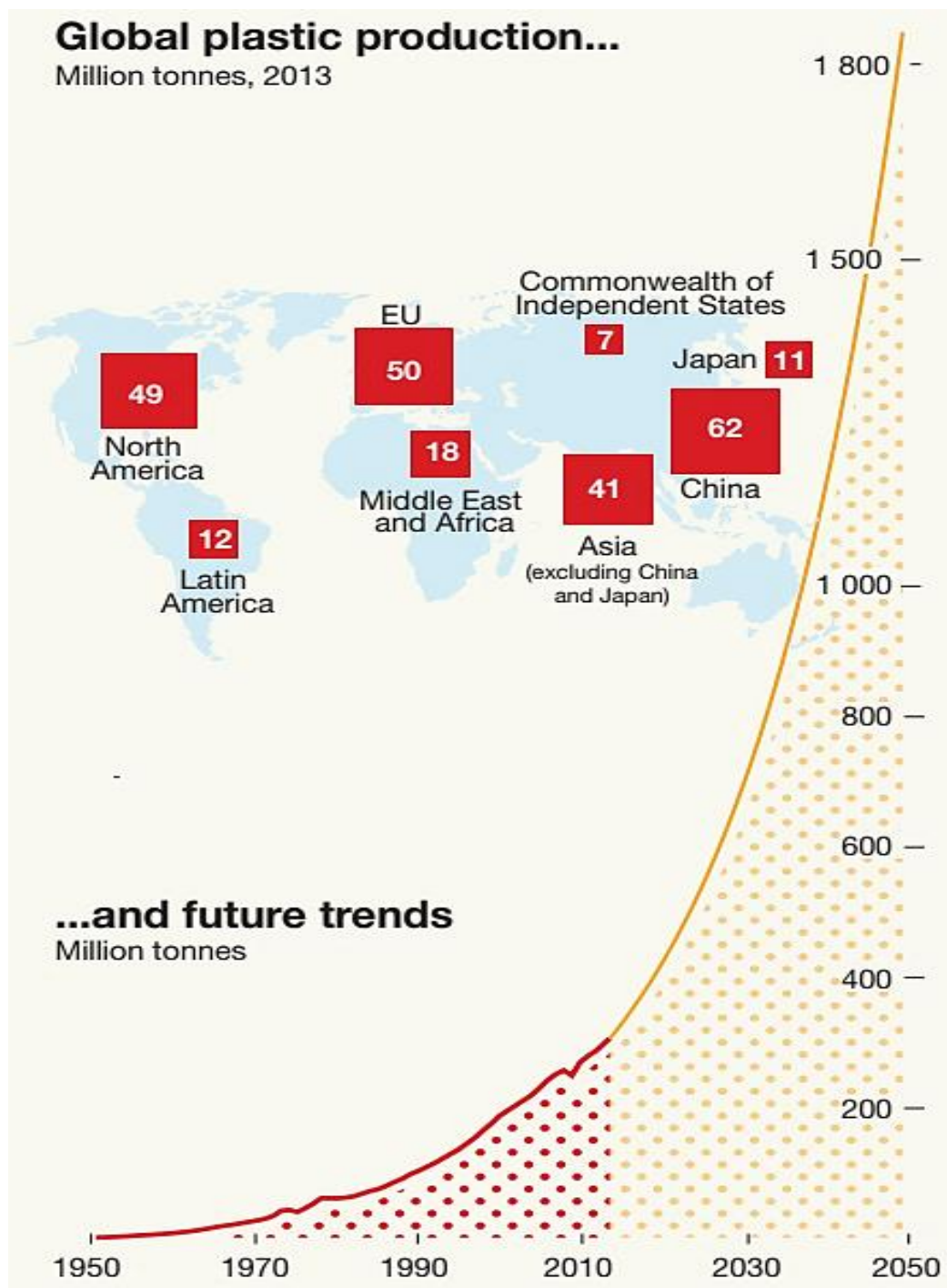
Figure 5-1: International and European production of plastics (1950-2018)



Source: Statista, 2020.

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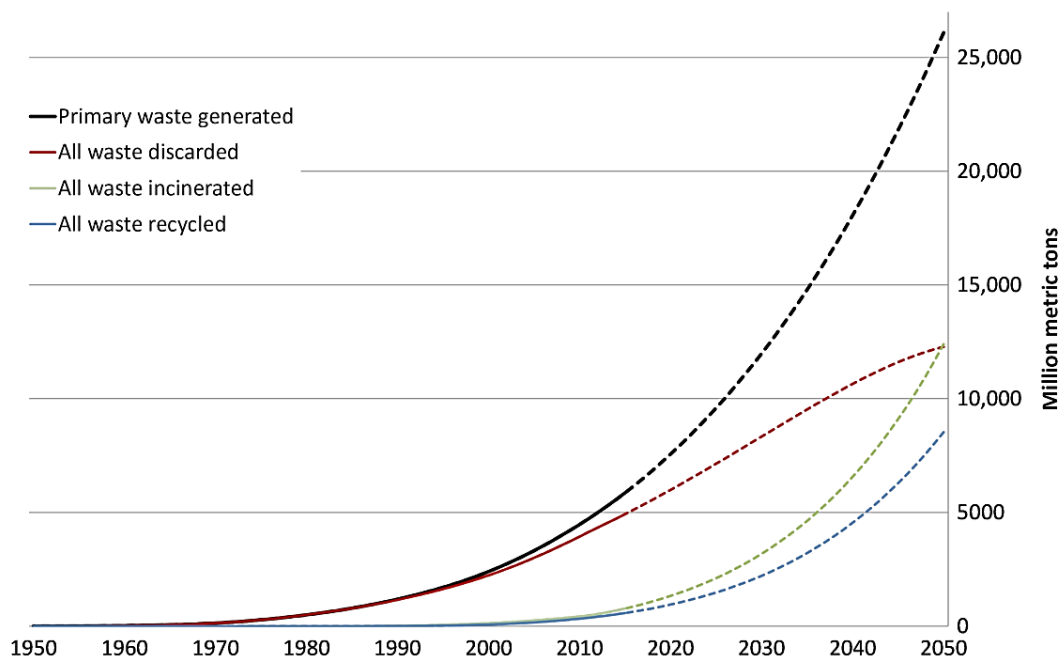
Figure 5-2: Global plastic production and future trends (1950-2050)



Source: Ryan, 2015.
<https://www.grida.no/resources/6923>

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Figure 5-3: Global plastic waste generation and ways of disposal 1950-2050



Source: Geyer et al., 2017.

As mentioned above, plastic waste has been reported as a threat for the marine environment since the early 1970s (Carpenter and Smith, 1972; Colton et al., 1974), while based on de Carvalho-Souza (2018) it has been detected in every major type of marine system. In particular, oceans and deep sea (Mordecai et al., 2011; Eriksen et al., 2014; Melli et al., 2017; Chiba et al., 2018), coral reefs and reef ecosystems (Al-Jufaili et al., 1999; Donohue et al., 2001; Chiappone et al., 2002, 2005; de Carvalho-Souza and Tinôco, 2011; Lamb et al., 2018; Reisser et al., 2013; Critchell et al., 2015) as well as remote islands (Lavers and Bond, 2017; Consoli et al., 2018; Lebreton et al., 2018).

5.1.2 Categories

Man-made litter, which falls under marine litter and specifically plastic waste, can be classified in three main categories: (a) macroplastics, (b) microplastics and (c) nanoplastics. The first category, macroplastics describes plastic litter characterized by a diameter greater than 5mm or alternatively within a range of between 2.5 cm and <1 m, as beyond the >1 m diameter threshold

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lies another scarcely used category commonly referred to as “megaplastics” (Barnes et al., 2009; Kroon et al., 2018). Subsequently, microplastics, less frequently referred to as “microlitter” (Gregory and Andrady, 2003), are associated with fragments in the range between 1 to 5mm, being not large enough to be seen or counted by the naked eye (Betts, 2008; Moore, 2008; Fendall and Sewell, 2009; Arthur et al., 2009; van Sebille et al., 2015; Ballerini et al., 2018).

Microplastics have existed and accumulated within the oceans for approximately over than 40 years (Thompson et al., 2004, 2005; Andrady, 2011), including small, fragmented plastic derived from bigger pieces of plastic debris, compounded pre-mixed pellets as well as virgin resin pellets (Moore, 2008; Andrady, 2011). Microplastics are usually composed of low density polyethylene (LDPE), high density polyethylene (HDPE), polypropylene (PP), polyvinyl chloride (PVC), polyethylene terephthalate (PET), polyurethane (PU), and polystyrene (PS). Due to their size, microplastics have been detected from marine and coastal ecosystems to surface waters, sand beaches, wastewaters, soil, sediments, sludges, biota as well as food and air (Barcelo, 2020).

Currently, the terms “mesoplastics” or “mesodebris” (when referred to plastic) also tend to appear in relation to plastics between 5-20mm (Gregory and Andrady, 2003; Blettler et al., 2017; Wang et al., 2019). The third category, referred to as nanoplastics accounts for the nano-sized particles of plastic debris/litter (less than 1000 μm), which though they are very difficult to accurately locate and isolate, currently pose a big threat to marine ecosystems and subsequently human health (da Costa et al., 2016; Mattsson et al., 2015; Mendoza et al., 2018; Peng et al., 2020). The statistics in reference to the actual detection and occurrence of nanoplastics in the marine environment are most probably underestimated, due to imposing technical limitations such as the fact that the number of particulates in samples taken might be below the detection level of the available monitoring techniques, while the separation, concentration and identification process of nanosized particles is very complicated, especially regarding waste and drinking water (da Costa et al., 2016). Nevertheless, according to Enders et al. (2015) micrometric plastic particles tend to be a lot more abundant compared to microplastics as in the case of the North Atlantic, having taken into consideration size classes from 10 to 690 μm .

Alternative forms of classification have also been proposed in an effort to effectively categorize marine debris while at the same time investigating its harmful effects on marine organisms. In particular, based on Kroon et al. (2018) marine microdebris can be classified as synthetic, semi-

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synthetic, and naturally-derived according to their characteristics. In that context, synthetic items are manufactured via chemical synthesis (and polymerization) and include thermoplastics (e.g. polyethylene, polypropylene, polystyrene) along with thermoset and elastomer plastics (e.g. polyester, polyurethane, etc.). The semi-synthetic category includes items produced synthetically based on substances of natural origin, such as rayon derived from cellulose. Lastly, the naturally-derived materials are constructed from natural origin substances, including plants (e.g. cotton, linen, ramie etc.), animals (e.g. wool and fur), and inorganics (e.g. calcium carbonate, calcium silicate) (Kroon et al., 2018).

Therefore, the proper and accurate categorization of marine debris and plastic waste in particular, becomes essential in improving and determining, on the basis of precision, the sources, transport and final destination of plastic waste with regard to the marine and coastal environment.

5.1.3 Sources

Marine plastic pollution (MPP) can mainly be attributed to land-based sources, shoreline and recreational activities, dumping and smoking. On an overall scale, land-based sources account for up to 80% of marine pollution worldwide, based on findings by the United Nations Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) (GESAMP, 1991; Sheavly and Register, 2007; Munari et al., 2016). In this context, coastal pollution, within the 50 km range of coastlines, contributes approximately 9 million tons on an annual basis, though the range for plastic waste inputs in the ocean has been estimated in the range between 4-12 million tons annually (Jambeck et al., 2015; Almroth and Eggert, 2019). This type of litter originates from daily activities taking place in parks, streets, parking areas etc., and is subsequently washed away, blown or carried away into waterways and sewers either by rain, wind or even snowmelt. Wastewater treatment plants (WWTP) are considered among the most viable methods of transporting plastic waste (especially microplastics) in the marine environment, as in the cases of lakes, rivers and seas, due to the fact that plastic solid waste is not effectively captured in WWTP (Mourgkogiannis et al., 2018). In particular, regarding Greece and 101 WWTPs across the country, evidence has shown that microplastics can pass through pre-treatment to the main WWTP, thus,

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making the presence of plastic debris such as cotton swab sticks, plastic pellets, bottle caps, and residues from plastic bags evident and great (Mourgkogiannis et al., 2018).

Additionally, among the most frequent sources is the improper or illegal dumping of domestic and industrial garbage, damaged or defective dumpsters and dump trucks along with processors and transporters (Sheavly and Register, 2007). Furthermore, inefficient sewage treatment combined with sewer overflows and the unintentional discharge of garbage from landfills highly contribute to the intensification of this problem. Nevertheless, reckless behaviour on behalf of beach users and fishermen associated with irresponsible practices of waste disposal highly exacerbates MPP (Munari et al., 2016).

Nevertheless, plastic waste and litter also originate from sea-based or ocean/waterway-based sources, usually related to human activities at sea. This type of activities includes commercial fishing, research vessels, merchant military, recreational boating, cruise ships as well as offshore petroleum platforms together with their associated supply vessels (Sheavly and Register, 2007; FAO, 2016). Once again, plastic debris may end up in the sea due to improper waste management and illegal dumping or accidental loss and potential system failures. In the case of commercial and recreational fishing, the disposal of marine debris (plastic fishing nets, ropes, plastic fishing equipment etc.) or ship-generated litter in the sea is considered a common practice (Sheavly and Register, 2007). In coastal parts of the central Mediterranean Sea, benthic litter mainly consists of plastic objects while it also accounts for 68% of total litter (Consoli et al., 2018), taking into consideration that the Mediterranean Sea is characterized by the highest density of marine litter due to several factors and physiographic attributes such as ocean currents, wind patterns, coastal shipping traffic and highly polluted coastlines (Galgani et al., 2000; Barnes et al., 2009; Bergmann et al., 2015; Consoli et al., 2018; Liubartseva et al., 2018).

In the case of rivers, regarded as a significant pathway for plastics into the ocean and seas (Schmidt et al., 2017; Tramoy et al., 2020), it has been estimated that approximately 1.15 to 2.41 million tons of plastic waste enters the ocean annually, based on a global model of plastic inputs from rivers integrating waste management, population density and hydrological information (Lebreton et al., 2017). Plastic waste tends to accumulate at every depth possible, though its spatial distribution is determined by river inputs, shipping routes and generally human activities (Gerigny et al., 2019).

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Despite the lack of quantitative data regarding accumulation patterns, plastic debris has been found even in one of the world's most remote and pristine islands in the South Pacific, the Henderson Island. The density of plastic debris on the surface of the island's beaches is among the greatest at a global scale, with approximately 37.7 million items of plastic debris weighing 17.6 tons in total existing on the island (Lavers and Bond, 2017). In this sense, though seldomly visited by humans, Henderson Island is considered to be a sink for plastic waste, together with other equally remote islands, accumulating an amount of approximately 26.8 new items/m of plastic debris on a daily basis (Lavers and Bond, 2017).

In reference to plastic debris, marine microplastics are considered most prominent as they have been documented to be discharged into the oceans at an increasing rate. Microplastic debris has been found in sediments in the three deepest hadal trenches worldwide located in the Pacific Ocean and characterized by a depth of up to 10,890 meters, therefore, confirming once again certain statements made that plastic waste has reached full-ocean depth (Peng et al., 2020). This unfortunate result can be described via certain cascading processes taking place, thus, enabling the transportation of microplastics from sea surface to seafloor, as in the case of land and sea-based input sources as well as ingestion by marine organisms and the subsequent trophic transfer among other physical processes (i.e. deep water currents, oceanic gyres) within the hadal trenches. Consequently, hadal trenches are regarded as major depositories for plastic pollution, prompting severe consequences for deep-sea ecosystems (Peng et al., 2020).

It has been estimated that approximately 245 tons of microplastics are produced on an annual basis, most of which end up in the ocean while they can also be classified into primary and secondary microplastics on account of their sources (Morris, 2015; Grossman, 2015; Auta et al., 2017). Primary microplastics are consisted of plastic particles widely applied in everyday products such as toothpaste, facial cleansers, resin pellets, shower gels, scrubs and peelings, deodorants, eye shadow, make up foundation, mascara, blush powders, shaving cream, baby products, nail polish, bubble bath lotions, insect repellents, sunscreen and hair coloring (Fendall and Sewell, 2009; Costa et al., 2010; Cole et al., 2011; Castañeda et al., 2014; Duis and Coors, 2016; Auta et al., 2017). In addition, they include synthetic clothing along with abrasives commonly found in cleaning products (Gregory, 1996). The patenting of microplastic scrubbers in the field of cosmetic products during the 1970s significantly contributed to the extensive and widespread use of

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exfoliating cleansers with microplastics, whilst the widely advertised micro-exfoliators and micro-beads contained within these products constitute a major part of plastic pollution (Fendall and Sewell, 2009; Auta et al., 2017).

The other category relates to secondary microplastics, essentially referring to macroplastic debris fragmented and reduced into smaller particles as a result of a series of chemical, physical and biological processes together with various environmental factors, such as ultraviolet radiation and high temperatures (Mailhot et al., 2000; Lucas et al., 2008; Andrady, 2011; Cole et al., 2011; GESAMP, 2014; Wagner et al., 2014; Norwegian Environment Agency, 2015; Auta et al., 2017). This continuous process of degradation into smaller pieces of plastic and microplastics significantly contributes to their accumulation in the marine environment along with all the associated harmful impacts with regard to marine organisms (i.e. ingestion, biomagnification etc.) (Law and Thompson, 2014; Shim and Thompson, 2015).

5.1.4 Statistics

Based on the recently developed database by the Global Oceanographic Data Center (GODAC) of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), more than 33% of the plastic debris was characterized as macroplastics, the 89% of which was single-use products. Plastic bags, one of the most common plastic single-use item worldwide, have been found in depths of up to 10,898 meters as in the case of the Mariana Trench (Chiba et al., 2018). As a result, one can deduce that land-based activities have affected even the deepest parts of the ocean in areas located more than 1km away from the mainland. Land-based inland pollution can produce up to half a million tons, while microplastics amount to approximately one million tons (Eunomia, 2016; Almroth and Eggert, 2019). The infamous gyre commonly referred to as the Great Pacific Garbage Patch (GPGP) or Pacific trash vortex, located between California and Hawaii, is the biggest collection of floating marine debris primarily formed by plastics resulting from land-based and sea-based plastic pollution. In particular, it is comprised of 1.8 trillion pieces of floating plastic debris, 94% of which can be attributed to microplastics (Lebreton et al., 2018; Almroth and Eggert, 2019).

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However, the answer to the crucial question regarding the total amount of plastic waste in the ocean is inconclusive, taking into account the fact that the ocean is currently under-sampled (Eriksen et al., 2014), whilst once plastics enter the ocean, they undergo a series of degrading processes such as biodegradation by microorganisms, photodegradation by sunlight and mechanical stress due to wave actions. As a result, they break into increasingly smaller pieces, thus, reforming as microplastics (Ballerini et al., 2018; Barcelo, 2020). Taking into account observational data and ocean models, it has been estimated that on a global level the aggregate amount of small plastic debris floating on the ocean surface weighs approximately between 93,000 to 236,000 Mt, representing only 1% (of microplastics) compared to the estimated 8 million Mt of plastic waste entering the ocean from land-based inputs on an annual basis (van Sebille et al. 2015; Jambeck et al., 2015; Ballerini et al., 2018).

Data derived from Ocean Conservancy's annual International Coastal Clean-Ups (ICC) have accounted for approximately 10,584 tons of litter regarding the year 2019, thus, incrementally increasing from the 7,000 tons during 2014 (Ocean Conservancy, 2014; 2019). Nevertheless, the detection and quantification of microplastics or even nanoplastics (smaller than 1000 μm) is very difficult and still at an early stage (Enders et al., 2015; ter Halle et al., 2017). In addition, contemporary research has shown that several marine microorganisms (plankton, filter feeders, small fish) consume microplastics, therefore, "concealing" in that way certain amounts of plastic waste (Van Cauwenberghe and Janssen, 2014; Cole et al., 2015; Ballerini et al., 2018). According to estimates based on 24 expeditions during the period 2007–2013 regarding the five sub-tropical gyres, the Mediterranean Sea, the Bay of Bengal and coastal Australia, the number of plastic particles accounted for at least 5.25 trillion weighing 268,940 tons (Eriksen et al., 2014). In brief, as previously mentioned approximately 4-12 Mt of plastics enter the oceans every year, while early projections indicate that by the year 2050 plastics will exceed the total number of fish in the oceans (WEF, 2016). As a result, roughly 57-78% of the plastic waste produced will enter the oceans, while the remaining 22–43% will most probably end up in landfills, bearing in mind that the majority of which is non-biodegradable, potentially requiring even 500 years to effectively decompose (Barcelo, 2020).

Studies have shown that roughly 75% of marine litter in the oceans, on a global level, is consisted of plastics, while it has been estimated that between 4.8 - 12.7 million tons of plastic waste

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generated on an annual basis, eventually enters the ocean (Jambeck et al., 2015). Plastics account for almost 85% of marine litter by count regarding European beaches, half of which refers to single-use items (European Parliament, 2017). The significance of marine litter as a contemporary environmental threat and “stressor” in relation to marine and coastal ecosystems is also evident when considering the fact that it relates to one of the 11 Descriptors (Descriptor 10) of the MSFD.

It has yet to be defined if we will or already have exceeded our planet’s critical threshold, and all the associated fatal repercussions with regard to ecosystem functions and ecological communities, in the case of marine plastic pollution, being considered an integral part of one of the nine planetary boundaries (novel entities/chemical pollution), but also closely associated with core planetary boundaries such as biosphere integrity and climate change (Villarrubia-Gómez et al., 2018). Chemical pollution is among those planetary boundaries that negatively affect human well-being on account of its detrimental impacts on the resilience of the planet’s ecosystems. This assertion is derived on the basis of Earth’s finite capacity for assimilation regarding chemical pollution, including chemicals such as plastics, continually released to the environment from local to global scale and backwards (Diamond et al., 2015).

The majority of surveys and expeditions performed worldwide on the measurement and discovery of plastic waste tend to focus on the North Atlantic and North Pacific accumulation zones. Nevertheless, research has shown that the accumulation of plastic marine debris, and especially microplastics, during the year 2014 ranged from 15 to 51 trillion particles globally, characterized by an aggregate weight of 93 to 236 thousand metric tons (van Sebille et al., 2015). Plastics constitute a major part (approximately 50-90%) of the total amount of marine litter found at a global scale, while roughly 4.8 to 12.7 million metric tons of consumer plastics enter the oceans on an annual basis. In addition, almost 100 million particles of macroplastics exist in 12 regional seas worldwide, while 51 trillion particles of microplastic float on the ocean surface globally (Periathamby et al., 2019). In that sense, based on previous research and available data, it can be said with confidence that the amount of debris entering the oceans on an annual basis is increasing (5.8 million tons of debris in 2009 and 8 million tons of debris in 2010 at a global scale) (UNEP, 2009; 2015).

The five oceanic subtropical gyres, as mentioned before, are located in the Indian Ocean, the North Atlantic, the North Pacific, the South Atlantic and the South Pacific respectively,

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accommodating an approximate amount of 91 million tons of marine debris (Vannela, 2012). At this point, it would be useful to denote that marine debris, plastics being prominent among them, can be classified in three main categories. In particular, deposited marine debris (i.e. stranded on beaches), floating marine debris (i.e. the ones which float on ocean surfaces) and submerged marine debris (i.e. submerged in the sea water) (Barnes et al., 2009; Keller et al., 2010; Costa et al., 2011; Eriksson et al., 2013; Pham et al., 2014; Andrady, 2015; Zhou et al., 2016). As presented in Table 5-1, plastic bags, bottles, drinking straws, bottle caps and netting, represent the most common items (marine debris) discovered, while they are also characterized by the highest demand, based on their resin types, in the case of Europe.

Table 5-1: Types of plastics which are frequently found in the marine environment

Type of plastics	Demand by resin type (Mt)*	Products produced
Low-density polyethylene (LDPE / LLDPE)	9	Plastic bags, bottles, drinking straws, six-pack rings, netting
High-density polyethylene (HDPE)	6	Milk and juice jugs
Polypropylene (PP)	10	Rope, bottle caps, netting
Polystyrene (PS)	2	Plastic utensils, food containers
Thermoplastic Polyester (PET)	4	Plastic beverage bottles
Polyvinyl chloride (PVC)	5	Plastic film, bottles, cups
Cellulose Acetate (CA)	-	Cigarette filters

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Nylon (PA)	1	Netting and traps
Foamed Polystyrene	-	Floats, bait boxes, foam cups

* Distribution of European (EU28+NO/CH) plastics converters demand by resin type in 2018 (PlasticsEurope, 2019).

Source: Adapted from Andrady, 2011.

Plastic production has kept up with high growth rates for several decades and an approximate annual average rate of 5% (Andrady and Neal, 2009), while global production increased to almost 360 Mt in 2018 from 348Mt in 2017. In the case of Europe, annual aggregate production reached 62Mt during the year 2018 (PlasticsEurope, 2019). Consequently, the plastic waste generated is characterized by similar growth patterns (Geyer et al., 2017), while hotspots of almost 1.9 million pieces per m² have been formed by microplastics as in the case of the Tyrrhenian Sea, representing the highest values to have actually been recorded regarding the deep-seafloor on a global level (Kane et al., 2020).

5.2 Effects on marine and coastal ecosystems

The pollution of marine and coastal ecosystems from marine debris, and especially plastic waste, has been deemed a major environmental threat globally (UNEP, 2011), whilst its negative effects on the marine environment have already been thoroughly presented (Shomura and Yoshida, 1985; Laist, 1997; Derraik, 2002; Katsanevakis, 2008). Plastics can be fragmented into progressively smaller pieces (microplastics, nanoplastics) less visible, though very dangerous for marine wildlife, either by abiotic factors or via animal digestion processes (Van Franeker et al., 2011; Kühn et al., 2015), with subsequent deleterious implications for humans, being at the top of the food chain (UNEP, 2011; Koch and Calafat, 2009; Galloway, 2015; Galgani et al., 2014; Deudero et al., 2015; Romeo et al., 2015; Fossi et al., 2019).

The most frequent and widely acknowledged problems caused by plastic waste and debris are related to ingestion, suffocation, entanglement, and the debilitation in general, of marine organisms. Nevertheless, there is a plethora of other less recognized problems such as damages

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to fisheries, commercial shipping, maritime activities along with the “hitch-hiking” effect on the basis of pelagic plastic debris. In the latter case, these “hangers-on” (or hitch-hikers) enable the dispersal and invasion of aggressive and harmful alien species to other marine and coastal environments, thus, endangering biomes and their native habitats (Gregory, 2013).

An efficient method to properly present the impacts of marine debris, and plastic waste in particular, on the marine and coastal ecosystems would be to classify them into four main categories: (i) injuries, death to marine organisms, (ii) harmful effects to the marine and coastal environment, (iii) negative effects to the global/local economy and (iv) adverse effects on human health (Derraik, 2002; Kühn et al., 2015; Periathamby et al., 2019; Fossi et al., 2019). Ingestion and entanglement are strongly associated with high mortality rates regarding many marine organisms in addition to inflicting damages and adversely transforming the benthic communities’ structure (Gall and Thompson, 2015; Katsanevakis et al., 2007; Consoli et al., 2018; CBD, 2016).

5.2.1 Ingestion

Marine organisms, microorganisms, and mammals tend to accidentally or mistakenly ingest plastic debris due to its appearance, as it can easily be mistaken for their natural prey (Day et al., 1985; Laist, 1997; Cole et al., 2011; Wright et al., 2013; Campani et al., 2013; Kühn et al., 2015; Romeo et al., 2016) or due to “filter feeding” while feeding on their natural prey, hunting, and secondary ingestion (Fossi et al., 2014; Romeo et al., 2015; Battaglia et al., 2016; Fossi et al., 2017).

The ingestion of plastic debris and rubber has been documented since the 1970s in Japan (Kubota, and Uyeno, 1970) as well as in the case of the U.S.A. during 1972 (Carpenter and Anderson, 1972). Ingested microplastics have been discovered in a variety of marine organisms from invertebrates to vertebrates including endangered species, wild caught organisms and many species fit for human consumption, marine megafauna and zooplankton located in water columns, sub-surface waters, deep sea floors, benthic sediments and coastlines (Thompson et al., 2004; Desforges et al., 2014; GESAMP, 2015; Enders et al., 2015; Fischer et al., 2015; Li et al., 2016; Ling, 2017; Sun et al., 2017; Germanov et al., 2018; Kroon et al., 2018; Wright et al., 2013; Kühn et al., 2015; Deudero and Alomar, 2015; Werner et al., 2016). The accumulation of plastic debris in their stomachs

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directly and adversely affects their well-being and fitness, even in cases with no fatal results (Van Franeker, 1985; Bjorndal et al., 1994; McCauley and Bjorndal 1999; Kühn et al., 2015).

In particular, depending on the size of the plastic debris and species at hand, pieces or particles of plastic are ingested and either jammed or gradually accumulated to the point where their gastrointestinal tract is blocked, causing either physical or/and mechanical damage as in the obstruction of the gastrointestinal tract, congestion of feeding appendages or filters, abrasions and inflammation, coupled with pseudo-satiation and subsequently reduced food intake and death (Cole et al., 2011; Wright et al., 2013; Kühn et al., 2015; Li et al., 2016; Peda et al., 2016; Werner et al., 2016; Fossi et al., 2017). Plastic ingestion has been associated with at least 91 Mediterranean species among different taxonomic groups including fish, seabirds, sea turtles, marine mammals as well as invertebrates, with strong implications indicating that this problem is highly underestimated as the majority of these species may fall prey to other predators or remain undiscovered in the vast bodies of water surrounding the continents (Wolfe, 1987; Laist, 1997; Derraik, 2002; Rizzi et al., 2019; Anastasopoulou et al., 2018).

On a global scale, approximately 700 species have been documented to ingest marine litter, especially Plastic Marine Litter (PML), while in the case of Greece, being an integral part of the Mediterranean Sea, recent studies have shown that even in deep waters microplastic ingestion occurs, as documented in the cases of the north eastern Ionian Sea and the Adriatic Sea, the latter being one of the most affected regions of the Mediterranean Sea (Pribanić et al., 1999; Madurell, 2003; Anastasopoulou et al., 2013; Gall and Thompson, 2015; Pellini et al., 2018; Vlachogianni et al., 2017; Liubartseva et al., 2018; Anastasopoulou et al., 2018). In addition, ingested plastic particles and debris (by marine organisms) are associated with chemical processes and impacts occurring within the context of marine food webs, eventually affecting human beings. As mentioned above, marine litter and debris can have adverse effects on human health, taking into consideration the fact that a lot of marine organisms may have already ingested plastic waste, therefore, becoming part of a process toward the potential transfer and subsequent accumulation of hazardous chemicals related to plastics (Farrel and Nelson, 2013; Setälä et al., 2014; Kühn et al., 2015; Ryan, 2016; Anastasopoulou et al., 2018).

This mechanism and process of “bioaccumulation” or “biomagnification” through the trophic web is associated with plastic debris (mainly microplastics and nanoplastics) acting as a direct or

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indirect vector for introducing and transferring harmful chemical substances across the food web (Koelmans et al., 2016; Fossi et al., 2017). Plastic additives such as PBDEs, phthalates and (PBT) substances can be transported via marine plastic litter to several marine organisms due to certain processes such as leaching and sorption. In the case of the Mediterranean basin, the extensive distribution of marine litter coupled with the high biodiversity strongly indicate that many species have been impacted, thus, inevitably and eventually impairing human health (Coll et al., 2010; Avio et al., 2015; Hermabessiere et al., 2017; Fossi et al., 2017). Taking into account the fact that human fish consumption is increasing, being an essential part of human diet, along with the ever-extensive global plastic production, serious concerns have been raised regarding the anticipated adverse effects on human health and well-being (Boerger et al., 2010; Lusher et al., 2013; Neves et al., 2015; FAO, 2016; Bråte et al., 2016; Nadal et al., 2016; Forrest and Hindell, 2018; Pellini et al., 2018; Anastasopoulou et al., 2018).

5.2.2 Entanglement

Another detrimental aspect of plastic debris and pollution to marine wildlife relates to entanglement, usually due to discarded debris or lost items such as fishing gear and ropes, often referred to as “ghost fishing” along with plastic bags, six-pack drink holders, balloons, and sheets (Breen, 1990; Norman et al., 1995; Laist, 1997; Matsuoka et al., 2005; Baulch and Perry, 2014; Votier et al., 2011; Bond et al., 2012; Rodríguez et al., 2013; Kühn et al., 2015). Entangled wildlife from various species (fish, marine birds, turtles, mammals, and invertebrates) gets restricted, and therefore unable to effectively move, hunt, feed or even breathe, whilst ghost nets are also responsible for inducing damages to benthic habitats (Plotkin and Amos, 1990; Bavestrello et al., 1997; Camphuysen, 2001; Pawson, 2003; Yoshikawa and Asoh, 2004; Chiappone et al., 2005; Good et al., 2010; Moore et al., 2013; Kühn et al., 2015). In addition, entanglement may cause amputations, skin infections, and septicemia to marine wildlife as in the case of turtles (Orós et al., 2005; Barreiros and Raykov, 2014). At this point, it is deemed necessary to refer to another negative impact contributed to plastic pollution, sometimes falsely categorized under entanglement, though it is quite different and referred to as “smothering”. Plastic seabed litter adversely affect marine flora and fauna, as they reduce the necessary light intake for

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photosynthesis or squash sensitive vegetation, therefore, forming anoxic sediments (Goldberg, 1994; Uhrin et al., 2005; Goldberg, 1995; Kanehiro et al., 1995; Hess et al., 1999; Derraik, 2002; Viehman et al., 2011; Uhrin and Schellinger, 2011; Kühn et al., 2015). It has been documented that due to these effects coral covers along with primary productivity and organic matter keep decreasing, while macroplastics hinder corals' capacity regarding phototrophic and heterotrophic nutrition (Katsanevakis et al., 2007; Richards and Beger, 2011; Schlining et al., 2013; Green et al., 2015; Kühn et al., 2015).

As previously mentioned, bioaccumulation or bioamplification phenomena tend to disrupt and contaminate the marine trophic web (Nelms et al., 2018; Carbery et al., 2018), whilst enabling the transportation of persistent organic pollutants (POPs) and all that it entails (Mato et al., 2001; Teuten et al., 2009; Mathalon and Hill, 2014; Rochman, 2016; da Costa et al., 2016; Periathamby et al., 2019). POPs usually enter the marine food web through partitioning based on mesoplastics and microplastics (Moore, 2008; Teuten et al., 2007; Andrady, 2011; Reisser et al., 2014). In the case of microplastics particularly, plastic bioaccumulation along with all the associated chemical pollutants tend to exacerbate (Rochman et al., 2015; Worm et al., 2017). The continuous intake of microplastics by marine organisms enables and further assists the absorption, accumulation and transfer of pathogens and toxic pollutants through the trophic web, resulting in decreased immune responses, impaired reproductive activity and malformation in marine organisms (and subsequently humans) (Barnes et al., 2009; Zarfl and Matthies, 2010; Andrady, 2011; Barcelo, 2020).

Furthermore, plastic litter and debris enable species transportation as well (Gregory, 2009; Farrell et al., 2013; Tutman et al., 2017), a critical issue which coupled with the aforementioned ingestion and entanglement hazards led to the adoption of the Candidate Indicator 24 *“Trends in the amount of litter ingested by or entangling marine organisms focusing on selected mammals, marine birds, and marine turtles”* under Ecological Objective 10 (Marine Litter) by the UN Environment Integrated Monitoring and Assessment Programme of the Mediterranean Sea and Coast and Related Assessment Criteria (IMAP) (Rochman et al., 2013). In this context, it is necessary to denote that the true extent regarding the global impact of marine litter, and specifically plastic debris, is probably underestimated as there is still a plethora of unexplored areas, whereas many studies do not account for quantitative data (de Carvalho-Souza et al., 2018).

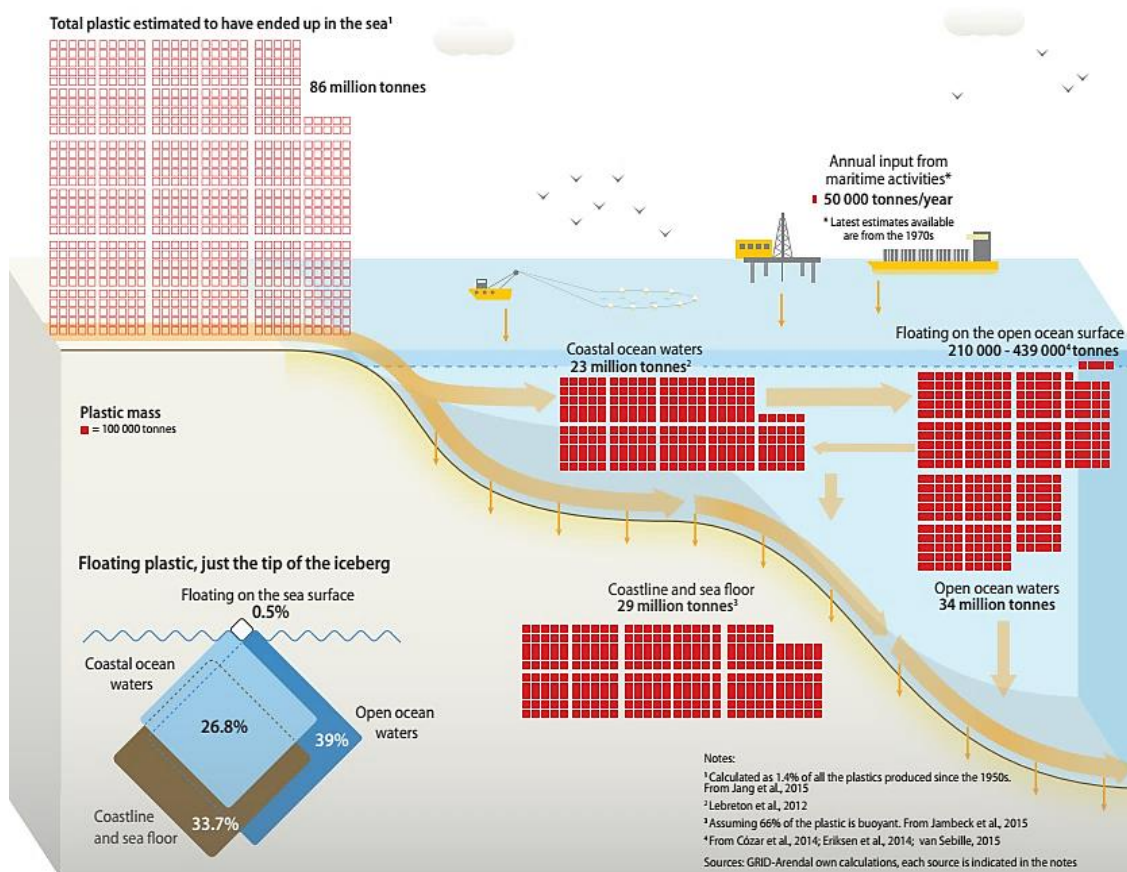
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5.2.3 Biodiversity

Plastic marine litter is associated with detrimental effects in terms of biodiversity and ecosystem processes, taking into account the fact that the majority of plastic litter ends in the ocean, through either land-based or sea-based inputs and human activities, adversely affecting marine habitats and biota. As depicted in Figure 5-4, PML is commonly detected on the open ocean surface (floating), in the water column, on the sea floor as well as in beaches and coasts, being the most visible options. In the case of the Mediterranean Sea, both on a regional and local scale, evidence has shown an abundance of PML, therefore, making it one of the most polluted (by marine litter) areas worldwide (Galgani et al., 2000; Aliani et al., 2003; Pham et al., 2014; Ioakeimidis et al., 2014; Suaria and Aliani, 2014; Vlachogianni and Kalampokis, 2014; Angiolillo et al., 2015; UNEP/MAP, 2015; Cozar et al., 2015; Fossi et al., 2016, 2017).

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Figure 5-4: Estimation on the quantity and fate of plastics in the oceans



Source: Maphoto/Riccardo Pravettoni; GRID-Arendal, 2018.

<https://www.grida.no/resources/6907>

Bearing in mind that the Mediterranean Sea is considered an essential biodiversity hotspot, the superfluity of plastic litter and debris entering and accumulating in the marine environment, habitats and domains can critically influence their healthy functioning and transform their consistency. Based on the results of Suaria and Aliani (2014), it was estimated that approximately 62 million macrolitter items floated on the surface of the Mediterranean basin. The first “interactions” of plastic litter with marine organisms (due to ingestion) were documented during 1988 in the case of the Mediterranean Sea (Gramentz, 1988) and since then they gradually increased in terms of frequency (Carrason et al., 1992; Massut   et al., 1998; Deudero, 1998; Madurell, 2003; K  hn et al., 2015; Fossi et al., 2017).

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The fact that plastic marine litter is considered a serious threat for Mediterranean marine organisms and biodiversity in general, is further supported by Deudero and Alomar (2015) reporting approximately 134 marine species (sea turtles, baleen whales, filter feeding sharks etc.) which have been affected by marine litter, including plastic additives (phthalates) and microplastics (Galgani et al., 2014; Romeo et al., 2015; Darmon et al., 2017; Fossi et al., 2017; Baini et al., 2017; Germanov et al., 2018; Fossi et al., 2019). Within this framework, a threefold monitoring approach is currently being tested in order to assess the harmful effects of plastic pollution in the Mediterranean Sea based on marine litter ingested, evaluation of plastic additives and POPs levels in tissues and the related toxicological effects (Fossi et al., 2019).

5.3 Economic impacts of plastic pollution

Plastic debris and litter constitute plastic waste which in turn represent a significant proportion of marine litter that is associated with major economic costs. In this sense, any economic value linked to plastic waste should reflect the social impacts induced by plastic pollution. However, bearing in mind that the marine environment pertains to public goods (Costanza et al., 1997), the accurate estimation of economic losses on account of plastic waste is an arduous process. The economic effects of plastic pollution may also be assessed from different perspectives. In particular, considering the impact of marine plastics on ecosystem services, the economic costs are evaluated on the basis of marine natural capital, referring to the global stocks of natural assets (Beaumont et al., 2019). This type of economic cost exclusively refers to the impacts of plastic waste on marine natural capital, thus, representing only a portion of the total or “potential” economic costs of marine plastic pollution.

In the case of Beaumont et al. (2019), after having conducted a semi-systematic literature review of 1,191 data points, a basis was formed for the identification of all the ecological, social and economic impacts on a global level, resulting in the utilization of a scoring system in order to indicate risks for certain ecosystem services worldwide which are correlated with potential social and/or economic costs or benefits. During the economic valuation of plastic waste it is important

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to accurately assess these impacts as they directly or indirectly affect human well-being and living standards (Lee, 2015).

In addition, it is essential when referring to economic costs, to differentiate among costs related to expenditure, costs of loss in revenue or output and the evaluation of welfare costs based on economic terms. In that regard, the aforementioned negative impacts of plastic pollution may induce direct or indirect costs. Direct costs are associated with foregone benefits for certain industries along with various economic activities in general (e.g. commercial shipping, fishing vessels, leisure craft, tourism etc.), while indirect costs usually refer to the effects of plastic pollution on non-market assets, such as ecological processes performed via marine and coastal ecosystems, therefore, influencing social welfare (McIlgorm et al., 2009). Welfare losses are considered a type of indirect cost due to the associated repercussions on non-market services, thus, incorporating indirect use values, non-use values and option values related to marine and coastal ecosystem services. Subsequently, public perception can be pivotal during the evaluation process of social cost, as it embodies the impacts and negative effects of plastic pollution on diminishing people's welfare.

Furthermore, costs can be differentiated on the basis of action and inaction. In particular, costs of inaction include several consumer groups affected by plastic pollution on the marine and coastal environment (i.e. direct and indirect costs related to reduced recreational values, impairment on human health etc.). On the other hand, costs of action are related to potential or required means of engagement and mitigation on behalf of both producers and consumers aiming at preventing or reducing plastic waste and marine litter (UN Environment, 2017). Economic costs associated with expenditure are usually comprised of costs regarding beach cleanups, damage costs to fishing vessels (e.g. obstruction of motors), loss of fishing gear, hospitalization costs due to health related issues induced by plastic debris etc., while economic costs referring to loss of revenue/output include among others revenue loss from fish catches, tourism and recreation. Welfare cost assessments often incorporate appraisals regarding certain economic values associated with losses in recreational activities or opportunities, cultural values such as landscape aesthetics etc. (Newman et al., 2015).

Several industries, as in the case of shipping and yachting industries, suffer from plastic pollution in the marine and coastal environment due to the additional costs of removing plastic litter from

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their facilities and vessels (anchors, propellers, rudders, blocked intake pipes and valves), need of repairs or replacements regarding damaged equipment induced by plastic marine litter and loss of revenue on account of contaminated or reduced catches (including ghost fishing) (Wallace, 1990; Sheavly and Register 2007; MacFayden et al., 2009; Mouat et al., 2010; Newman et al., 2015). Aquaculture industry faces similar costs due to the fact that plastic debris often get entangled in propellers and block intake pipes, whilst the constant removal of marine plastic litter from or around fish farms is time consuming and expensive (Mouat et al., 2010; Newman et al., 2015). In addition, though it may seem odd even business in the agricultural sector are impacted by plastic waste, especially in certain locations as a result of wind and coastal tides, blowing and washing up plastic debris and litter on coastal farmlands, thus, inflicting damages to equipment and negatively affecting livestock due to ingestion and entanglement (Newman et al., 2015).

Plastic marine litter and debris are most commonly associated with significant economic costs in relation to coastal tourism and recreational activities, as they aesthetically and visually diminish landscape quality values, therefore, limiting the overall beach attendance along with recreational opportunities and land-based tourism activities (UNEP, 2009; Mouat et al., 2010; Munari et al., 2016; Brouwer et al., 2017). However, plastic waste is also closely linked to indirect costs which represent welfare losses due to impacts on non-market services associated with indirect use values, non-use values (i.e. existence value, bequest value and altruistic value), and option values regarding marine and coastal ecosystem services. In this context, stated preference methodology is commonly applied in order to estimate these values via the elicitation of people's preferences and their willingness to pay (WTP) for the reduction/removal of plastic debris and litter from the marine/coastal environment.

Hence, social cost is estimated according to public perception on the impact of plastic waste on the beaches/coasts and how it affects them (their experiences). In addition, their willingness to assist within the framework of certain collective actions (volunteering for beach cleanups etc.) or via donating money, taxation, and paying entrance fees reflect elements of social cost. It is often inferred that higher WTP values are correlated with increasingly higher intensity with respect to the negative effects of plastic waste on the marine/coastal environment. WTP values tend to differentiate on the basis of location, public perception and the socio-economic as well as demographic status of beach visitors, while the progressive reduction of plastic waste (resulting

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from successful mitigating actions) is associated with gradually lower WTP values for further reducing plastic waste (Faris and Hart, 1994; Coe and Rogers, 1997; Blakemore and Williams, 2008; Ostberg et al., 2012; Beharry-Borg and Scarpa, 2010; Brouwer et al., 2017; Latinopoulos et al., 2018).

Plastic pollution and the impacts of plastic litter are closely related to ecosystem degradation, environmental damage and a growing showcase of public health and safety concerns (National Research Council, 2009; Thompson et al., 2009; Manzoor and Dar, 2020; Cook and Halden, 2020). The evaluation of the socio-economic impacts induced by plastic waste on the marine and coastal environment is usually conducted via the utilization of specific economic values regarding marine/coastal ecosystems and their resources. The most commonly quantifiable aspects and sectors are associated with tourism, fisheries, and transport while there is a currently rising interest in human health as well. However, limitations exist in terms of omissions or underestimations regarding social and/or economic costs not easily quantifiable, therefore, being excluded during the assessment process of the aggregate economic cost of marine plastic pollution. Furthermore, the life-cycle of plastic litter from macro to micro and/or nano also complicates the evaluation procedure, whilst the existing complexity in terms of ecological information coupled with publishing biases regarding specific species and locations limit the available existing database (Beaumont et al., 2019).

5.3.1 Case studies

Based on Ofiara and Brown (1999), it was estimated that due to a decrease of roughly 8-33 % on beach visitation for the Jersey shores, resulting from plastic pollution regarding the 1987-1988 time period, a 15-40% economic loss equivalent to USD 0.25-1.23 billion occurred. In addition, during the year 1988 losses in tourism revenues in the New York Bight, USA reached USD 379.1–1597.8 million on account of plastic waste and pollution (Ofiara and Brown, 1999). Marine debris flowing from the Nakdong River are closely linked to economic loss in tourism revenues of approximately USD 29–37 million (Jang et al., 2014). In the case of the EU, marine litter (plastic being prominent among them) induced a total cost of up to €259 - 695 million on an annual basis

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for the tourism industry, €630 million for recreational activities and almost €62 million for the fisheries sector (European Parliament, 2017).

In Los Angeles, California costs of approximately USD 68 million on an annual basis regarding tourism are linked to marine debris (Leggett et al., 2014), while coastal communities in Oregon, California and Washington, D.C. invest almost USD 520 million annually for marine debris control (Stickel et al., 2012). The significance of this type of negative impacts induced by plastic waste is most evident when calculating the time and funds spent by coastal communities along with volunteer organizations towards mitigating and resolving them. In particular, as far as removal efforts are concerned, they are typically comprised of daily raking with tractor-type equipment from the relevant municipality authorities, volunteer beach cleanups, and adopt-a-beach programs, whilst prevention efforts usually include public outreach programs, street sweeping, and installation of in-stream catchment devices (Leggett et al., 2018).

It has been documented on various studies that beach selection and visitation is correlated with landscape quality and marine litter generation, therefore, denoting that extensive litter presence negatively affects visitors, further deterring them from choosing that specific beach (Tinch et al., 2012; Santos et al., 2005; Brouwer et al., 2017). Several contingent valuation studies evaluating the non-market values of beach litter management based on the WTP values of the respondents have confirmed for the most part these correlations (Smith et al., 1997; Loomis and Santiago, 2013). In this sense, within the framework of a successful and efficient DCE (discrete choice experiment) it is important to thoroughly investigate public perception on marine litter for each of the selected beaches, WTP for volunteering beach cleanups as well as WTP entry fees and municipality taxation at a local scale for reducing marine litter (particularly plastic waste). The WTP values are usually elicited via the presentation of alternative beach cleanup scenarios to the respondents (potential/actual visitors), as the WTP value is associated with potential welfare losses for the visitors, due to the presence of plastic litter on the beaches, from which social cost can be derived (Brouwer et al., 2017).

At this point, it is deemed important to convey the significance of differentiating between plastic pollution sources, i.e. marine litter and/or plastic debris washed ashore, and litter left behind by beach visitors, as a substantial amount of plastic litter originates by beach visitors (OSPAR, 2009). Based on Leggett et al. (2018), through a combination of revealed preferences valuation

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methodology and field measurements regarding marine debris at beaches for Orange County, CA, it was discovered that marine debris was an essential factor in terms of beach recreation decisions. In particular, projections indicate that if a reduction of roughly 25% in the quantity of marine debris for 31 beaches in total were to take place, it could potentially lead to aggregate benefits of approximately USD 29.5 million for the local residents of Orange County within a three-month period. In addition, the estimated aggregate consumer surplus originating from beach trips at all 31 sites was evaluated at USD 742 million, on account of the estimated loss due to potential beach closures (Leggett et al., 2018). In terms of aggregate consumer surplus, the aforementioned welfare gain generated from the 25% reduction in the amount marine debris, is equivalent to approximately 4% of the aggregate consumer surplus, whilst a 75% reduction may even lead to a welfare gain of up to 13% (of aggregate consumer surplus).

In the case of South Korea, a single though extensive rainfall incident brought about revenue losses of USD 29–37 million due to coastal debris (Jang et al., 2014; Schuyler et al., 2018). With regard to China, it is estimated that coastal tourism contributes over 10% to the country's GDP (EEA, 2006; Shi, 2015), whilst in the case of Tianjin the approximated WTP values for a 10% reduction in marine litter and oil pollution has been estimated to USD 3.54 on an annual basis (Zhai and Suzuki, 2008).

The socio-economic costs of marine litter for coastal tourism and recreational activities have been characterized as substantial at a global scale (Galgani et al., 2013; Newman et al., 2015; Munari et al., 2016; Williams et al., 2016; Keswani et al., 2016; Shen et al., 2019), with notable cases studies the Lee (2015) for the United Kingdom, where it was estimated that the aggregate cost of marine litter for coastal tourism industry was within the range of USD 8.67-26 million, while based on Mouat et al. (2010) estimations for the Netherlands and Belgium an aggregate annual cost of USD 16.20 million was reported for beach litter removal.

In reference to specific sites of the island country of Seychelles (Beau Vallon, La Digue, Ste. Anne Island, etc.), the economic value of marine and coastal ecosystems and their resources respectively was estimated within the context of certain benefits generated for sectors such as tourism, recreational activities, fisheries together with amenity/coastal protection, and research/biodiversity. These values were evaluated based on net present value terms, applying a 3% discount rate for a 25 year time period. The net present value of Beau Vallon was estimated

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at USD 320.17 million, while for La Digue it was USD 159.39 million and USD 359.49 million for Ste. Anne Island accordingly (Cesar et al., 2004). Furthermore, considering the approximated benefit cost ratio, it is deduced that net benefits for society largely exceed net-costs (e.g. USD 2.73 million for Beau Vallon, USD 5.93 million for La Digue etc.) (Cesar et al., 2004). In that sense, further financial investments toward the proper management of MPAs (Marine Protected Areas) as in the case of the aforementioned may prove to be rather profitable.

From an economic cost perspective with regard to beach cleanups/litter removal (costs of action), the overall cost (for litter removal from beaches) in the case of Peru and one particular municipality reached USD 200,000 (McIlgorm et al., 2011). Based on Fanshawe and Everard (2002) and their estimations, costs associated with marine litter for the UK add up to USD 35 million on an annual basis, while the cost of marine litter to UK's aquaculture has been estimated at USD 475,000 due to certain necessary actions that must be taken (cage clearance, fouled propellers and intakes etc.). At the same time, the cost of marine litter for tourism may range from USD 2.27 million to USD 823 million annually, based on simulations for selected UK sample regions according to Van der Meulen et al. (2014) for the 2010-2100 time period. These figures have been calculated on the premise that aggregate regional costs for beach cleanups will amount from USD 188,735 to USD 2.5 million on an annual basis (UN Environment, 2017).

As far as the shipping industry is concerned, during the year 2008 the cost of damaged ship propellers for 286 cases in UK waters was estimated within the range of USD 1.1 million to USD 2.9 million (Mouat et al., 2010), whilst the recovery and disposal of marine litter in ports and harbors along with the provision of rescue services reached USD 9 million (MaLiTT 2002). Regarding the USA and the year 2005 in particular, marine submerged litter induced property damages of USD 2.9 million in total as well as 15 deaths, 116 injuries and 269 boating incidents (USCG, 2005; UN Environment, 2017). In the case of Korea, a marine litter related damage to the propeller of a vessel resulted in 292 deaths, taking into account that 9% of all reported Korean shipping accidents involved marine litter during the period 1996-1998 (Cho, 2005; UN Environment, 2017).

The total amount of marine litter, and especially MPL, entering the oceans globally is growing at an alarming rate, negatively affecting marine ecosystem services delivery. As a result, it has been inferred that a decline within the range of 1-5% for marine ecosystem service delivery is

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equivalent with an economic loss of USD 500–2500 billion annually on a global level in terms of value with regard to benefits originating from marine ecosystem services (Beaumont, et al., 2019). This approximation of economic cost is derived by Constanza et al. (2014) estimations, based on which marine ecosystem services provided benefits to society amounting to approximately USD 49.7 trillion on an annual basis for the year 2011. In this context, this annual economic cost linked to marine plastic pollution is directly associated with reductions (degradation) in marine ecosystem services delivery and marine natural capital and will keep on rising as long as the stock of MPL in the marine environment increases (McKinsey, 2015; Jang et al., 2015; Beaumont, et al., 2019).

5.4 Implications for human health

Plastic pollution is associated with a variety of plastic materials that are usually either made of or further refined through the application of certain chemical additives. These chemical substances can be detrimental for human health if consumed, thus, justifying the necessity for proper food labeling to prevent unintentional consumption regarding this type of plastic substances (Zimmermann et al., 2019; Trasande et al., 2018). Taking into account the fact that plastics are extensively used during our daily activities and though they are persistent materials under certain circumstances (UV radiation etc.) they tend to get fragmented into microplastics and nanoplastics. The additives applied during the mixing process of plastic materials can be highly toxic for biological organisms if consumed, most commonly via ingestion or inhalation. Beyond additives, there are various degradation products existing in plastics resulting from abiotic degradation or through the adsorption of contaminants (Rodrigues et al., 2019).

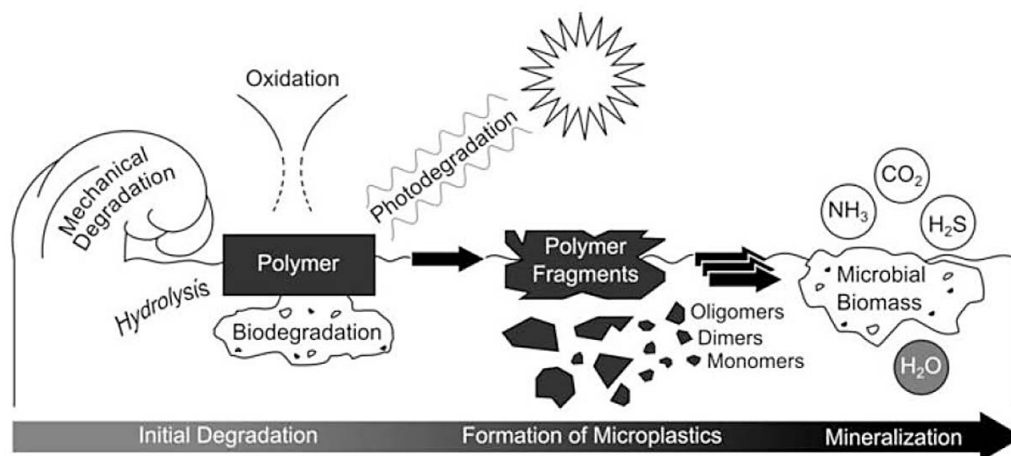
Additives migration tends to augment particle toxicity, therefore, marking this process as one of the most significant indirect effects of “everyday” plastic products consistently used during day-to-day human activities. Particle toxicity of plastics has been investigated and examined at various scales, from micrometer size to smaller ones (Rist et al., 2018). However, the available data and research referring to this particular type of domestic appliances and products on the basis of PE,

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PP, PVC, PA, PS polymers and their correspondent additives is limited. In order to achieve an efficient level of risk assessment in each one of these plastic materials, it is necessary to first acquire all the required information on the composition of all polymer matrices (i.e. polymers, monomers and additives), the adsorption of contaminants along with all the relevant degradation products (Rodrigues et al., 2019).

At this point, it is deemed important to examine the potential human exposure to plastics pathways mainly comprised of aquatic and terrestrial environments. Aquatic environments, for the most part, indicate marine environments and secondarily freshwater systems regarding certain species intended for human consumption (Smith et al., 2018; Barboza et al., 2018). However, it would be helpful to denote that microplastics are regularly characterized as the most frequent and critical danger for human health. Microplastics presence has been documented both on air samples as well as types of food consumed by humans (Wright and Kelly, 2017). Synthetic polymers subjected to specific degradation processes (mechanical degradation, hydrolysis, oxidation, biodegradation, photodegradation etc.) are fragmented into microplastics, which in turn through a series of intermediate steps become completely mineralized in aquatic environments, as better depicted in Figure 5-5.

Figure 5-5: Degradation steps and process of synthetic polymers towards mineralization in aquatic environments



Source: Klein et al., 2018.

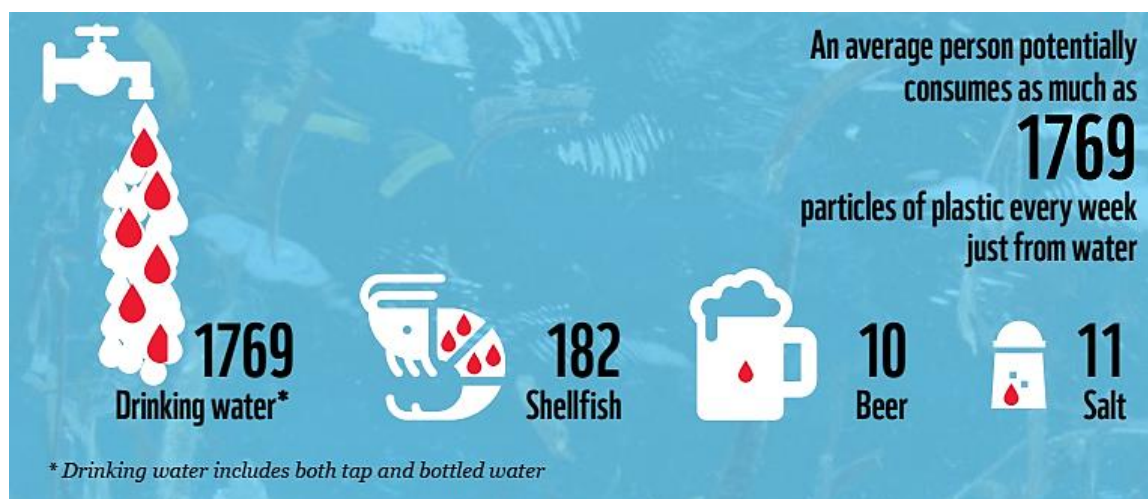
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Based on results for the year 2015, global seafood consumption represented 6.7% of total protein consumption and almost 17% of animal protein consumption, whilst per capita consumption of seafood is over 20kg on an annual basis worldwide (Fisheries of the United States, 2015; FAO, 2016; Smith et al., 2018). In addition, in 2016 seafood trade was estimated at USD 132.6 on a global level, while regarding USA approximately 90% of seafood is provided by regions seriously afflicted from pelagic plastic pollution (Lusher et al., 2017; Smith et al., 2018). Microplastics intake in the case of marine organisms is performed either by direct ingestion or indirectly through biomagnification (building on the food chain), as more extensively analyzed in a previous chapter (see 5.2). From minuscule organisms such as larvae and plankton (Cole et al., 2013; Lee et al., 2013; Steer et al., 2017) to invertebrates and fish of various shapes and sizes intended for human consumption (Thompson et al., 2004; Murray and Cowie, 2011; Farrell and Nelson, 2013; Van Cauwenberghe and Janssen, 2014; Mattsson et al., 2015; Rochman et al., 2015; Lusher et al., 2017; Smith et al., 2018).

Marine organisms and shellfish characterized by intact gastrointestinal and digestive tracts, having consumed bivalves or small fish, tend to accommodate plastic particles, thus, exposing microplastics to human diet when in turn consumed by people, the toxicity of which depends on the size, chemicals and portions consumed (GESAMP, 2016; Smith et al., 2018). An extensive review based on existing studies was performed on behalf of the University of Newcastle, Australia to evaluate the results of plastic ingestion on the basis of inhalation, food and beverages consumption. This set of evidence, though relatively confined, concluded that an ordinary person could ingest approximately 5 grams of plastic on a weekly basis, varying on his/hers consumption habits (WWF, 2019). The most common sources of food and beverages containing microplastics were among others drinking water (tap and bottled water), shellfish, beer, and salt, as shown in Figure 5-6.

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Figure 5-6: An approximate on consumed microplastics via ingestion based on common foods and beverages (0-1mm particles weekly)



Source: WWF, 2019.

Nevertheless, plastic exposure may also occur through dermal contact taking into consideration the fact that microplastics exist in the vast majority of daily products as well as in the air and food (Prata et al., 2020). Plastic related microbes may contribute to spreading infectious and harmful to humans diseases, as the hard surface of plastics constitute the “perfect” environment for opportunistic microbial colonisers, eventually forming the so-called “Plastisphere”, a type of biotope acting as a vector for spreading various pathogens, harmful algal bloom species (HABs) and fecal indicator organisms (FIOs) throughout bathing environments (Keswani et al., 2016). Even though, microplastics’ harmful effects on human health are currently under scrutiny “scientifically speaking”, complimentary scientific fields strongly indicate toward chemical and microbial hazards, if inhaled or ingested (microplastics) by humans (Wright and Kelly, 2017). In this case, they may accumulate and trigger localized particle toxicity as they induce immune responses or alternatively stimulate chemical toxicity resulting from the localized leaching of certain endogenous additives and adsorbed environmental pollutants.

Chronic exposure to microplastics may also induce oxidative stress, inflammatory lesions, and translocation. The human immune system cannot efficiently remove synthetic particles, hence, leading to chronic inflammation and increased risks of neoplasia (Prata et al., 2020). Inhalation, ingestion, and thus gastrointestinal exposure to microplastics is especially dangerous on account

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of microplastic toxicity regarding specific parameters such as particle properties, adsorbed contaminants, exposure concentration, pathogenic organisms and individual susceptibility (Prata, 2018; Cox et al., 2019; Vianello et al., 2019). Taking into account that microplastics and particle toxicity may occur within the micrometer or even nanometer size range of plastic particles, the human health implications concerning food products and beverages expand (Rist et al., 2018). The presence of microplastics in seafood and aquatic organisms is well-documented (von Moos et al., 2012; Rochman et al., 2013; Wright et al., 2013; Mattsson et al., 2015; Lu et al., 2016; Paul-Pont et al., 2016) though their exact impact on human health is currently evaluated and assessed (Rist et al., 2018).

Among the most common root causes and aspects of plastic pollution in relation to microplastics and the modern way of life are chemical legislation, waste management, and overconsumption of plastic products. On certain occasions, domestic dust may proportionally contribute more to the amount of fibers ingested by humans compared to fiber intake via the consumption of mussels, therefore, necessitating the adoption of certain food safety risk analysis frameworks in order to properly assess the risks and threats posed by seafood consumption, especially in the case of (micro)plastic contamination (Lusher et al., 2017; Catarino et al., 2018). In this context, microplastics arise as an emerging health issue regarding food safety and human well-being that requires further analysis with respect to the dietary exposure of humans to a variety of foods and other parameters related to microplastics such as polymeric composition, particle size, particle shape, surface area, density, sorbed pollutants, persistence and additive content (Hale, 2018; Barboza et al., 2018).

In addition, there are several issues regarding the association between microplastics and human health which remain to be scientifically substantiated, though strong implications already exist, as in the case of microplastics concentration and cancer development in marine animals, and thus ultimately in humans via the biomagnification process (Erren et al., 2015; Barboza et al., 2018). Microplastics within the range of up to 20 μm are able to penetrate human organs, whilst smaller ($0.1 > 10\mu\text{m}$) may enter almost every organ, cross cell membranes, the blood-brain barrier or even the placenta (Browne et al., 2008; von Moos et al., 2012; Bouwmeester et al., 2015; Galloway, 2015). In this sense, any potential interaction between microplastics/nanoplastics and the immune system may result in immunotoxicity, immunosuppression, immune activation, and

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abnormal inflammatory responses (Wright and Kelly, 2017; Lusher et al., 2017; Schirizzi et al., 2017; Barboza et al., 2018).

5.4.1 Case studies

At this point, certain studies have already been published regarding potential anthropogenic impacts due to plastic pollution, while there is also a plethora of relevant to this issue research and experiments in progress. Based on Catarino et al. (2018), the annual per capita consumption of plastic particles on account of shellfish consumption has been estimated at 123 particles for UK consumers, while for certain countries associated with higher shellfish consumption rates (per person) this amount may even reach 4,620 particles per capita on an annual basis. In addition, dust fallout may in turn result in fiber exposure during a meal with estimations ranging from 13,731 to 68,415 particles per capita annually (Catarino et al., 2018).

In the case of the Xiamen coastal areas in China, an area currently under extensive industrialization and urbanization, an abundance ranging from 103 - 2,017 particles per m³ in surface seawater and 76 - 333 particles per kg in sediments has been documented (Tang et al., 2018). Furthermore, concentrations of dissolved PAHs vary within the range of 18.13 - 247.75 ng/L in surface seawater, while FTIR analysis has validated that the most frequent type of plastics in the samples taken refer to PP and PE. Based on these results, it was further corroborated that river runoff along with population and urbanization have influenced the distribution of microplastics in estuary surface water in Xiamen coastal areas, whilst agricultural practices may in turn contribute as well to this problematic situation as a consequence of the extensive use of plastic film (Tang et al., 2018).

Taking into consideration the findings of Porter et al. (1999), Burkhart et al. (1999), Barroso et al. (2002) and Atis et al. (2005), it becomes evident that certain types of microplastics such as PE, PP and Nylon are closely associated with adverse respiratory effects, gastrointestinal cancer and lung inflammation, while equally detrimental health issues ranging from respiratory effects, gastrointestinal and lung cancer together with liver tumors are strongly correlated with PVC,

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based on Mastrangelo et al. (1979) and (2003), Jones et al. (1988), Casula et al. (1977), Boffetta et al. (2003) and Xu et al. (2004).

In Ragusa et al. (2020), microparticles and microplastics presence in human placenta was documented within a sample of six human placentas, where 12 microparticles varying from 5 - 10 μm , were found in 4 out of 6 placentas. In particular, 5 microparticles were located in the fetal side, 4 in the maternal side and 3 in the chorioamniotic membranes. The presence and accumulation of these microplastics may induce or enhance immune responses, thus, compromising the defense mechanisms against pathogens (Ragusa et al., 2020). In addition, microplastic concentration in the human placenta may also lead to adverse pregnancy outcomes, such as impaired immunity mechanisms during pregnancy, functions of atypical chemokine receptors governing maternal-fetal communication, trafficking of uterine dendritic cells, natural killer cells, T cells and macrophages during normal pregnancy, etc. (Ilekis et al., 2016; Ragusa et al., 2020). The potential release of harmful for humans chemicals by microplastics constitutes a critical problem as well, bearing in mind that plastic waste may be covered with dangerous contaminants and micromolecular substances such as bisphenol A, phthalates and various brominated flame retardants, all of which are considered highly hazardous endocrine disruptors (Ragusa et al., 2020).

In view of the fact that PP-based products are extensively used during food preparation, especially in the case of infants due to formula preparation (infant feeding bottles – IFBs), their potential for microplastic discharges is often ignored. Nevertheless, values of up to 16,200,000 particles per liter have been documented, as PP-IFB sterilization along with exposure to high-temperature water considerably increase the risk of microplastic discharges, usually characterized by periodic fluctuations (Li et al., 2020). In this regard, values of approximately 14,600 to 4,550,000 particles per capita on a daily basis were recorded in the case of a global survey regarding 48 regions in reference to food preparation for infants of up to 12 months old (Li et al., 2020).

The long-term effects of plastics for human health are not yet fully documented, though as mentioned above, several studies have already denoted that constant exposure to plastics (mainly through ingestion or inhalation) may induce inflammation of the respiratory tract and various toxic effects on the lungs, liver or even brain for any living organism (GESAMP, 2015; Keswani et al., 2016). These effects, taking also into account all the various chemicals and additives

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embedded to most of plastic products, may generate adverse cascading effects to human health and well-being (Melzer et al., 2010; Linares et al., 2015; Gasperi et al., 2018; Rodrigues, et al., 2019).

It is imperative that further research is promoted in order to develop more effective methods and techniques to properly identify and analyze plastics and their effects on human health based on larger samples, whilst successfully coping with any existing difficulties (e.g. digestion of tissues, tissue availability, minimizing the potential contamination of the samples, etc.) (Prata et al., 2020).

5.5 The case of plastic bags

Plastic bags are considered to be among the most widespread and well-known plastic products worldwide characterized by ever-increasing consumption rates. Single-use plastic bags are commonly used as shopping or carrier bags since their introduction during the 1970's, as the main alternative to paper bags for carrying consumer products. As a result of their durability, their low cost and effectiveness, due to the fact that we can usually reuse plastic bags more than once (especially the multi-use type), plastic bags are quite “popular” in terms of consumer choice (Derraik, 2002; UNEP, 2005; Macur and Pudlowski, 2009; O'Brien and Thondhlana, 2019). In addition, retailers also favour their use on account of their functionality, the fact that they are lightweight and somewhat of a hygienic method for transporting goods and products (Smith, 2004; UNEP, 2005; Alam et al., 2018).

Plastic bags are also extensively used as means of packaging for food, medicine, chemicals, pharmaceuticals, and several types of products, whilst plastic bag production for packaging purposes exclusively has been growing increasingly on a daily basis (Bahri, 2005; Ayalon et al., 2009; PlasticsEurope, 2020). Lightweight single-use thin-film plastic carrier bags are generally water-resistant, durable and inexpensive, as already mentioned, while consumers tend to incorporate them for several other uses beside transporting goods (Lewis et al., 2010; Wagner, 2017). Nevertheless, from the 1980's until the early 2000's consumers had grown accustomed to

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expecting or even “demanding” free, single-use plastic carrier bags, since they are regarded as the most preferable choice provided to them in grocery stores and supermarkets (Sharp et al., 2010; Wagner, 2017). Convenience and grocery stores constitute the largest supplier of lightweight thin-film single-use plastic shopping bags, as denoted in the case of Montgomery County, MD where grocery stores account for approximately 70% of the total amount of bags provided (Montgomery County, 2016), while the mean shopping trips for groceries per week in the USA are estimated at 1.6 (FMI, 2016; Wagner, 2017).

Plastic bags and packaging products are made by using various organic and inorganic materials as well as different types of polymers including carbon, silicone, hydrogen, and nitrogen among the most common (Shah et al., 2008; O’Brien and Thondhlana, 2019). The basic inputs for the production of plastic bags are extracted from non-renewable resources such as oil, natural gas, and coal, all of which are considered to be formidable pollutants for the environment (UNEP, 2005; Seymour, 2006). During the production process of plastic bags, heavy metals and various additives in the form of organometallic compounds are also incorporated, as they are encapsulated with polymer matrix in order to reduce production cost, whilst at the same time optimizing its properties (Dilli, 2007; Lajeunesse, 2004; Alam et al., 2018).

The most widespread and prevalent types of plastic carrier bags are based on High Density Polyethylene (HDPE), which is the primary material for thin film, mostly associated with convenience stores, grocery stores, supermarkets, fast-food restaurants and generally take-out restaurants (Verghese et al., 2006; Wagner, 2017). Single-use HDPE shopping bags, provided in grocery stores and supermarkets, range from 0.7 to 1.77 millimeters in terms of thickness and generally include handles, thus, differentiating from other similar single-use plastic bags (i.e. barrier bags, bags for meat, fish, dry cleaning, etc.) (Verghese et al., 2006). The other major category of plastic carrier bags is the Low Density Polypropylene (LDPE), provided by retailers for use in the case of higher value goods and products. This type is usually imprinted with logos and characterized by plastic or fiber handles, ranging from 2.25 to 3 millimeters in thickness (Verghese et al., 2006; Wagner, 2017).

These types of plastic shopping bags (HDPE and LDPE carryout bags, grocery bags, lightweight bags, etc.) that are extensively used and provided to consumers via retailers, are regarded as a symbol of the modern consumption society, as they are light and frequently thrown away after a

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single use, often even in the case of the reusable (multi-use) bags (EC, 2013; Martinho et al., 2017). At a global scale, it has been estimated that within the range of 1 – 4 trillion plastic bags are approximately consumed on an annual basis (Derraik, 2002; Spokas, 2007; Rayne, 2008; O'Brien and Thondhlana, 2019; Barcelo, 2020). Based on other estimations, plastic bag consumption can reach 160,000 bags per second (TheWorldCounts, 2020), whilst during the year 2014 approximately 103,465 billion single-use plastic shopping bags were consumed in the USA (Wagner, 2017).

In Table 5-2 several estimations of annual per capita consumption of single-use plastic shopping bags are presented on a global level. Despite the urgent need for more contemporary information on the subject, it can be said that the EU-28 average of 200 plastic bags per citizen is among the most moderate estimations. In the case of Greece, a typical example of a Mediterranean country that is also a member-state of the EU, several estimations have been made ranging from 242 plastic bags/person (Eunomia, 2012), to 363 plastic bags/person (IELKA, 2016) or approximately 200 plastic bags/person (AHPI, 2016).

Table 5-2: Estimations of per capita consumption of single-use plastic shopping bags on an annual basis

Country	Plastic bag consumption (per capita)	Type	Sources
Australia	303	HDPE bags only	Cain and Oke (2008), Montoya (2013)
Japan	360	Plastic bags only	Ohtomo and Ohnuma (2014)
Israel	300	Plastic bags only	Ayalon et al. (2009)
USA	319.5	Plastic bags only	US ITC (2016)

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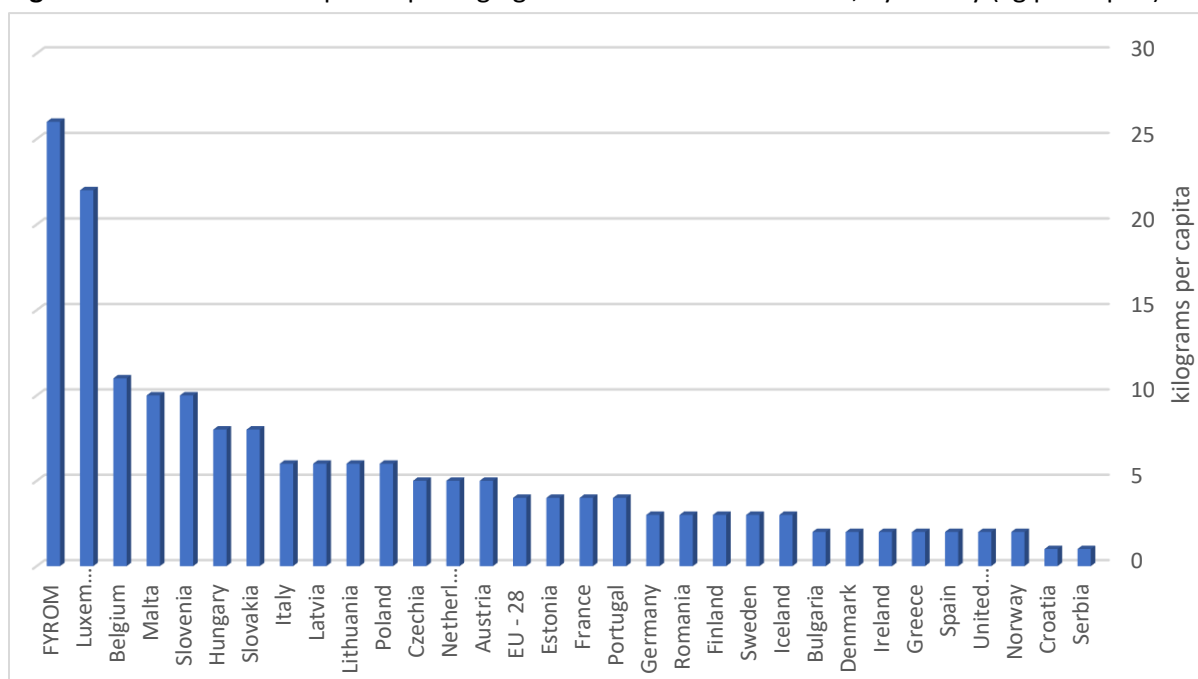
California, USA	703	Plastic bags only	AECOM (2010)
Los Angeles County, California	600	Plastic bags only	LA County (2007)
Austin, TX (USA)	335	Plastic bags only	Waters (2015)
EU – 28	200	Plastic bags per EU-28 citizen	EP Directorate for Relations with National Parliaments (2017)

Source: Adapted from Wagner, 2017.

The high consumption rates of plastic bags and plastic packaging in general, can also be further corroborated in terms of plastic waste generated. Taking into account that a large proportion of single-use plastic shopping bags and plastic packaging is only used once and afterwards discarded (most frequently improperly), the associated environmental implications can be detrimental. In Figure 5-7 and Figure 5-8 the generation of plastic packaging waste in the EU-28 during the year 2018 is presented for each member-state expressed both in kg per capita as well as in thousand metric tons. Though individual consumption of plastic bags is usually higher in countries characterized by high GDP growth rates, a fact which is confirmed based on Figure 5-7 and Figure 5-8, developing countries experience relatively more environmental problems on account of plastic waste pollution, resulting from shortages in environmental awareness together with illegal plastic waste disposal (Bahri, 2005; Islam, 2011; Alam et al., 2018). In the case of countries such as China, the aggregate amount of plastic packaging waste for the time period 2015-2017 significantly increased from 0.2 to 1.5 million metric tons, bearing in mind that postal/courier businesses would consume approximately 331 million packages in a single day, thus, generating 0.16 million tons of plastic packaging waste (Song et al., 2018; Shanghai Reuters, 2017).

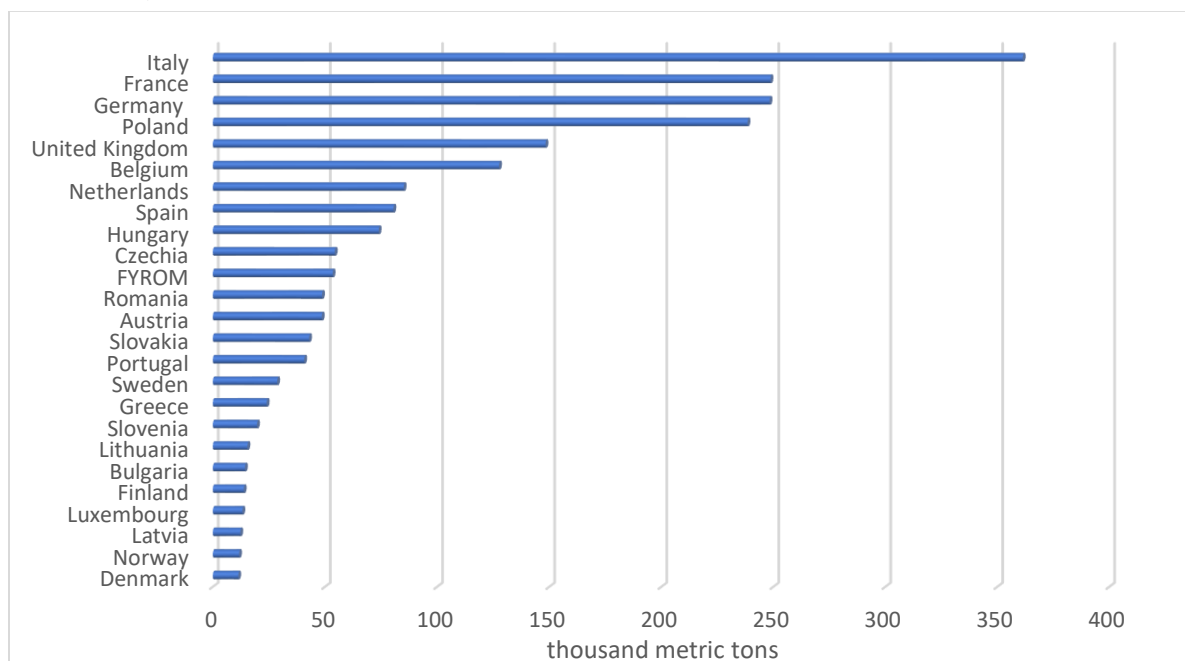
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Figure 5- 7: Generation of plastic packaging waste in the EU-28 in 2018, by county (kg per capita)



Source: Eurostat, 2020.

Figure 5-8: Generation of plastic packaging waste in the EU-28 in 2018, by county (thousand metric tons)



Source: Eurostat, 2020.

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Plastic bag litter and plastic packaging waste are also associated with several adverse environmental impacts. Single-use plastic bags are commonly used only once and are afterwards discarded, either ending up in landfills requiring many years to eventually break down or even worse in the coastal and marine environment as macro and microplastics (Thompson et al., 2004; Wright et al., 2013; UNEP, 2005; Stevens, 2001; Ritch et al., 2009; O'Brien and Thondhlana, 2019). The environmental impacts of plastic bags are linked to every stage of their lifecycle, from their formation (production process) associated with specific energy demand to their brief lifespan and disposal in landfills or pollution for marine/coastal ecosystems (Derraik, 2002; Ritch et al., 2009; Ayalon et al., 2009; Adane and Muleta, 2011; Borrelle et al., 2017; Haward, 2018). The organometallic compounds (additives) contained in plastic bags gradually wash out into the environment during their lifecycle due to exposure to heat or light, whereas the annual release of this type of additives from common plastics (e.g. PE, PS, PVC, PET) into the marine environment has been estimated to approximately 35 - 917 tons worldwide (Cheng et al., 2010; Ahmad et al., 2012; Whitt et al., 2012; Suhrhoff et al., 2016; Alam et al., 2018).

Plastic bag waste is also connected with substantial economic costs for both governments and businesses in the forms of waste collection, removal, transportation, disposal, and recycling (Hopewell et al., 2009; Schirinzi et al., 2017; O'Brien and Thondhlana, 2019). Plastic bag litter is often associated with blocking or generally impairing storm collection drainage and sewerage systems, thus, necessitating separate collection mechanisms for plastics bags to ensure the proper disposal of plastic bags and prevent wind dispersion phenomena along with their subsequent consequences for the marine and coastal environment (Wagner and Broaddus, 2016; Martinho et al., 2017). In particular, wind dispersal in association with plastic bags induces indirect economic impacts in the form of reduced aesthetic quality, property values, and tourism, as plastic bags tend to accumulate in beaches, streets as well as recreation sites, therefore, diminishing the overall landscape and aesthetic quality (Ayalon et al., 2009).

Nevertheless, plastic bag waste along with plastic packaging waste can indirectly affect people in a negative way after or even during the stage of disposal. This specific hazard refers to short and long-term health effects related to plastic bags and plastic packaging waste, resulting from induced damages in drainage and sewerage systems. In particular, the blockage of these systems may lead to overflow and flooding, hence, contributing to disease transmission or the formation

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of suitable breeding grounds for certain diseases, as in the case of malaria (Huerta-Pujol et al., 2010; Al-Qutob et al., 2014; Alam et al., 2018; Rayne, 2008; Gupta, 2011; Adane and Muleta, 2011; O'Brien and Thondhlana, 2019).

Plastic bag waste and plastic packaging waste are also characterized by low recyclability, therefore, further contributing to the expansion of the existing and “overcrowded” landfill areas (Williamson, 2003; Luijsterburg and Goossens, 2014; Bhogayata and Arora, 2017). In addition, the illegal disposal of plastic bag waste may generate negative effects for human health, as mentioned above, but also increase soil, air and water pollution, whilst bearing adverse impacts on agricultural production along with proliferating urban flash-floods (Ellis et al., 2005; Njeru, 2006; Shamim et al., 2010; Ramaswamy and Sharma, 2011; Jalil et al., 2013; Briassoulis et al., 2014; Eagle et al., 2016; Alam et al., 2018). Furthermore, plastic bags tend to reduce the effectiveness of automated recycling systems, while compared to paper bags standard plastic shopping bags have approximately 50% less carrying capacity (Sapphos, 2010; Wagner, 2017).

These environmental hazards associated with plastic bags, ranging from the generation of unnecessary energy demands to their inability to properly biodegrade, thus, expanding landfill areas have been characterized a representation of the modern throw-away society (Ritch et al., 2009). Examples such as these do not conform to the basic principles of sustainable consumption or sustainable development. However, certain actions have already been taken in the form of waste management legislation in order to cope with this problem. Enhanced resource efficiency is currently heavily promoted on a global level as means of mitigation, though early examples of such actions have existed since the late 1990's in South Asia regarding issues associated with human health mainly (Clapp and Swanston, 2009; UNEP, 2016).

From the year 2010 and onward, for the most part, a gradual phase-out of lightweight plastic carrier bags has taken place, mainly through public policies and the introduction of certain environmental levies, partial or total bans and taxes regarding plastic bags. As of August 2020, it has been documented that approximately 76 countries worldwide have introduced bans to the use of plastic bags (total or partial), while 37 countries have imposed some type of environmental tax, fee or charge, in general, per plastic bag. In the EU-27, conforming to the tenets of the European Circular Economy, as of April 2015 Directive (EU) 2015/720 (amending Directive 94/62/EC) has been introduced to reduce the consumption of lightweight plastic carrier bags (EEA,

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2015). The first European countries to pass legislation against the use of plastic bags were Ireland (2002) and Denmark (2003), where the effects of the imposed taxes were significant, especially in the case of Ireland (reduction of up to 90% in plastic bag consumption) (Convery et al., 2007). In other examples, the introduction of a tax per plastic bag in England (October 2015) reduced the overall amount of plastic carrier bags used by almost 85% (Single-use plastic carrier bags charge: data in England for 2015 to 2016 - GOV.UK, n.d.), while in the case of Greece since the introduction of the environmental levy (January 2018) an approximate reduction of 98.6% has been documented regarding the consumption of lightweight plastic bags for the years 2017 and 2019 respectively, based on relevant research (IELKA, 2020).

Plastic bags with a thickness ranging from 20-50µm have already been banned in many countries, both developing and developed, in accordance with suggestions made by environmental researchers (Miller, 2012; Alam et al., 2018). However, the use of other types of bags, though often promoted, has proven to be unsuccessful due to the fact that customers tend to prefer plastic bags compared to the rest of alternatives (Ritch et al., 2009; He, 2012; Dikgang et al., 2012). At this point, it is deemed important to indicate that any regulation regarding the consumption of plastic carrier bags should include both lightweight and heavyweight (> 50µm thickness) plastic bags, as the latter are usually excluded from taxation, thus, contributing even more to increasing the aggregate amount of plastic in circulation and plastic waste volume (Steensgaard et al., 2017; Alam et al., 2018).

The decoupling of plastic bag use from consumer behaviour has been described as a critical goal in the effort of achieving sustainable consumption on a global level (SDG 12), whilst further research within the context of promoting circular economy principles (product design, maximizing resources circularity, ensuring less waste and more efficient waste treatment technology, etc.) is strongly required and advised (Ritch et al., 2009; Nakashima et al., 2011; Alam et al., 2018).

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5.6 Policies and governance solutions

An important axiom in the field of economics refers to those who are responsible for certain cost inducing actions, as in the case of marine plastic pollution, and their obligation (in principle) to incur that particular cost for their actions. However, this principle is often circumvented as there are no adequate incentives to properly influence (alter) this type of “polluting behaviours”, while at the same time aiming at minimizing the negative impacts they produce for the marine and coastal environment (Oosterhuis et al., 2014; Brouwer et al., 2017). As a result, the need for effective policy measures, governance, and managing interventions emerges in order to adequately integrate the economic value of marine plastic waste impacts, thus, conforming and promoting the basic notions of sustainable development.

In this sense, the policy instruments applied in order to fulfill this goal (reduce/manage marine plastic pollution) fall under two main categories: (a) Economic Policy Instruments (EPIs), and (b) legislative action/initiatives (Hennlock et al., 2015; Lago et al., 2015). The EPIs are typically comprised of market-based policy tools in the form of incentives toward individuals or stakeholders (firms, public managers, productive sectors) aiming at adapting their decisions to specific objectives and agreements. They incorporate pricing (tariffs, fees, taxes, charges, subsidies), trading (exchanging of rights, permissions, entitlements for resource use), cooperation (voluntary agreements, subsidies) and risk management schemes (insurance premiums, compensation insurance) (Lago et al., 2015). The second category integrates both legislation action/initiatives and national policies designed and implemented to reduce the negative impacts of plastic waste and marine plastic pollution such as EU Directives, regulations and decisions, international agreements, National targets, etc.

There have been plenty examples of government policies at a global scale taking action to mitigate plastic waste and ultimately marine plastic pollution via reducing the consumption of single-use plastics by means of regulations, market-based instruments, and voluntary actions. In particular, these mechanisms incorporate tools and resources in the form of information, persuasion, organization and finance, therefore, transforming the associated policies by reason of coercion into 4 basic types: i) distributive policies, ii) regulatory policies, iii) redistributive policies and iv) constituent policies (Hood, 1986; Lowi, 1966; 1972; Ritch et al., 2009). The first type of policies

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(distributive) can be characterized as individually targeted and weakly sanctioned, contrary to redistributive policies which are generally targeted and strongly sanctioned. Regulatory policies are individually targeted but strongly sanctioned, while the last type (constituent policies) is described as generally targeted and weakly sanctioned (Ritch et al., 2009).

Based on contemporary literature, certain economic policy instruments emerge concerning the reduction of marine litter and plastic use aspiring to eventually alleviate plastic waste pollution in the marine and coastal environment. In this context, it would be useful to separate these instruments into **disincentives** and **incentives**. Disincentives are used as means of dissuading behaviour which would contribute to the production of plastic waste, whilst if properly and adequately applied they may raise significant government revenue as well. On the other hand, incentives usually appear in financial form in order to promote and stimulate behaviour that will contribute toward the mitigation of plastic waste (Oosterhuis et al., 2014). Disincentives usually assume the form of financial penalties (e.g. discouraging the illegal disposal of marine litter in marine/coastal environment) as well as taxes, fees or charges on plastic products.

In addition, charges, as in the case of pay-as-you-throw (PAYT) system for municipal waste collection, are also typically implemented for households and small enterprises (OECD, 2006; Oosterhuis et al., 2009; Hogg et al., 2011; Oosterhuis et al., 2014). Liability is frequently attached to disincentives, as it applies the “polluter pays principle” of environmental economics, though in practice it is often constrained due to the arduous process of establishing solid and undisputable links between the polluting behaviour and the associated damage caused. Nevertheless, the customary policy approaches regarding “pollute and pay” behaviour refer to command-and-control and market-based measures (Oosterhuis et al., 2014).

Incentives are commonly applied to encourage the “proper” behaviour that will help along in mitigating the plastic waste problem via the stimulation of good practices, such as recycling and reusing materials together with proper waste disposal. The most common types of financial incentives are subsidies and fiscal incentives, direct payments and awards, Deposit-Refund Schemes (DRS), price differentiation (especially in the case of plastic recycling) as well as applying preferential treatment and public procurement when governments or local authorities get involved in market transactions (Oosterhuis et al., 2014). The application of financial incentives in the form of DRS also promotes effective waste management and recycling, as they entail a down

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payment upon the purchase of plastic polluting products (e.g. bottles) which is afterwards refunded when this product or its residues are returned to the seller (Ochiewo et al., 2007; McIlgorm et al., 2011). In the case of plastic bags (statistically being one of the most common types of plastic waste), disincentives such as taxes, charges and fees have proven successful in reducing their use both in developed and developing countries (Oosterhuis et al., 2014).

Nevertheless, economic policy measures and regulatory instruments applied to reduce plastic use also include bans, total or partial, as well as plastic charges on the use of the selected plastic products (notably plastic bags). Within the framework of more contemporary and less coercive measures, psychological interventions have been promoted in the form of educational approaches and infrastructure improvements (Heidbreder et al., 2019). Their main objective is to increase public awareness and understanding with regard to plastic pollution and further stimulate behavioural changes toward more environmentally friendly alternatives to plastic. Most psychological interventions promote the threefold tenet of waste management which refers to reduce, reuse, and recycle (Thompson et al., 2009).

From the stakeholders' point of view, certain actions have often been recommended for reducing plastic waste "at their source". In particular, these actions can be further categorized based on a timescale into short-term, mid-term and long-term. The **short-term policies** include: i) regulation of production and consumption via the application of bans or taxes on the selected plastic products which have been proven harmful for the marine and coastal environment, thus, acting in the best interest of public health and food safety, ii) Incentivizing plastic recycling through benefits or sanctions on virgin plastics, and iii) Reducing plastic consumption via cutting down any unnecessary plastic packaging, promoting eco-designing, proper labelling, raising awareness and educational measures (Prata et al., 2019).

Mid-term actions and recommendations usually appear as: i) improvements in waste management via the application of better waste collection systems for reducing waste generation, implementation of door-to-door collection systems as well as deposit-refund systems on the basis of the "pay-as-you-throw" rule, ii) waste reducing and recycling at the early production stages coupled with extended producer responsibility (EPR) regarding plastic waste and their hazardous impacts, and iii) focusing on proper and effective recycling methods along

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with the promotion of feedstock and waste-to-energy (WtE) techniques minimizing the use of landfills as means of waste disposal (Prata et al., 2019).

In accordance with priority purposes **long-term actions** refer to the following: i) promoting and applying renewable energy sources during waste collection and recycling aiming at minimizing the negative environmental impacts of recycled plastics, ii) implementing life-cycle assessment (LCA) for plastic products, improving eco-designing, properly acknowledging end-of-life products (EOL products), iii) boosting the recyclability capacities of e-waste and promoting efficient disposal methods such as waste-to-energy, and iv) encouraging the use of bio-based plastics contrary to the fossil fuel based ones, applying biodegradable plastics where composting is preferable (as in the case of agricultural films), whilst promoting efficient waste management systems for biodegradable materials, minimizing the production of certain types of harmful degradable plastics based on which microplastics are formed (e.g. microbead, micro-exfoliates etc.) (Prata et al., 2019).

EPR (extended producer responsibility), as mentioned above, is often regarded as a type of mid-term measure and an integral part of environmental policy, extending the producers' responsibility for plastic products to the product's postconsumer stage. Therefore, producers are required to finance the collection, recycling, and safe disposal of these products, thus, further stressing the need for proper product design (eco-design) according to the particular environmental specifications. EPR may potentially reverse the linear product flow, from virgin material extraction to waste generation, while stimulating instead a circular flow providing additional incentives to producers for cost reductions through the implementation of more appropriate and efficient waste management techniques (Walls, 2006; Almroth and Eggert, 2019). EPR is at present heavily promoted at EU level, as part of the circular economy strategy, applied to plastic packaging waste and included in the form of mandatory EPR schemes for the recycling of plastic waste. By 2025 a specific target for plastic packaging recycling of 50% must be fulfilled, while single-use plastic cutlery, straws, plates, cotton bud sticks made of plastic as well as expanded polystyrene cups are banned from 2021 and onward (European Parliament, 2019).

In the same context, another widely applied type of economic incentive in the form of legislative action is the container deposit legislation (CDL). This particular measure aims at the reduction of waste entering the oceans worldwide, mainly targeting beverage container litter, resulting in

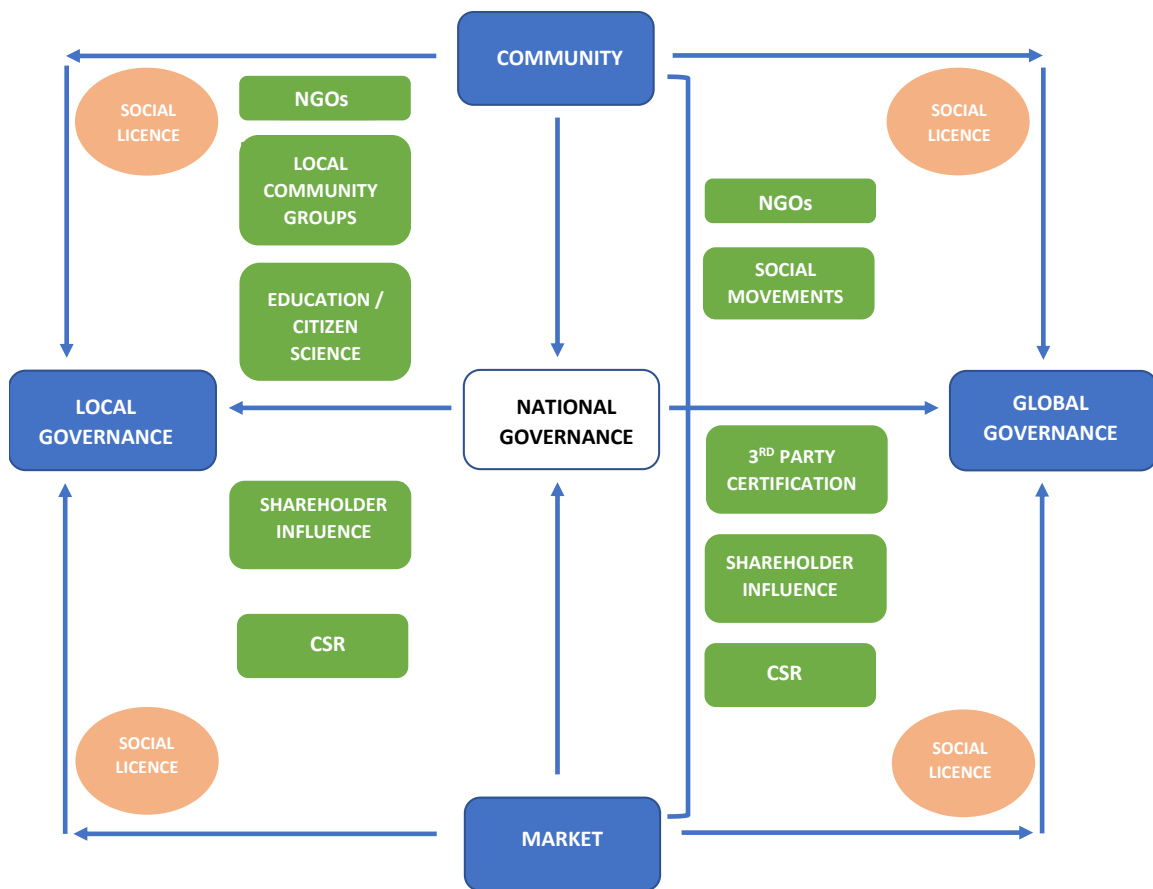
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approximately 40% decrease in debris (of beverage containers) in states with CDL compared to the ones without in the USA and Australia for the period 2007-2015 (Schuyler et al., 2018). In layman's terms, CDL involves the collection of a monetary deposit regarding beverage containers at the point of sale, while a refund value is subsequently paid to the consumers. Afterwards, if the container is returned to an approved redemption center this deposit is partly/fully refunded to the redeemer. Legislative measures, as in the case of CDL, have contributed to altering the social acceptance of littering behaviour for the better, which along with rising public awareness on plastic pollution and the associated environmental impacts can promote more effective waste management strategies (Lerner, 2011; Willis et al., 2017; Jambeck et al., 2018).

However, the application of the aforementioned measures, actions and policy recommendations would be most effective if performed via a more holistic and integrated approach at a global scale, efficiently combining economic instruments together with market-based instruments in reference to the associated communities in order to adequately mitigate marine plastic waste. Within this proposed framework, local governance is closely linked to global governance attending to national governance embedding and consolidating initiatives and principles related to local community groups, social movements, NGOs, shareholder influence, corporate social responsibility (CSR), 3rd party certification, education and citizen science whilst abiding by the axioms of the social license to operate (Figure 5-9).

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Figure 5-9: A comprehensive framework of effective international governance for the mitigation of marine plastic waste



Source: Adapted from Vince and Hardesty, 2018.

5.6.1 International policy measures

At the present juncture, it is imperative to reduce at once the amount of plastic litter and debris (entering and existing) in the marine environment in order to mitigate and prevent any further disruptions regarding critical ecological processes and losses in terms of biodiversity (Gall and Thompson, 2015; Villarrubia-Gómez et al., 2018; Beaumont et al., 2019). Certain efforts have already been made on a global level since 1973, as in the case of the International Convention for the Prevention of Pollution from Ships (MARPOL 73/78), whilst more contemporary ones refer to the Global Partnership on Marine Litter (GPML) in June 2012 at Rio +20 as well as the Leader's

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Declaration of the 2015 G7 Summit, acknowledging plastics as a global risk for marine and coastal ecosystems with palpable implications for human health. There are currently several notable international strategies and legislative frameworks in effect aiming at the reduction of plastic marine debris and marine litter in general, as more concisely presented in Table 5-3, on the basis of applying market-based strategies and policies. Most prominent among these strategies and policies are the Marine Strategy Framework Directive (MSFD), the Barcelona Convention Regional Plan for Marine Litter Management in the Mediterranean (the first Regional Sea Programme to sanction a legally binding Regional Plan on Marine Litter Management), the European Commission's circular economy action plan, SDG 14 (Target 14.1: *by 2025, prevent and significantly reduce marine pollution of all kinds, particularly from land-based activities, including marine debris and nutrient pollution*) as well as the European Commission's Revision of the Waste Framework Directive (call for 50% reduction by 2025 on 2015 levels) (Eunomia, 2016; Xanthos and Walker, 2017; Fossi et al., 2019).

Table 5-3: A synopsis of the major global agreements and policies regarding plastic pollution

Legislative framework	Organizations	Year	Objective(s)
London Dumping Convention	International Maritime Organization	1972	Impedes the intentional disposal of waste from vessels, platforms, and aircrafts at sea
The International Convention for the Prevention of Pollution from Ships (MARPOL 73/78)	International Maritime Organization	1973/1978	Sets restrictions regarding the disposal of garbage from ships/vessels into the sea. Bans the disposal of plastics or waste containing plastic into the oceans by ships
The Regional Seas Programme (RSP)	United Nations Environment Programme	1974	18 regional seas programs differentiating in scope within a certain range. They address the

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			ever-growing degradation of the oceans and coastal areas globally via the sustainable management and use of the marine and coastal environment, though engaging neighboring countries in specific actions to protect their shared marine environment
UNEP/MAP Barcelona Convention	United Nations Environment Programme	1975/2013	An institutional framework promoting cooperation toward tackling common challenges regarding the marine environmental degradation. The first Regional Sea Programme to approve a legally-binding Regional Plan on Marine Litter Management during 2013
United Nations Convention on the Law of the Sea (UNCLOS)	United Nations	1982	Delineates rights and responsibilities for nations and enterprises regarding their utilization of oceans, environment, and the management of marine resources. (In particular on the basis of Articles 192–237)
Basel Convention	United Nations	1989	Aims at reducing the transfer of dangerous waste between nations, whilst preventing the transfer of this type of waste from developed to developing countries. Further amended during 2019 to include plastic waste within a more rigorous legislative framework and monitoring process

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The EU Packaging and Packaging Waste Directive (94/62/EC)	European Commission	1994	Aiming at harmonizing national measures regarding the management of packaging and packaging waste, whilst preventing any impact on the environment. Restricts the presence of certain heavy metals in packaging (Hg, Pb, Cr6+, Cd)
Washington Declaration/The UNEP Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (UNEP/GPA)	United Nations Environment Programme	1995	A voluntary agreement aiming at preventing the degradation of the marine environment due to land-based activities. It has been adopted by 108 Governments, and the European Commission
Stockholm Convention	United Nations	2001	The goal of this global treaty is the protection of human health and the environment from chemicals (POPs) which remain intact in the environment for extended periods, are able to be widely distributed geographically, accumulate in the fatty tissue of humans/wildlife, and generate harmful impacts on human health or on the environment
The EU Marine Strategy Framework Directive (MSFD, Directive 2008/56/EC)	European Commission	2008	Descriptor 10 regarding good environmental status (GES) pertains to marine litter

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The Waste Framework Directive (WFD, 2008/98/EC)	European Commission	2008	Establishes measures to protect the environment and human health via the prevention or reduction of the harmful impacts regarding the production and management of waste
The Honolulu Strategy	United Nations Environment Programme and the US National Oceanic and Atmospheric Administration	2011	A voluntary strategy comprising of guidelines and actions to combat marine litter. Consists of 3 goals, 19 strategies, and several specified Actions
Global Partnership of Marine Litter (GPML)	United Nations Environment Programme	2012	A multi-stakeholder partnership bringing together all actors to prevent marine litter and microplastics. It provides a unique platform on a global level to share knowledge and experience to preserve the global marine environment, human well-being, and animal welfare by mitigating marine litter
Sustainable Development Goals (SDGs) 6, 11, 12 and 14	United Nations	2015	Regarding plastics, plastic waste: SDG 6: Clean water and sanitation. SDG 11: Sustainable cities and communities. SDG 12: Responsible consumption and production. SDG 14: Life below water.
The United Nations Environment Assembly	United Nations Environment Assembly	2016/2017/2019	Advocating actors and member states toward the mitigation of

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Resolutions on Marine Litter and Microplastics			microplastics, single-use plastics, and marine litter environmental threats
UNEP Clean Seas Campaign	United Nations Environment Programme	2017	Aiming at engaging governments, the general public and the private sector in the effort of reducing marine plastic pollution. Targets the production and consumption of non-recoverable and single-use plastic
EU Plastics Strategy	European Commission	2018	Sets goals for recycling, packaging design, and innovation; sets reduction targets for marine litter and single-use items; promotes global partnerships among the EU and other countries as well as international organizations
Global Plastics Platform	United Nations Environment Programme	2018	Endorses countries/cities in setting plastic reduction targets; explores ways to change the design, production, consumption, and disposal of plastics worldwide, whilst promoting a transition to a more circular economy
New Plastics Economy Global Commitment	Ellen MacArthur Foundation	2018	Signed by over 350 organizations, representing more than 20% of all plastic packaging produced at a global scale, aims at eliminating plastic waste and pollution at the source

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Global Plastic Action Partnership	World Economic Forum	2018	Co-founded by several partners across the public and private sectors (e.g. Coca-Cola, PepsiCo, Dow chemical) intends to promote collaboration among governments, businesses, and civil society to translate commitments into meaningful action at both the global and national levels
Platform for Accelerating the Circular Economy	World Economic Forum	2018	Formulates public-private partnerships in support of CE; provides policy advice and support to address barriers; advances projects that are pioneering or scaling the circular economy (over 50 members from the public and private sectors)
Circular Plastics Alliance	European Commission	2019	Aims at boosting the EU market for recycled plastics to 10 million tons by 2025. It includes more than 175 organizations representing industry, academia, and public authorities. New stakeholders can join the alliance by signing its declaration
Plastic Leak Project	Quantis International & Shaping Environmental Action	2019	A pre-competitive multi-stakeholder initiative partners 35 public, private and scientific organizations (18 major companies, UNEP, and other international organizations); delivers the first science-based methodology to map, measure and forecast plastic leakage along their value chain

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The EU Circular Economy Action Plan	European Commission	2020	Aims at reducing marine litter by 30% until 2020 for the ten most common types of litter found on beaches, including fishing gear found at sea, with the list adapted to each of the four marine regions in the EU

Source: Adapted from Nielsen et al., 2020.

It is deemed necessary to efficiently address the sources and impacts of marine litter on a legislative level, whilst promoting policy measures and taking into account fisheries policies, waste and wastewater management, consumption and behavioural patterns together with shipping and product design (Newman et al., 2013; Gold et al., 2013; Trouwborst, 2011; Maes et al., 2018). Beside the well-known MSFD and its implications, legislative measures and “customized” technical directions are required in certain occasions, such as marine litter originating from fishing. In this direction, the Food and Agriculture Organization of the United Nations (FAO) has produced the Recommendations for the Marking of Fishing Gear (FAO, 2016) as well as the Code of Conduct (FAO, 1995), though the abandonment of fishing gear is prohibited since 1973 by the International Maritime Organisation during its Convention for the Prevention of Pollution from Ships (Convention, 1973).

In regard to Europe, the most significant legislative measures refer to the Common Fisheries Policy (CFP), the necessity to properly mark fishing gear promoted by the European Commission, as well as the majority of measures for the removal of lost fishing gears from the seafloor supported by European Maritime and Fisheries Fund (Council of the European Union, 2002; Brown and Macfadyen, 2007; Fossi et al., 2017). In the case of the Mediterranean Sea, the most pertinent measures and legislation fall under the Regional Plan on Marine Litter Management in the Mediterranean (UN Environment/Mediterranean Action Plan), MSFD’s Descriptor 10 appertaining to European marine waters specifically, the Union for the Mediterranean (UfM) via its “Plastic Busters project” and all the relevant National Action Plans at country level (Fossi et al., 2017).

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In this sense, the urgent need for action to mitigate the negative impacts of plastic marine litter on the marine environment can be further justified on the grounds of the documented steady increase in marine litter related legislation. As a result, the necessity for long-term monitoring programs to evaluate the performance of measures being implemented together with solid-waste management measures and public awareness-raising actions (e.g. information campaigns for the reduction of use of single-use plastic items) become high-priority (Latinopoulos et al., 2018; de Carvalho-Souza et al., 2018). In addition, the formation of long-term datasets on seabed marine litter combined with the exploration of less easily accessible and visible marine litter (beside shorelines or floating on the ocean surface) can prove to be pivotal in the effort of successfully mitigating plastic marine litter worldwide (Schluning et al., 2013; Galgani et al., 2014; Maes et al., 2018).

Scope for improvement

Plastic marine pollution is currently perceived as a serious concern, being among the most complex environmental challenges worldwide, yet its impact is often not adequately understood nor appraised. Legislation sometimes becomes outdated or nonviable, while revisions or updates linger further exacerbating these complicated ongoing environmental issues.

In particular, although the MSFD has been a major step toward the effective protection of the marine environment, and thus mitigation of marine plastic pollution, certain “amendments” have been suggested to tackle with any existing barriers. In this context, it would be highly beneficial to properly delineate and apply terminology with consistency, whilst remaining specific when defining requirements as well as their associated indicators. In addition, it is important to not exclusively rely on pressure-state change relationships (Berg et al., 2015). As a case in point, based on Berg et al. (2015), the following recommendations were proposed:

- Adequately define criterion 4.1 in order to include production of primary and secondary producers as well,
- Re-examine and decide whether to use descriptor D6 as pressure descriptor exclusively, whilst subsequently integrating all state-related aspects of sea floor

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integrity into descriptor D1, or as a state descriptor which will also include functional aspects,

- Include indicators regarding ecosystem services and ecosystem functioning throughout descriptors (i.e. biological control in D1 and D4, gene pool protection in D1 and D6, etc.) (Berg et al., 2015).

Marine plastic pollution and marine litter have been characterized as a significant and very intricate challenge regarding the Mediterranean region as well. However, several obstacles hinder the effectiveness of efforts made to successfully alleviate this environmental problem. The lack of expertise and thorough understanding regarding the impacts of marine plastic pollution on marine species, habitats and human health is considered to be one of the most crucial among these obstacles. In addition, the weak implementation or/and enforcement of existing legislation has contributed to this situation. In the same context, poor managing and monitoring regarding waste management frameworks and strategies can pose significant problems in terms of effectiveness (Fossi et al., 2019).

Nevertheless, certain financial barriers arise when considering the highly cost intensive waste collection services along with the operational expenses for every waste management facility. Even though responsible and sustainable consumption and production is at the moment a prerequisite at a global scale (SDG 12), the implementation of suitable and innovative technological solutions is still cumbersome. It is imperative, yet very complicated, to apply the most suitable technological compound that will efficiently combine reliability, applicability in situ, and cost effectiveness. Furthermore, insufficient environmental awareness and communication pertaining to the issue of marine plastic pollution may further intensify the negative aspects of this problem. The lack of responsibility and sensitization on behalf of citizens and stakeholders regarding plastic waste, plastic consumption and their implications for marine/coastal environment aggravates this problematic situation, whilst at the same time foreshadowing more difficulties to come (Latinopoulos et al., 2018; Fossi et al., 2019).

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Potential and proposed solutions

As analyzed above, plastic pollution can be detrimental for the marine and coastal environment on a global level, though the implications of the currently accelerated global plastic production are not solely limited to these adverse impacts. The GHG emissions from plastic production may potentially reach 15% of the global carbon budget till the year 2050, while life-cycle GHG emissions of conventional plastics at a global scale were estimated at 1.7 Gt of CO₂-equivalent (CO₂e) during 2015, a figure which may rise to 6.5 Gt of CO₂e by the year 2050, based on current growth rates (World Economic Forum, 2016; Geyer et al., 2017; Zheng and Suh, 2019).

In this context, mitigation strategies should also address the life-cycle GHG emissions of plastics, in accordance with innovative techniques and measures in terms of recycling, renewable energy, and demand-management strategies. The integration of energy, materials, recycling, and demand-management strategies combined with the promising substitution of fossil fuel feedstock with biomass could potentially sustain 2050 emissions to a level equivalent to its corresponding one for the year 2015, thus, suppressing the accelerated growth of life-cycle GHG emissions from plastics (Zheng and Suh, 2019). To this end, fossil fuel based plastics can be replaced by bio-based plastics (from corn, sugarcane etc.) and gradually be fully phased out as well (Yates and Barlow, 2013).

Next steps should include the steadfast promotion of renewable forms of energy (wind power, biogas), whilst simultaneously de-carbonizing the existing energy mixture of plastics supply, further boosting recycling as in the case of End-of-Life (EoL) plastics, therefore, minimizing GHG emissions resulting from inefficient processes such as incineration (Zheng and Suh, 2019). Ultimately, through the effective implementation of similar strategies, significant reductions to curve the accelerating growth in plastics demand worldwide may prove to be feasible, also taking into account the fact that they are necessary.

Nevertheless, the implementation of mitigation strategies in terms of “1-size-fits-all” solutions is not always possible or realistic, as plastic waste is not evenly distributed worldwide due to differences in waste management infrastructure or the associated policies applied at each case (Jambeck et al., 2015; Rochman et al., 2016). In such cases strategies ought to differentiate according to the situation at hand and the geographic location, acknowledging the available

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infrastructure and budget constraints. However, it is also deemed equally important to assess the plastic pollution issue via a more holistic approach, especially with respect to plastic governance, a fact that it is currently encouraged based on efforts made in the form of various global plastics conventions and treaties as well as the promotion of a circular type of plastics economy (Nielsen et al., 2020). As already mentioned above, proper economic and legislative incentives must be offered toward the reduction of plastic pollution in the marine and coastal environment. These incentives should include bottom-up governance together with state and federal legislation through the application of both soft and hard law. Both consumers and producers should be morally responsible for product stewardship, advancing from the linear type economy to a circular one on the basis of reduce, reuse, repurpose, and recycle principles (Schuyler et al., 2018). Within this framework, multinational cooperation in the form of sharing innovative techniques and methodologies can prove to be very successful.

As part of a relatively modern age approach, the promotion of educational and awareness raising campaigns and programs is strongly recommended. Educational outreach at every level (formal and non-formal) and at source as well as informative education within a context of encouragement regarding actions and measures for the prevention, reduction, monitoring and efficient management of plastic waste are deemed crucial toward the successful mitigation of this issue (Xanthos and Walker, 2017; Latinopoulos et al., 2018; Fossi et al., 2019). In addition, the formation of partnerships aiming at successfully implementing initiatives at various levels (government, private sector, civil society, international organizations, scientific community) with respect to prevention measures, technological solutions and research is highly advised for effective decision-making. Additional suggestions to fill in knowledge gaps should include investing in research in order to properly evaluate the effectiveness of bans/levies, thus, ensuring that the implemented policies are adequate. Projects and partnerships consisting of all the relevant stakeholder groups and communities together with scientific experts within a society-science-policy interface, as in the case of Plastic Busters MPAs, are prime examples toward a more integrated and holistic approach (Fossi et al., 2019).

Furthermore, there are other initiatives currently taking place or in the making such as the integrated marine debris observing system (IMDOS) which will provide long-term monitoring regarding the state of this issue, while simultaneously supporting any operational activities for

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mitigating any potential impacts on ecosystems (Maximenko et al., 2019). This proposed system is based on observations in situ and remote sensing technology providing spatially consistent coverage from local to global scale. These in situ observations include reports from citizen scientists, volunteers, and ships of opportunity, therefore, maximizing the data provision for more effective monitoring pertaining to the actual extent of plastic pollution and marine debris (Maximenko et al., 2019). On the other hand, the application of more “traditional” techniques and methodologies, as in the case of discrete choice experiments (DCEs) on an international level, can also be fruitful when performed within comprehensive frameworks. In particular, the implementation of identical international DCEs in an effort to validate the transferability of non-market costs or benefits regarding environmental changes is critical for advancing our knowledge about context particularities and spatial variation or distribution with reference to the environmental costs and benefits of implemented policies across different countries (Brouwer et al., 2015; Lopes da Silva et al., 2015; Brouwer et al., 2017).

As far as plastic bags are concerned, being among the most prominent type of PML as well as a primary policy objective in environmental policy associated with mitigating plastic pollution, the results are evident bearing in mind the gradual proliferation of major public policies aiming at reducing plastic bag consumption since the 2000s, from approximately 20 policies in 2003 to 160 during 2018 (Ritch et al., 2009; Clapp and Swanston, 2009; Nielsen et al., 2020). The majority of the existing published literature in reference to plastic bags investigates attitudes along with behavioural changes and patterns in association with the effects of the corresponding public policies for reducing plastic bag consumption for each individual country (Convery et al., 2007; Romer and Foley, 2011; Dikgang and Visser, 2012; Jakovcevic et al., 2014; Poortinga et al., 2016; Martinho et al., 2017; Wagner, 2017; Rivers et al., 2017). Particular studies as in the cases of Clapp and Swanston (2009), Xanthos and Walker (2017) and Nielsen et al. (2019) explore specific plastic bag related initiatives on a global level.

Levies and bans (total and partial) are often implemented toward the reduction of plastic bag consumption, though on some occasions certain legislation has been enacted to restrict local governments from regulating single-use plastic carrier bags (Wagner, 2017). These aforementioned policies have indeed contributed toward reducing plastic bag consumption, yet the effects on an aggregate level and at a global scale remain to be determined (Nielsen et al.,

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2020). Be that as it may, an integrated and holistic approach incorporating market-based strategies, community participation, and scientific expertise is necessary in order to successfully address the contemporary plastic pollution challenges for marine and coastal ecosystems integrating both local and global governance (Vince and Hardesty, 2016).

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6. Environmental preferences and information provision

6.1 Environmental behaviour and awareness

Theory of planned behaviour (TPB)

The theory of planned behaviour (TPB) constitutes a notion originally introduced in the field of psychology by Icek Ajzen, delineating the relationship between a person's beliefs and behavioural patterns on the basis of subject norms, attitude, and perceived behavioural control (Ajzen, 1991). It has been characterized as an efficient model which builds on the predictive power regarding the theory of reasoned action, while also enhancing it and it has since been applied to several fields of expertise including environmental studies. In particular, based on this theory human relations are thoroughly investigated in accordance with the beliefs, behavioural intentions, and general disposition of an individual toward certain aspects of environmental and ecological interest such as recycling, sustainability practices, etc. (Knussen et al., 2004; Tonglet et al., 2004; Huang et al., 2014; Ohtomo and Ohnuma, 2014; Ari and Yilmaz, 2017).

This type of social-psychological theories on environmental behaviour are useful when examining the psychological determinants of environmental sensitivity regarding ecological threats and environmental problems such as plastic pollution. TPB incorporates a prototype model to improve its predictions integrating both intentional and unintentional motivation, which ultimately shape social behaviour (Ajzen, 1991; Gibbons et al., 1998). The intentional motivation refers to behavioural intention which describes a deliberate thought process resulting in intentional behaviour, while unintentional motivation relates to behavioural willingness which can be explained as the reaction to a specific situation resulting in an unintentional or unpremeditated behaviour. In that sense and based on the prototype model, evaluations can be made regarding processes which affect and influence pro-environmental behaviours as it integrates both intentional motivation (individual preferences) as well as unintentional

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motivation on the basis of certain context and situations (Gibbons et al., 1998; Ohtomo and Ohnuma 2014; Ari and Yilmaz, 2017).

However, the TPB model has also been criticized as being restrictive in its capacity to properly predict behaviour, taking into account that it mainly emphasizes on deliberate choices, while changes in intention may often result in relatively few behavioural changes (Bamber and Möser, 2007; Webb and Sheeran, 2006; Gerrard et al., 2008). In addition, any differences between actual behaviour and planned behaviour might originate from a “*habitual reaction*” or a “*non-intentional route to behaviour*” separately from what the behavioural intention actually represents (Ohtomo and Ohnuma, 2014).

Environmental behaviour and awareness

Environmental behaviour usually refers to the part of human behaviour associated with environmental issues and topics which can be characterized as positive or “pro” when the individual makes conscious choices aiming at minimizing the negative impact of their actions on the environment or alternatively negative when the opposite is true. A plethora of studies has investigated the determinants of environmental behaviour on different subjects (Stern, 2000; Schultz, 2001; Gardner and Stern, 2002; Klöckner, 2013; Gifford, 2014; Pahl and Wyles, 2016; Hartley et al., 2018) producing theories such as the aforementioned TPB (Ajzen 1991), the Norm Activation Theory (NAT) (Schwartz and Howard, 1981; Thøgersen, 1996), as well as the Value-Belief-Norm-Theory (VBN) (Stern, 2000). Additional models include Klöckner (2013) and Gifford (2014) exploring behavioural patterns based on certain predictors (attitudes, intentions, knowledge, awareness of impact, perceived and personal responsibility, ethics, social norms, personal experiences regarding the issue at hand).

Nevertheless, environmental behaviour is shaped and influenced on the basis of environmental awareness as well. In this context, environmental education has proven to be a very useful tool when properly applied toward the mitigation of crucial environmental problems such as marine litter, plastic marine waste, and plastic pollution. Research has shown that through

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intergenerational learning and environmental education, it is possible to influence environmental attitudes and dispositions both on children and adults (children's influence on them) for the better (Uzzell, 1994; Ballantyne et al., 1998; Duvall and Zint, 2007; Damerell et al., 2013). In the case of marine litter specifically, young adults have frequently been characterized as crucial in mitigating this particular environmental threat through the application of environmental knowledge together with specific social norms which form pro-environmental behaviour (Gusmerotti et al., 2016). Based on Hartley et al. (2015), during their investigation of 176 British schoolchildren (from 8–13 years old), it was deduced that participation in educational intervention (appropriate waste disposal, recycling, beach clean-ups, preferring recyclable items, etc.) improved children's perceptions and recognition in regards with marine litter and the associated negative impacts and solutions. In addition, they became more engaged "actionwise", resembling similar adult behaviours concerning mitigation strategies (Barnes et al., 2009; Wyles et al., 2013). Furthermore, besides representing the next generations these children may also influence their families to adapt pro-environmental behaviours regarding marine litter and so on and so forth.

However, during this process of appropriately influencing youth perceptions toward more environmentally friendly and sustainable solutions in relation to ecological threats such as marine debris and litter, environmental education should be carefully organized. In particular, complex environmental issues such as plastic pollution require constant educational support based on up-to-date information and data. It is imperative to provide students with follow-up educational material and supplemental assessments regarding current trends on the topic under examination in order to attain longer-term learning gains (Torres et al., 2019). In addition, the provision of information and knowledge along with communicating the problem should be as clear and distinct as possible. Students need to be aware of the fact that even if they are considered to be part of this problem, they are also part of the solution as they may be influenced by the so-called "observer bias".

In that sense, proper adult role models should be presented through positive interactions, lifestyles, attributes, and pro-environmental norms (Torres et al., 2019). Litter reduction educational programs are most efficient when engaging every relevant stakeholder and actor (educational staff, facility staff, students, parents) on the grounds of creative peer outreach, non-

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judgmental information communication, participation in assessment activities, positive behavioural changes and joint program developing along with mitigating the environmental problem at hand (Curnow et al., 2013; Torres et al., 2019).

On certain occasions, it may be practical to divide the factors that potentially affect environmental awareness and pro-environmental behaviour into two main categories: external and internal (Kollmuss and Agyeman, 2002). In the internal factors category, personal experiences, connection with nature, inclinations provided by teachers and parents together with personal observations on environmental pollution are regarded as the most prominent for predicting and conceptualizing environmental awareness (Palmer et al., 1998; Chawla, 1998; Miller, 2005; Kiessling et al., 2017). In addition, socio-economic factors such as age, income, gender, education, and residence (urban or rural) are also regarded as important predictors of environmental awareness, but they are often case-specific and inconclusive (Van Liere and Dunlap, 1980). In particular, referring to coastal environments, female visitors of higher education and income level as well as senior citizens are less prone to littering (Santos et al., 2005; Slavin et al., 2012; Dias Filho et al., 2011; Eastman et al., 2013; Kiessling et al., 2017).

Taking the aforementioned into consideration, it has been demonstrated that the application of certain practices aiming at enhancing public awareness may be very beneficial from an environmental policy point of view. Global environmental threats, as in the case of marine litter and plastic pollution, should be viewed as complicated societal problems where the “one solution fits all” principle does not apply. Within this framework, initiatives such as MARLISCO, based on encouraging societal awareness along with co-responsibility throughout the various sectors involved have been proven to be effective (Veiga et al., 2016).

The MARLISCO project was comprised of several activities across 15 European countries in an effort to raise public awareness and participation regarding marine litter through a combination of various practices. In particular, it incorporated public exhibitions in approximately 80 locations, educational and decision-supporting material and tools together with 12 national participatory events aiming at promoting dialogue and improving interactions among approximately 1,500 stakeholders focusing on preventive measures and solutions (Veiga et al., 2016). During the implementation shows several evaluations were carried out indicating that activities such are

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these may turn out to be quite effective in improving individuals' perceptions in regards with this problem, whilst encouraging participation/commitment in being part of the solution (Veiga et al., 2016). In addition, the impact on participants' perceptions and knowledge was substantial, taking into account their increased sense of individual responsibility as well as the resulting higher level of concern for both stakeholders and individuals.

The impact of information provision on the basis of environmental valuation

Numerous environmental valuation studies have systematically examined the impact of environmental information and environmental awareness on individual preferences for environmental goods and services, most commonly on the basis of revealed and stated preferences methodology. In this context, the main goal is to properly assign values to these environmental goods and ecosystem services.

Environmental awareness often refers to a particular attitude with regard to the consequences induced by human actions and behaviour, in general, to the natural environment (Ham et al., 2016). In addition, it also represents people's knowledge and interest regarding the environmental impacts of their choices and behaviour (Fu et al., 2019). In this sense, environmental awareness actively contributes toward shaping people's preferences and consumption patterns, whilst affecting purchasing habits within the framework of various types of markets (Wierzbinski et al., 2021). An increased knowledge in environmental issues may presumably lead to more pro-environmental or eco-friendly behaviour and attitudes (Flamm, 2009; Gram-Hanssen, 2010; Khan et al., 2020).

In this context, citizens characterized by increased environmental awareness have an essential role in promoting and enhancing the effectiveness of certain environmental policy measures. Based on an amalgamation of De Young's and Tietenberg's tools to alter behaviour, and particularly the information tool (De Young, 1993; Tietenberg, 1997), the provision of information through education, mass media and publication can affect awareness and significantly contributes toward motivating people to take action and assume pro-environmental behaviours. Within this

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framework, there are some key aspects regarding the successful provision of information via the application of suitable models in order to form awareness for specific needs, responsibility and ultimately encourage collective actions. On an environmental policy level it is also deemed crucial to gradually build trust toward governmental bodies, thus, facilitating the acceptance of all the relevant policy initiatives (Iizuka, 2000).

In particular, (i) the provision of general information on the environment in order to increase people's awareness with respect to the issue at hand, (ii) the provision of specific information that will clarify and associate the causal relation characterizing an environmental problem as well as suitable mitigation actions, (iii) the provision of information on any activities and their content performed by others, and (iv) the provision of accurate information with regard to any relative government policies in order to prove that both public and private sectors participate in this transformation process (Iizuka, 2000).

Nevertheless there are certain inherent limitations in existence associated with insufficient information, knowledge, and experience on behalf of individuals with regard to ecosystem functions and processes that contribute to this problematic situation, thus, paving the way for terms such as "information bias" and "information effect" to arise. From this perspective, the significance of information in association with the resulting awareness on individuals' preferences is deemed very important and useful to explore as a policy tool, therefore, necessitating further research. People's awareness has become a vital tool toward promoting environmental policy measures, a trend which can be traced back since the Agenda 21 of the United Nations (UN, 1992).

Within this framework, it is essential to examine in what way and extend individual preferences and values may change when additional information is provided to the participants (respondents) of a survey regarding environmental issues, the functions and services provide by ecosystems, environmental impacts and existing or potential environmental risks and threats. As mentioned above, information bias is often associated with changes in environmental values assigned by people (consumers) on account of the quantity (and quality) of information provided to them. Integrated information and awareness raising campaigns have often been applied as tools of environmental policy aiming at enhancing knowledge as well as raising environmental awareness and responsibility with regard to specific environmental actions and/or projects (Marschak and Miyasawa, 1968; Marschak and Radner, 1972; Bikhchandani et al., 2013; Samples et al., 1986;

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Bergstrom et al., 1990; Latinopoulos et al., 2018). The vast majority of environmental valuation studies investigates the instant effects of information as an integral part of the valuation study based on the hypothesis that additional and/or information of higher quality may alter respondents' willingness to pay for certain products or services (Randall, 1986; Aravena et al., 2018). The information effect is usually estimated via the use of econometric models and comparisons made between the stated WTP (willingness to pay) values before and after the provision of environmental information. In this context, it has been documented that in general environmental values are positively influenced when more information is provided to individuals in relation to the environmental impact of the selected activities, a fact further validated by their higher WTP estimates for environmental conservation (Lusk, 2003; Urama and Hodge, 2006; Moynihan and Hawes, 2012; Schoenefeld and McCauley, 2016). Willingness-to-pay values are usually sensitive to specific information provided on environmental goods or services being evaluated, most notably in the case of goods/services respondents are unfamiliar with or not well-known (Tisdell et al., 2008). In addition, the provision of information on native ecosystems along with value-congruent information about the benefits of environmental protection, may contribute to making environmental management strategies more acceptable and desirable (Ribe, 1999; Ford et al., 2009; Bateman and Mawby, 2003; Ryan, 2012; Rambonilaza and Brahic, 2016; Latinopoulos et al., 2018).

There are several factors influencing the information effect within the context of environmental valuation most prominent of which appear to be focus groups composition (e.g. focus groups are formed to appropriately represent specific populations of interest), the choice between focus groups and individual interviews, the information content provided as well as the different levels of the assessment (i.e. national, sub-national, regional and local) (Foster and Just, 1989; Krieger and Hoehn, 1999; Shwom et al., 2008; Hill and Daniel, 2007; Luthe and Schläpfer, 2011; Straka et al., 2016; Schoenefeld and McCauley, 2016). In addition, the accuracy together with the extent of information provided may affect the acceptability rates of sustainable policies for the better (Kearney, 2001). However, it has been demonstrated that the information effect bears a higher impact when emphasizing on future environmental and especially human health risks (Jalan et al., 2003; Madajewicz et al., 2007; Hill and Daniel, 2007; Orset et al., 2015; Latinopoulos et al., 2018).

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As earlier mentioned, environmental awareness plays an important role in shaping consumption patterns by means of influencing consumer behaviour and purchase decisions (Shao, 2016; Wierzbinski et al., 2021). Consumers who choose to follow a pro-environmental lifestyle tend to seek and eventually gain a deeper understanding in regard to environmental issues, while at the same time taking responsibility about the environment during their purchasing decisions (Young et al., 2010). A pro-environment consumer would buy products on the basis of environmental awareness bearing in mind all the relative ecological concerns and environmental criteria associated with these products (Souza et al., 2007).

The need for information also constitutes an intriguing thematic in terms of consumer awareness with respect to the rights of the consumer in the marketplace. The right to information which in turn is associated with the right to freely choose among various alternatives and the right to an unpolluted environment are vital for shaping consumers' responsibility and ultimately allowing them to make informed choices, potentially altering their consumption behaviour in favour of environmentally friendly alternatives to certain goods and products (Rousseau and Venter, 1992, 1995; Mainieri et al., 1997; Chartrand, 2005; Rhein and Schmid, 2020). Insufficient information may set limitations in potential alternative product choices, thus, affecting the willingness to pay in relation to products characterized as "more sustainable", while increased consumer awareness may trigger changes in consumer behaviour (Grunert, 2011; Csutora, 2012; Ishak and Zabil, 2012; Gantman et al., 2017 Ketelsen et al., 2020).

Consumer awareness is currently gaining ground in topics closely related to sustainability issues and possible ways or methods based on which sustainability communication will encourage consumer behaviour toward specific choices (Galbreth and Ghosh, 2013; Dach and Allmendinger, 2014). Nevertheless, aiming at the formation of the ideal sustainable consumer behaviour, it is crucial to ensure the provision of extensive information and knowledge with respect to all the relevant aspects of consumer awareness and their associations to behavioural changes (Hansen and Schrader, 1997; Rhein and Schmid, 2020).

In addition, the amount of information provided to individuals coupled with their personal taste experiences may also increase their WTP values (Lusk et al., 2001). The provision of information on product quality may also serve as a substitute to experience, potentially combined later on with personal taste experiences regarding the products under valuation (Lusk and Schroeder,

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2006; Gracia et al., 2011; Su et al., 2017). On certain occasions, anchoring and information may be considered as potential reasons for fragility in WTP estimates regarding choice experiments when compared to experimental auctions, resulting in different WTP estimates for the individuals participating (Su et al., 2017). In this sense, the additional information provided may affect WTP values differently in accordance with the method applied (experimental auction or choice experiment), and particularly in the case of less-experienced participants, as auction participants receive additional information via the observation of other participants behaviour (their bids) contrary to choice experiment participants where this is not possible.

In addition, greater awareness with regard to the number of ecosystem services has been shown to affect preferences for ecosystem management. In particular, the communication of additional information regarding the number of ecosystem services may encourage individuals to acknowledge a wider range of benefits provided by ecosystems, which in turn may affect their preferences toward more environmentally friendly choices (Richards et al., 2017). Nevertheless, the decision-making process, and thus people's preferences are optimized when detailed and more empirical data on ecosystem services are provided rather than simply describing more ecosystem services to individuals (Richards et al., 2017).

In this context, an effort toward improving the communication of ecosystem service valuation research may further facilitate policy makers as well, during the process of policy formation and/or environmental management. The effective communication of research associated with the economic valuation of ecosystem services may also lead to better assessments regarding trade-offs and synergies in ecosystem-based management, as often documented in reference to marine and coastal ecosystems (Torres and Hanley, 2017). In this way, the social efficiency of the decision-making process is increased, as management frameworks may substantially gain from the information embedded in WTP estimates.

An increased environmental awareness regarding major and contemporary issues such as marine litter and plastic pollution may greatly contribute to reducing the extent of these problems (Löhr et al., 2017). On several occasions, empirical approaches or citizen science methods in reference to the marine litter threat have proven successful in raising awareness, and thus subsequently motivating individuals to mitigate this critical problem for the marine and coastal environment

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(Marin et al., 2009; Hartley et al., 2015; Veiga et al., 2016; Wyles et al., 2016; Owens, 2018; Rayon-Viña et al., 2019).

Be that as it may, there currently is a shortage of published literature about the examination of temporal variation in environmental preferences, especially in regard to an extended period of time. Most studies conduct test-retest stated-preference experiments for short-time periods, commonly referring to less than two years while incorporating the same respondent samples (Rolfe and Dyack, 2019). In this sense, their primary goal is to evaluate the validity of their initial assessments, therefore, excluding any potential factors producing random results over a time period. In other cases, potential changes in terms of temporal variation regarding the values under examination is examined more systematically on the basis of multiple survey repetitions over longer time periods, usually referring to two years or more (Neher et al., 2017).

In several studies contingent valuation methodology has also been applied, though only in few of them choice experiment methodology with multi-factor designs has been utilized (Liebe et al., 2012; Brouwer and Logar, 2014; Schaafsma et al., 2014; Czajkowski et al., 2016; Brouwer et al., 2017). The overall conclusions of the published research and studies such as the aforementioned denote toward a relative stability for environmental values over short-time periods, whilst exemptions do exist (Bliem et al., 2012; Schaafsma et al., 2014; Rigby et al., 2016; Matthews et al., 2017). Any occurring fluctuations in environmental values, if properly recognized, may be attributed to changes in underlying preference structure, yet there is no concrete evidence regarding the role or the particular effects of information provision in those differences.

6.2 The case of plastics

The perceived public awareness levels regarding environmental threats such as plastic pollution have increased within the context of modern society during the last decades, mainly on account of the unhindered and uncontrolled plastic proliferation in the natural environment, and particularly in marine and coastal ecosystems (Syberg et al., 2018; Leal Filho et al., 2020). Nevertheless, plastic production and consumption continue to expand at alarming rates, while

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public perception is often in favour of plastic use, even though people acknowledge the negative impacts of plastic pollution (Heidbreder et al., 2019).

Based on Leal Filho et al. (2020), it has been documented that the limited availability or lack of relevant information regarding plastic pollution and environmentally friendly alternatives to plastics (e.g. bioplastics) pose a significant obstacle toward the successful mitigation of plastic pollution. Despite a validated interest in adopting sustainable alternatives to plastics and committing to reduce plastic use, the lack of environmental policy tools such as information campaigns may hinder the overall effort of reducing plastic pollution in the marine and coastal environment (Leal Filho et al., 2020). Individuals who are more informed and confident in their knowledge in reference to environmental threats are more inclined to pro-environmental behaviour as in the case of plastic recycling, participation in environmental programs and campaigns, and generally diminishing their plastic waste production (Afroz et al., 2016). Factors such as gender and educational level are able to influence the level or awareness on plastic pollution (Hammami et al., 2017; Leal Filho et al., 2020).

The encouragement of pro-environmental behaviour regarding plastic pollution is more efficient when performed within a suitable environment, from the educational system to education life and active learning. Environmental education from an early stage (primary and elementary schools), public authorities (government bodies, municipalities) together with the private sector, utilizing contemporary techniques and platforms (social networks, online gaming etc.) may significantly contribute to raising awareness toward the reduction of plastic pollution (Hammami et al., 2017). Within this framework, the investigation of the factors that shape and eventually affect consumer awareness, attitudes and behaviour are of great importance in the interest of applying effective environmental policy measures and form appropriate plastic strategies (Pahl et al., 2017; Hartley et al., 2018; European Commission, 2018; Heidbreder et al., 2019).

At this point, it is important to emphasize on the fact that in the absence of adequate information regarding consumers' awareness, and thus consumers' behaviour oversights are bound to be made within the context of certain strategies aiming at mitigating plastic pollution (Laurenti et al., 2016; Latinopoulos et al., 2018; Taylor, 2019). Consumer awareness with regard to plastic pollution is closely associated with the corresponding level of environmental awareness of a particular individual along with his/her personal experiences within the framework of consumer

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behaviour (Rhein and Schmid, 2020). Environmental awareness has been linked to marine pollution and plastic waste regarding their impacts on human health (Fletcher et al., 2009; Jezewska-Zychowicz and Jeznach, 2015; Hammami et al., 2017; Dilkes-Hoffman et al., 2019b) as well as changes in consumers' behaviour resulting from environmental information campaigns (Lam and Chen, 2006; Kollmuss and Agyeman, 2002; Latinopoulos et al., 2018). In addition, environmental awareness has also been associated with consumer behaviour in relation to people's willingness to buy environmentally friendly alternatives to plastics and increase their plastic recycling (Iyer and Kashyap, 2007; Ayalon et al., 2009; Martinho et al., 2015; Ari and Yilmaz, 2017; Dilkes-Hoffman et al., 2019a; Dilkes-Hoffman et al., 2019b; Ketelsen et al., 2020; Rhein and Schmid, 2020).

Consumerism is strongly connected with plastic waste, therefore, justifying the need for consumer awareness-raising measures within the context of environmental policy. However, consumer awareness is not limited to environmental consciousness exclusively, as it incorporates crucial aspects such as consumer diversity. For this reason, customized strategies are usually proposed in an effort to attain broad social acceptance, whilst informing and integrating the general public on the decision-making process and formation of suitable and sustainable plastic strategies with high acceptance rates right from the start (Rhein and Schmid, 2020).

Nevertheless, the provision of information alone, even if certain prerequisites are satisfied (simplicity, accuracy, good presentation, action oriented, etc.), cannot drastically change behaviour patterns for the better (NCC, 2005; Ritch et al., 2009). More coercive policy measures are sometimes needed with respect to consumer behaviour and the use of plastics, as the fact that consumers seem to be receptive to more information does not guarantee that they will take action accordingly (Ritch et al., 2009; Miller, 2011). In addition, the implementation of policy measures if not properly substantiated, as in the case of Bangladesh and the banning of plastic carrier bags which was praised by other countries as well (Gupta, 2011), may lead to insufficient results. Based on Synthia and Kabir (2015), it has been demonstrated that practices such as distributing for free alternatives to plastic carrier bags together with weak law enforcement regarding the ban of plastic bags may at times be inadequate, while on the other hand environmental awareness campaigns are more likely to affect the actual behaviour of individuals.

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Pro-environmental intervention, stimulation and social pressure may trigger eco-friendly behaviour in terms of consumer habits (Geller et al., 1971; Houghton, 1993; Austin et al., 1993; Ari and Yilmaz, 2016). Furthermore, voice prompt intervention encouraging eco-friendly behaviour and choices has also been found to greatly contribute to reducing plastic bag use in supermarkets (Ohtomo and Ohnuma, 2014). On the other hand, the implementation of solely economic measures if not properly conducted may also lead to unfavourable results, as was the case in Taiwan and the implementation of a fee on plastic bags (Asari et al., 2008). Environmental awareness regarding plastic bags, social pressure and positive attitude aiming at banning plastic bags are regarded as crucial constituents toward the actual reduction of plastic bag consumption (Ari and Yilmaz, 2016). Subjective norms and a sense of social pressure may significantly affect the willingness to use environmentally friendlier alternatives to plastic bags, as in the case of cloth bags (Ari and Yilmaz, 2016). Actions such as pro-environmental banning may influence or alter the intentions and behaviour of an individual, whilst behavioural intention may also be significantly affected by subjective norms as well (Ohtomo and Hirose, 2007; Ari and Yilmaz, 2016).

6.3 Environmental information campaigns as a policy tool

By virtue of the fact that information provision and environmental education may affect environmental preferences, thus, compensating for the lack of personal experiences (Kikuchi-Uehara et al., 2016; Lang and Cavanagh, 2018; Chen and Cho, 2019), environmental policy has integrated the notion of environmental awareness in its arsenal of tools, combined with more conventional measures such as taxation, standards, etc. for maximum efficiency. In that sense, information campaigns have emerged as a relatively contemporary policy tool disassociated from the implementation of command and control approaches or the creation of incentives and disincentives respectively, as most economic instruments are based on (Weiss and Tschihart, 1994). Information campaigns may influence environmental preferences both on a behavioural level affecting attitudes regarding the provision of public goods or services of environmental origin, as well as, on the basis of a “heuristic” level for acquiring familiarity with these goods and services, and thus enabling individuals to make informed economic decisions.

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Information campaigns, utilized as awareness raising measures or educational tools for making informed decisions and forming responsible behaviour with respect to environmental issues, may be categorized under psychological interventions further substantiated by a plethora of successful examples in existence. In particular, it has been observed that the inclination for recycling along with the levels of awareness and self-reported disposal behaviour were increased when information campaigns, incorporating flyers, posters, TV screens and websites, were included to the implementation of recycling schemes (Pearson et al., 2014; Ofstad et al., 2017; Cheung et al., 2018). Similar examples include Klaiman et al. (2016) in the USA, Saidan et al. (2017) in Jordan, Uehara and Ynacay-Nye (2018) in Japan and Poortinga and Whitaker (2018) in the UK. In addition, several studies have investigated the effects and influence of information campaigns on the WTP values of the individuals participating, most of which concluded that these effects may be characterized as positive (van der Wal et al., 2014; Szabó and Ujhelyi, 2015).

In the case of Latinopoulos et al. (2018), the effectiveness of a public information campaign designed to improve the knowledge base of citizens regarding the environmental problems created by plastic bags in the marine and coastal environment of Syros Island in Greece was thoroughly examined. This particular information campaign focused on substantially increasing the knowledge of individuals on the impacts of plastic waste for certain ecosystem services in the marine and coastal environment. Furthermore, an additional goal was to determine if a public information campaign can affect the stated WTP values of the citizens regarding environmental programs which aim at protecting the marine and coastal ecosystems from plastic waste.

Within this context, a choice experimental method was applied in order to analyze the effects of the campaign on the preferences and WTP values of the participants for mitigating the various impacts of plastic waste on marine/coastal ecosystem services along with their willingness to take part (action) as individuals toward reducing their plastic bag consumption. Based on the results, participants assigned higher economic values to marine/coastal ecosystem services (i.e. higher WTP values) compared to non-participants in order to reverse the decline or loss of these services, a fact further validated by their mean WTP estimates which are significantly higher in comparison with the WTP of non-participants (Latinopoulos et al., 2018).

Another interesting approach toward the development of effective awareness raising combined with educational tools was the case of the aforementioned MARLISCO project (see Chapter 6.1) .

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Its aim was to enhance the decision making process for various stakeholder groups and the wider public in an effort to make more informed decisions and follow responsible behaviour regarding marine litter based on a set of awareness raising activities and educational tools (Alampei et al., 2014; Orthodoxou et al., 2014; MIO-ECSDE, 2015; Hartley et al., 2015; Veiga et al., 2016).. The selection and “calibration” of the relevant state-of-the-art knowledge into informative awareness raising and educational tools was deemed crucial as well as demanding. Taking into consideration certain results of the project, such as the number of subscriptions to a series of pledges to take action (e.g. extensive recycling, reduce use of packaging) and the impact of the online training course on educators along with the broad geographic project outreach, it appears that initiatives such as MARLISCO may prove to be beneficial.

In the case of Australia, state and local governments were forced to implement certain policy measures and actions, including information campaigns, aiming at reducing marine litter and plastic waste (microbeads, plastic shopping bags, etc.) before entering the coastal and marine environment. This particular course of action resulted from all the negative environmental impacts due to plastic pollution, damages incurred in the sector of tourism as well as potential future threats to human health. Based on their results it was concluded that councils that invested in coastal waste management programs and strategies drastically reduced the frequency of plastic waste and litter items on the coastline within their jurisdictions (Willis et al., 2018). The use of outreach programs such as “Clean Up Australia”, “Don’t be a Tosser”, “Bin your Butts” cigarette campaign coupled with state-enacted policies, as in the case of the Plastic Shopping Bag Ban and the Zero Waste Strategy and Recycling Strategy which targeted human behaviour for the reduction of waste, produced significant results within this goal. It was documented that the investments made for these information campaigns, and thus awareness raising, generated larger plastic waste reductions in the marine/coastal environment compared to investments made within the context of more conventional policies (Willis et al., 2018).

In the case of Turkey, throughout a campaign organized by Dicle University, the International Science and Technology Clubs, the Environmental Club, and the Association for Raising Environmental Awareness, cloth bags were distributed to citizens as alternatives to plastic carrier bags, while they were also informed about the dangers of using plastic bags (Temel, 2011). In addition, Temel (2011) proposed that maximum efficiency could be achieved by means of

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combining certain measures such as the implementation of a fee in plastic shopping bags along with promoting instructive classes in schools and community centers and providing information via the media regarding the use of plastic bags.

Nevertheless, the temporal variation of preferences and environmental values shaped by the influence of information campaigns aiming at raising environmental awareness has not been thoroughly examined yet, taking into account the currently relevant published literature. In this sense, it is crucial to accurately determine the duration of the influence induced by information campaigns for environmental policy purposes in order to properly assist during the formation of the appropriate strategies as well as for the effective monetary valuation of public goods and services. In particular, it would be very beneficial to evaluate any existing intertemporal effects on environmental preferences and values in relation to recurring information campaigns taking place in discrete time steps (Latinopoulos et al., 2018). In addition, the investigation of the time-decay effect within the framework of differentiating between the short-run and long-run effects of information campaigns and the factors that influence preferences over time (e.g. seasonal variations, etc.) may offer valuable insight in terms of environmental policy.

Ultimately, even though information campaigns and awareness raising activities are often cost-effective, they do not necessarily guarantee positive changes in environmental behaviour. Therefore, it would be most productive if a variety of different approaches were explored on the basis of a systematic evaluation of all the relevant activities and tools incorporated in order to better comprehend their potential benefits. Contemporary and critical environmental threats, as in the case of marine plastic pollution, require a combination of approaches and measures, whilst at the same time mobilizing all the associated actors and stakeholders to take part and accept their responsibilities.

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Part III: Application

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7. The case studies

7.1 A baseline national survey on awareness in relation to plastic bags and the marine environment

Directive (EU) 2015/720 of the European Parliament and of the Council of 29 April 2015 refers to and also aims at reducing lightweight plastic carrier bags' consumption. In that regard, after having taken into account the negative impact of plastic packaging and the associated waste generated on the environment, it states in Article 4 that *“all Member States shall take measures to achieve a sustained reduction in the consumption of lightweight plastic carrier bags on their territory”*. These measures include the use of national reduction targets, maintaining or introducing economic instruments as well as marketing restrictions in derogation from Article 18, etc. These particular measures must ensure that the annual per capita consumption does not exceed 90 lightweight plastic carrier bags by 31 December 2019 and 40 lightweight plastic carrier bags by 31 December 2025, respectively.

In this context, a web-based survey was conducted at national level in Greece during October-November 2017 to assess the level of awareness of the general public regarding this environmental issue (plastic bags and their negative impact on the environment), whilst at the same time eliciting information on plastic bag consumption. The survey was based on a structured questionnaire (see Annex) consisting of several questions aiming at extracting data on the general public's perception and knowledge in regards with this environmental problem, the policies which are to be implemented at EU level, the average consumption of lightweight plastic carrier bags per household per visit to supermarkets, grocery stores, farmers market, and the majority of convenience shops as well as shopping in general.

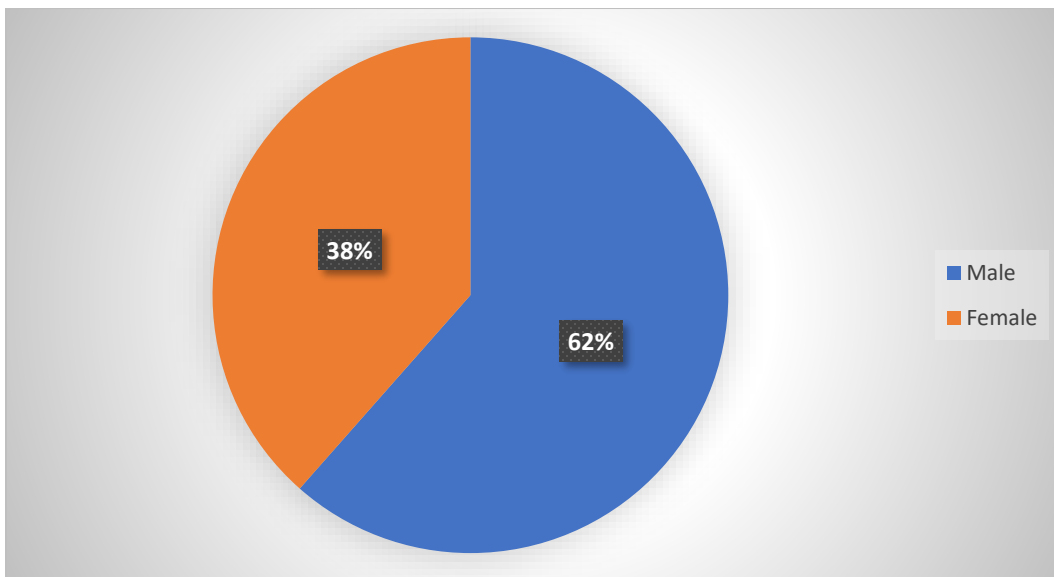
In addition, we attempted at obtaining feedback regarding any potential changes in consumers' behaviour on the basis of the environmental fee per plastic bag (implemented as of January 1st, 2018) and in terms of other forthcoming policy measures in the future. The ultimate goal of this web-based questionnaire survey was primarily to explore the environmental preferences and state of awareness of Greek citizens in relation to plastic pollution (mainly on the basis of plastic

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bags) in the marine and coastal environment and form a baseline level for more specific research to come.

According to the web-based survey results, administered at national level in Greece during October-November 2017, the majority of the sample consisting of 1,072 participants agreed that plastic waste, and especially plastic carrier bags, constitute a grave danger for the marine and coastal environment, while they would also easily replace them with other eco-friendlier means for carrying their groceries during their daily visits to the stores (supermarkets, grocery stores, farmers market, convenience stores, etc.). Figures 7-1, 7-2, 7-3, and 7-4 graphically present the main individual and household socio-economic characteristics of the respondents (sex, age, educational level, income level). Approximately 55% of the respondents reside in the region of Attica, while the second largest demographic group is associated with the region of Central Macedonia with 12%, respectively. The residual 33% is almost equally divided among the other 11 administrative regions of Greece.

Figure 7-1: Distribution of the respondents by sex



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Figure 7-2: Distribution of the respondents by age

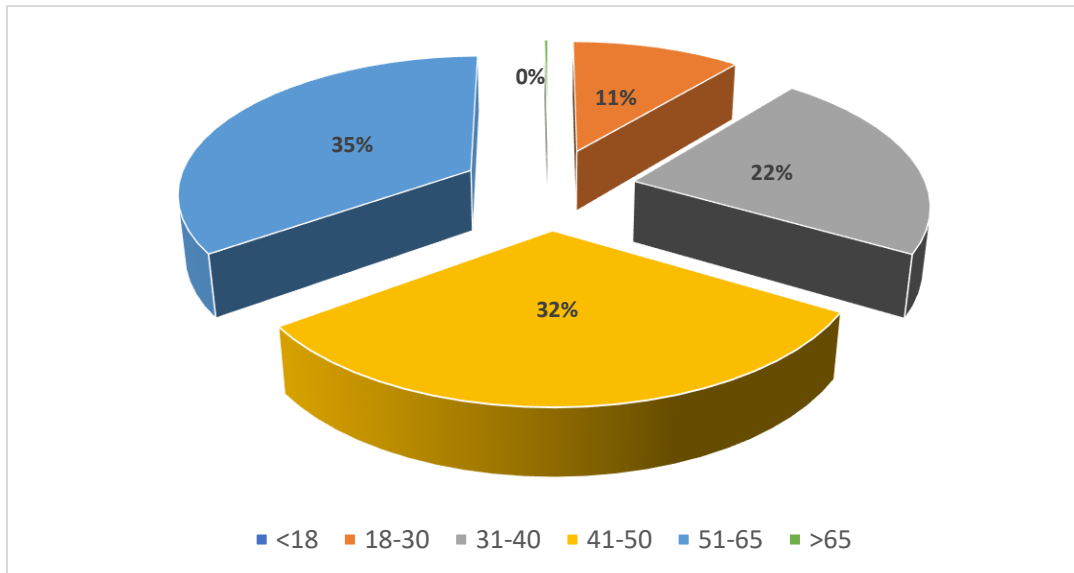
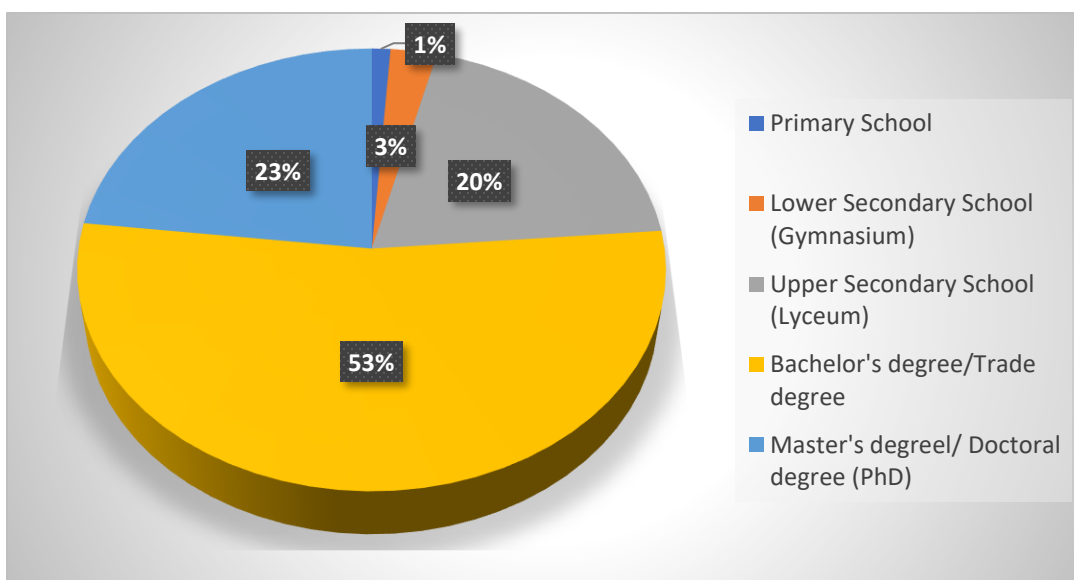
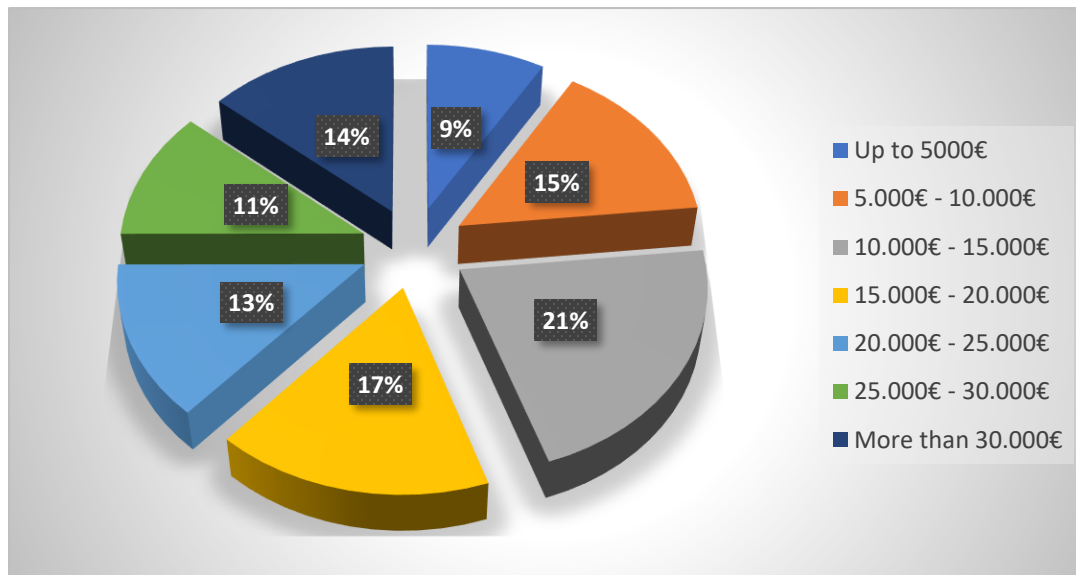


Figure 7-3: Distribution of the respondents by educational level



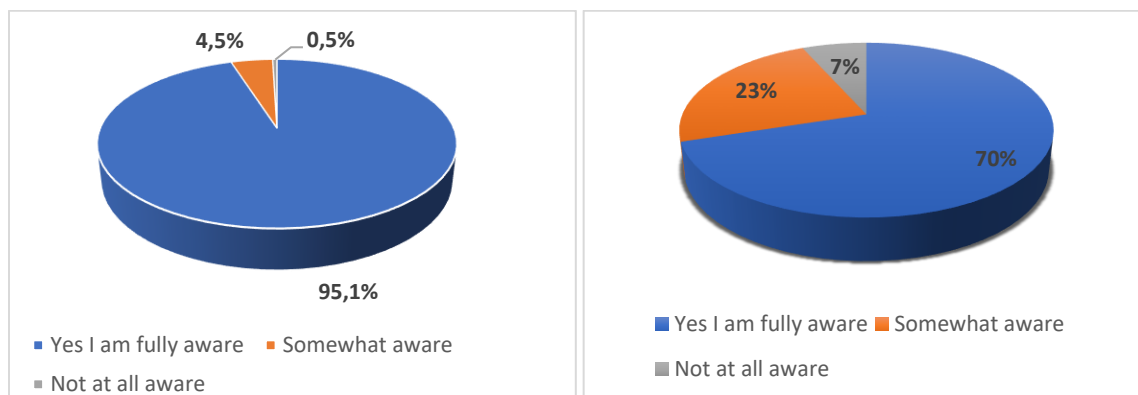
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Figure 7-4: Distribution of the respondents by income level



Based on Figure 7-5, it is estimated that 95% of the respondents are well aware of the negative impacts of plastic bags on the marine and coastal environment, whilst 70% are fully aware of the associated policies which will be or already have been implemented at EU level targeting the reduction of plastic bag consumption to address their impact on the environment.

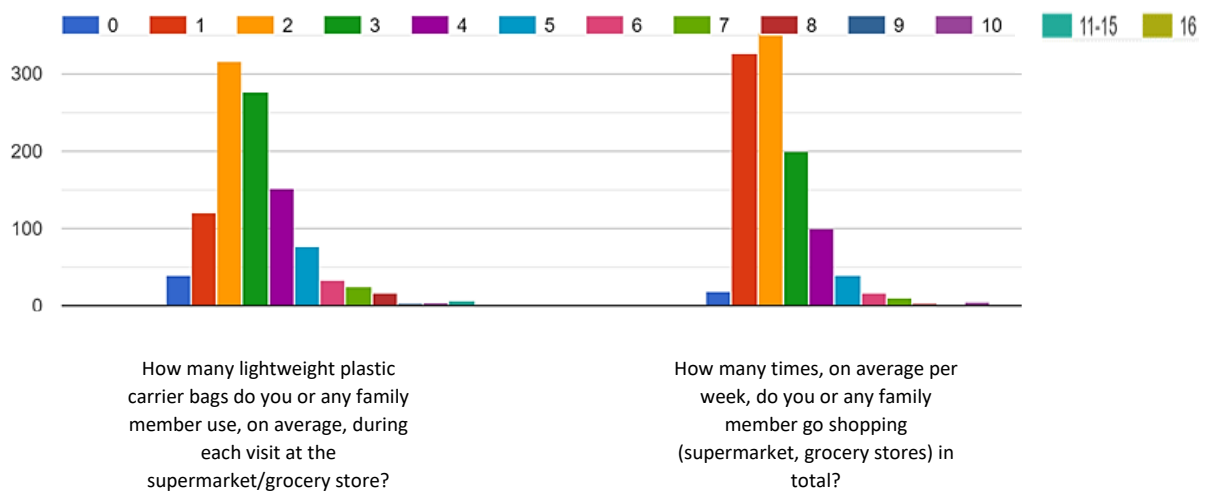
Figure 7-5: Level of awareness regarding the negative impact of plastic bags on marine ecosystems (left side) and EU policies being implemented to address this environmental issue and drastically reduce plastic bag use (right side)



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In relation to plastic bag consumption, Figures 7-6 – 7-9 illustrate the average lightweight plastic bag consumption per household (for each family member) per visit to supermarkets, grocery stores, farmers market, convenience stores, and general shopping (clothes, electronics, etc.) based on their average frequency of visits during the week. In this sense, the bulk of day-to-day shopping habits is represented in order to form a baseline on the basis of citizens' stated preferences regarding plastic bag consumption. As depicted in these figures, the majority of the respondents tend to use 2-3 plastic bags per visit to a store, therefore, and in accordance with their visit frequency it is deduced that they consume (per week and for each family member) at least 4 plastic bags in the case of supermarkets and grocery stores, 2 plastic bags regarding the farmers market, 2 plastic bags in reference to convenience stores, and 1-2 plastic bags for general shopping (clothes, electronics, etc.).

Figure 7-6: Average (lightweight) plastic bag consumption and supermarket/grocery store visit frequency



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Figure 7-7: Average (lightweight) plastic bag consumption and farmers market visit frequency

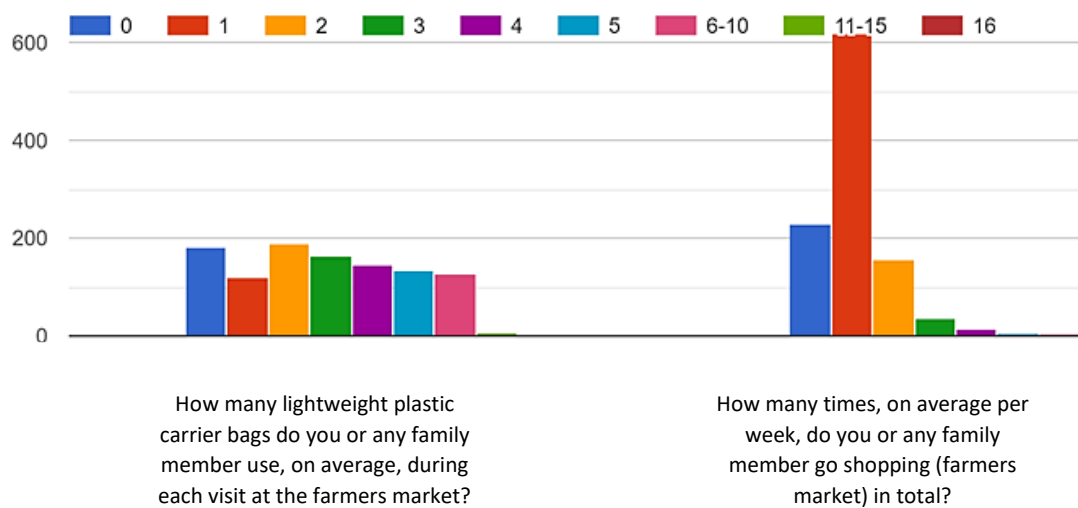
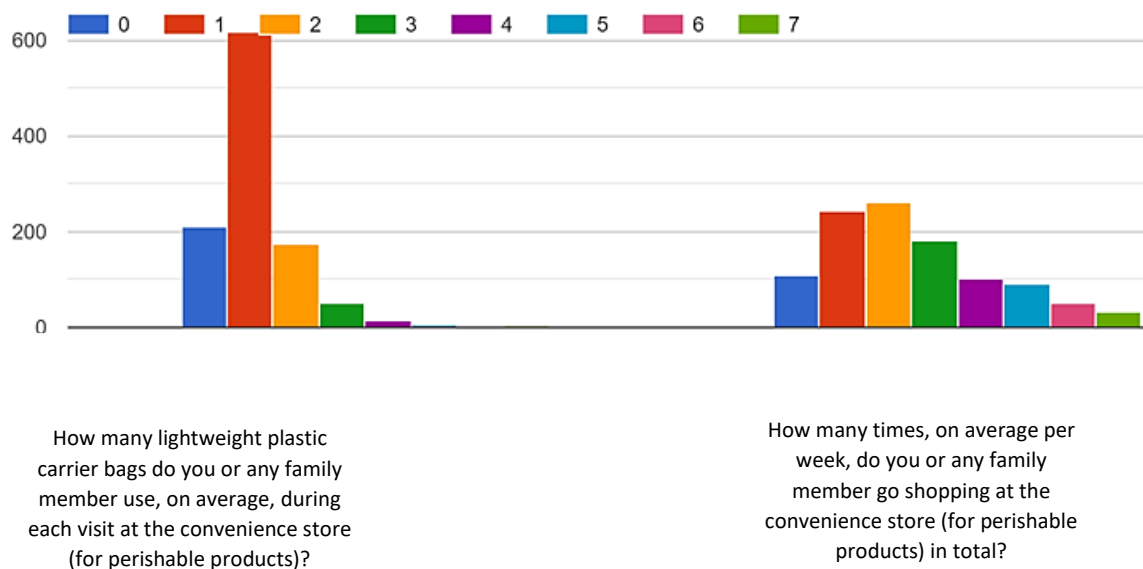
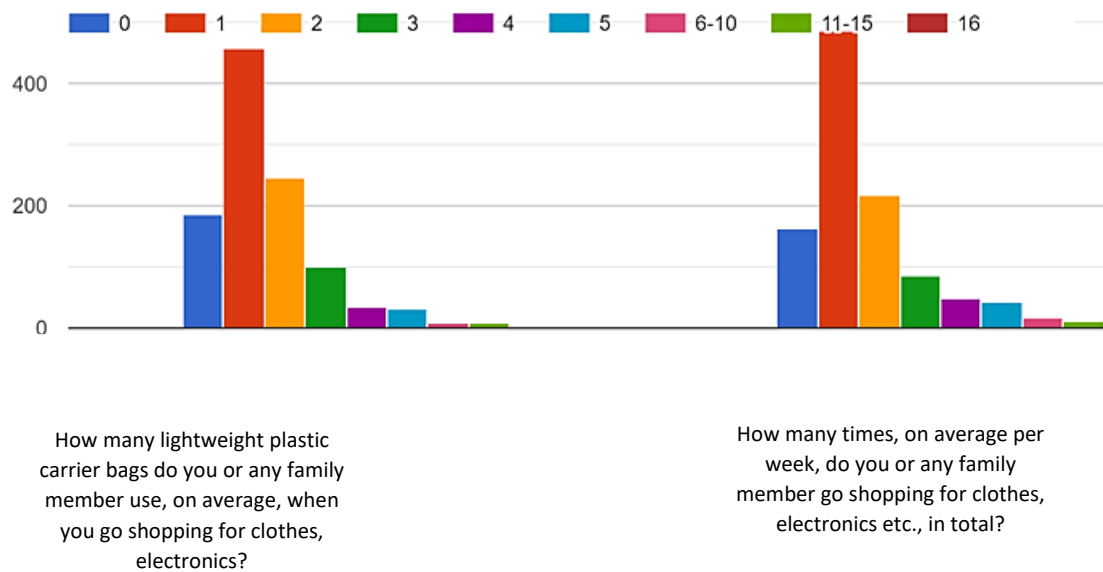


Figure 7-8: Average (lightweight) plastic bag consumption and convenience store visit frequency



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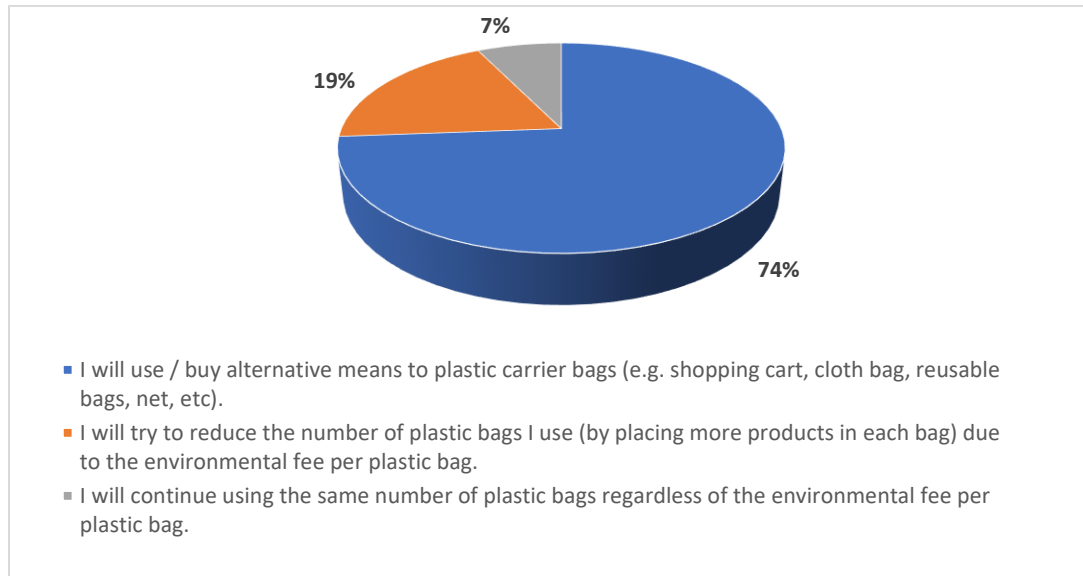
Figure 7-9: Average (lightweight) plastic bag consumption and general shopping visit frequency



Furthermore, 74% of the respondents stated that the impending environmental fee per plastic bag (starting January 1st, 2018) will most probably urge them to use or buy alternative eco-friendlier means compared to plastic bags (e.g. shopping cart, cloth bags, reusable bags, net, etc.) to carry their merchandise. Only 7% will continue using plastic bags regardless of the environmental fee per plastic bag (Figure 7-10).

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Figure 7-10: Implementation of the environmental fee per plastic bag and effects on consumer behaviour



In addition, as depicted in Figure 7-11, most of the participants (79%) acknowledge the need for and also agree with implementing the environmental fee per plastic bag in kiosks and farmers market as well, which are excluded contrary to the rest of retail stores (supermarkets, grocery stores, convenience stores, clothing stores, electronics stores, etc.). Moreover, 86% of the 1,072 respondents stated that they agree with the implementation of a total ban on plastic bags ubiquitously (Figure 7-12).

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Figure 7-11: Rates of agreement on implementing the environmental fee on kiosks and public markets, farmers market, etc.

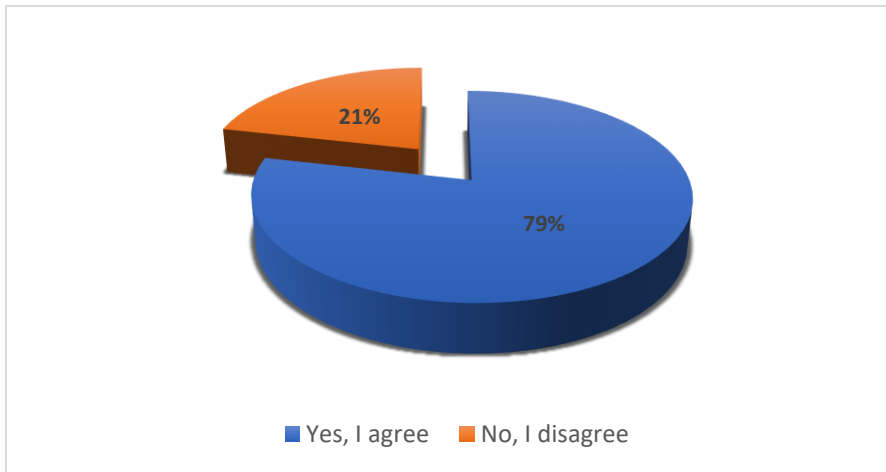
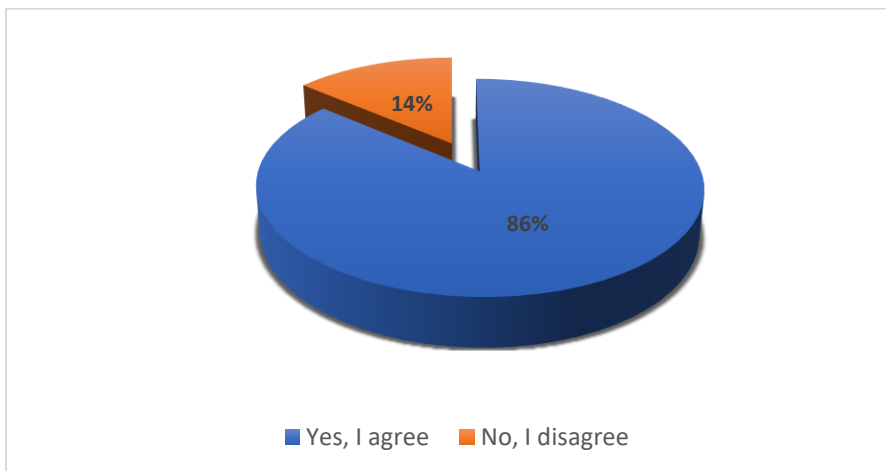


Figure 7-12: Rates of agreement on implementing a total ban on plastic carrier bags in stores, markets, etc.



Thus, and in accordance with the aforementioned results, it is safe to assume that the majority of the 1,072 individuals are in favor of policies and measures to drastically reduce plastic bag consumption per capita, taking into consideration the associated diverse effects for the marine and coastal environment. Furthermore, they would endorse eco-friendlier “solutions” to plastic

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bags, whilst the implementation of the environmental fee per plastic bag will further propel them toward this direction as well.

7.2 The island of Syros

Chapter 7.2 is mainly presenting and discussing the results of the published paper of "Latinopoulos, D., Mentis, C. and Bithas, K. (2018). The impact of a public information campaign on preferences for marine environmental protection. The case of plastic waste. Marine pollution bulletin, 131, 151-162" and the in-revision paper of "Bithas, K., Latinopoulos, D., Mentis, C. and Chatzivasileiadis, T. (2022). Does environmental information matter? Evaluating temporal effects on environmental preferences raised by information campaigns. Ecological Economics". In this regard, the conceptualization, statistical analysis and interpretation of the results are attributed to Dr. Kostas Bithas and Dr. Dionysis Latinopoulos.

7.2.1 Conceptual framework

Case study description and the information campaign

Aiming at evaluating the effectiveness of information campaigns as an environmental policy tool regarding contemporary and critical environmental issues, as in the case of plastic pollution, a choice experiment was conducted in Syros Island, Greece during the time period 2016-2018. In particular, the information campaign aimed at reducing plastic waste-and specifically plastic bags-in the local marine and coastal environment, taking into account the urgency of this environmental problem on a global level.

The choice experiment was constructed in a manner suitable for the evaluation of the effects of this particular information campaign on individual preferences for reducing plastic waste pollution under different status of environmental awareness, comparing respondents' (participants') preferences before and after the information campaign had taken place as well as intertemporally. It is important to denote that the evaluation process was as far as possible

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independent of the information campaign, whilst different respondent samples were formed on the basis of participation in the environmental campaign (i.e. before and after the information campaign). Within his framework, the main goal was to assess any differences among the preferences of the various respondent samples, variations in their respective willingness to pay values for protection of the marine and coastal environment, and differences in their commitment to take action (e.g. change their current plastic bag use behaviour).

The study area was the island of Syros (also known as Syra) representing the Mediterranean ecosystems, located in the Cyclades Islands, approximately in the center of the Hellenic Aegean archipelagos in Greece (Figure 7-13). Syros Island is located 144 km south-east of Athens, covering an area of 83.6 km² and is characterized as the most populated Cycladic island and the economic, administrative, and cultural center of the Cyclades as well as the South Aegean region of Greece. To this effect, its proximity and frequent connections to the port of Piraeus are deemed significant, particularly when combined with the island's well-developed tourism infrastructure. The population of Syros is approximately 21,507 inhabitants (2011 Census). In addition, Syros has 4,200 permanent households and 27 local businesses/SMEs (Cyclades Chamber of Commerce, 2019).

Syros Island can be characterized as a socio-economic system strongly associated with several provisional and cultural ecosystem services provided via the healthy functioning of the local marine and coastal ecosystems (e.g. fisheries, tourism, recreational activities, etc.). These services support the local economy of the island, but they are heavily dependent on functional ecosystems unencumbered by environmental stressors such as plastic waste. Marine litter, and plastic pollution in general (either washed ashore or detected on beaches) induce biodiversity loss and impede the aforementioned ecosystem services, therefore, hindering local economic development and social well-being as well.

In addition, islands are typically regarded as an essential component of coastal ecosystems (Lin et al., 2013) being described as part of land isolated and surrounded by water, with a high proportion of coast to hinterland. It is deemed important to denote that island ecosystems can be particularly sensitive to environmental disturbances and shocks, taking also into account the fact that numerous recorded extinctions have occurred on islands (Millennium Ecosystem Assessment, 2003).

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In the case of the survey at hand, initiated in Syros Island in May 2016, the inappropriate use and disposal of plastics and particularly plastic bags by consumers (residents and tourists alike) was regarded as the main marine litter source, corroborated by local residents' and stakeholders' statements. In addition, solid waste from landfills, shipping activities (both recreational and commercial) together with the operation of a shipyard on the island were deemed important sources of marine litter as well (Latinopoulos et al., 2018). Among the less important sources were the inadequate waste-water treatment along with tourism associated activities (besides the disposal of plastics and plastic bags).

A long term, integrated and content intensive information and awareness raising campaign took place on Syros, lasting approximately two years (May 2016 – May 2018) aiming at reducing plastic waste - and especially plastic bag – pollution in the local marine and coastal environment. The principal objective of this information campaign was to enhance the knowledge of residents, visitors and stakeholders alike with respect to the environmental problems caused by plastic pollution (Leal Filho et al., 2019) on the coasts and in the marine environment of the island. The campaign was particularly focused on plastic bags on the basis of several significant reasons.

In particular, (i) plastic bags are considered as one of the most common types of plastic waste as well as marine litter, (ii) suitable and eco-friendly substitutes to plastic bags offering the same level of utility are currently in existence and quite widespread, (iii) the principles of circular economy can easily be applied in the case of our particular target group of consumers (e.g. substitutability, reusability), (iv) plastic bags are associated with impacts on multiple categories of ecosystem services, thus, several benefits may arise from restrictions implemented in their use, and (v) as recommended by the European Directive (EU) 2015/720, both restrictive and economic measures can be applied in order to drastically reduce the consumption of plastic bags and their associated negative impacts on the environment.

The campaign involved constant activities throughout the whole period, together with super-intensive milestones, the so-called “Plastic Bag Free Weeks” targeting the general public, the regional local authorities, and certain stakeholders. Through the dissemination of certified environmental information and knowledge (relevant to this issue universities were involved during the preparation of the educational material/actions), the objective was to affect people's behaviour toward reducing both total waste and plastic bag consumption. In this sense, via the

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reduced use and appropriate disposal of plastic bags the quality of the marine and coastal environment is expected to significantly improve, therefore, positively influencing the provision of ecosystem services with their associated benefits for the local economy and society. Furthermore, the campaign targeted the majority of Syros Island's citizens including the general public, SMEs (small and medium-sized enterprises) and the bulk of any relevant to the importance of effective plastic waste control and recycling authorities contributing to an improved marine and coastal environment.

In this context, an extensive door-to-door awareness raising campaign was implemented on Syros Island informing approximately 4,300 households and 700 retail shops and SMEs, in relation to plastic bags and the impacts of their improper use and disposal. This particular information provision was performed face-to-face on the basis of verbal presentations along with the distribution of educational leaflets.

In addition, a minimum of 400 hotels and room rental facilities owners were informed in a similar way, whilst they were also provided with info sheets (leaflets) in 5 different languages to be placed in approximately 5,000 rooms. Taking into account calculated estimates, at least 30,000 permanent habitants together with visitors and tourists were informed during this information campaign. Based on an in-site evaluation of the information campaign, the majority of households and SMEs were indeed informed, while a significant number of hotel owners were approached as well.

Within this framework, the main actions of the aforementioned milestones (i.e. Plastic Bag Free Weeks) of the information campaigns conducted on Syros Island were the following:

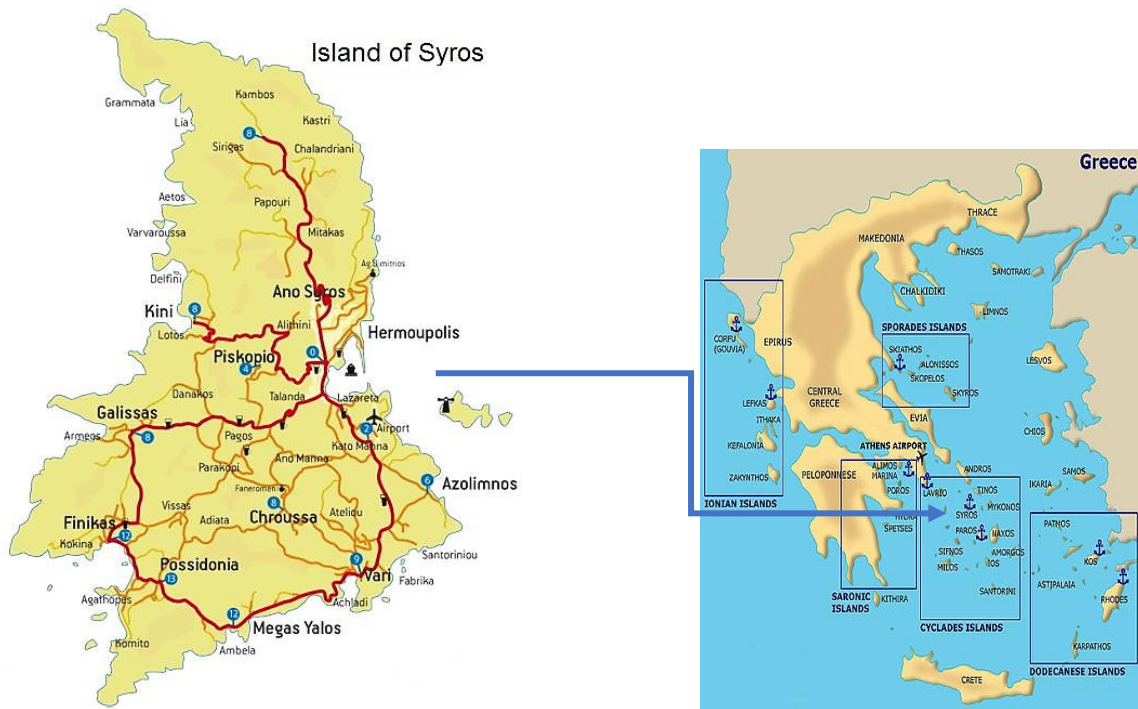
- Presentations and exhibits to local authorities and stakeholders regarding the negative impacts of plastic waste pollution,
- information provision to local shop owners and employees in relation to: (a) the impacts of single-use plastic bags on the marine and coastal environment, and (b) alternative (eco-friendlier) options to single-use plastic bags they could adopt,
- free distribution of reusable bags to citizens, supermarket/retail shops owners and visitors (tourists), combined with information leaflets on the environmental impacts of plastic bags on the marine and coastal environment,

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- introduction of information kiosks operating on specific locations of interest (town center, municipal council, etc.) to effectively educate both residents and tourists on the impact of plastic bags on the marine and coastal environment,
- special workshops were conducted regarding the most recent developments in environmental legislation (in relation to single-use plastic bags), as well as on the environmental issue at hand,
- training seminars for the teaching staff with regard to primary and secondary education,
- lectures on environmental education and good environmental practices in reference to plastic waste regarding 21 schools and approximately 3,500 students,
- extensive mass media presence on various national and local news media, newspapers, magazines, television networks and social networking websites (YouTube channel, Facebook, twitter, Instagram).

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Figure 7-13: Map of Syros Island



Source: https://www.greecetravel.com/aegean/map_of_syros_island.htm and <http://www.island-ikaria.com/SailingGreece.asp>

7.2.2 Methodology

Choice experiment methodology

In the case of Syros Island, stated preferences methodology was applied in order to elicit citizens' preferences regarding the mitigation of the environmental impact on account of plastic waste on the marine and coastal environment of the island. In particular, a choice experiment was conducted to assess the values regarding certain, representative for an island such as Syros,

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ecosystem services most likely to be affected by plastic waste and plastic pollution in marine and coastal ecosystems. For this effort, it was important to integrate all the relevant impacts perceived by the island's residents, which may ultimately influence their welfare on an individual level.

The choice experiment methodology derives from Lancaster's theory of value (Lancaster, 1966) combined with a model of random utility maximization (McFadden, 1973). In this context, the utility function U_{ij} of an individual for choice j is consisted of a deterministic component V_{ij} and a random error term e_{ij} , which captures the effect of unobserved and omitted variables:

$$U_{ij} = V_{ij}(Z_{ij}) + e_{ij} \quad (1)$$

In this sense, local residents of Syros were asked to choose among several alternative coastal protection programs (forming a choice set), on the basis of the most preferable one which generates the highest utility. This utility regarding coastal protection, and specifically measures aiming at reducing plastic bags in the marine environment, is subsequently extracted via a set of attributes. Residents' utility for coastal protection (i.e. for measures aimed at reducing plastic bags in the marine environment) can then be derived from a set of attributes ($Z_{i,j}$) in relation to the coastal protection program. These attributes are either related to the proposed program's impact on the various ecosystem services (e.g. fishing, biodiversity, swimming, etc.) or/and to certain instruments of the program (e.g. individual costs, measures for reducing/banning plastic bags). Any choices made among alternative programs (i.e. suggested options) will be a function of the probability based on which utility linked to a particular option is higher compared to that linked to other options (Birol et al., 2006).

Thus, the following assumptions are made: (a) the relationship between utility and attributes is linear in the parameters and variables, and (b) the random error terms are independently and identically distributed with a type I extreme value distribution, the probability of choosing the specific coastal protection program j among the set C of all the available alternative programs, is expressed by the following conditional logit model:

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$$P(U_{ij} > U_{in}, \forall n \neq j) = \frac{\exp(V_{ij})}{\sum_{n \in C} \exp(V_{in})} \quad (2)$$

Taking into account that the systematic component is a linear function of attributes, the conditional indirect utility function is specified as follows:

$$V_{ij} = \beta_{ASC} ASC + \sum_k \beta_k Z_{j,k} \quad (3)$$

where β_k is the coefficient (to be calculated) of the k -th choice attribute Z_k and β_{ASC} represents the coefficient of the alternative specific constant (ASC), a dummy assuming the value 1 if the status-quo alternative is chosen or the value 0 if one of the hypothetical alternative programs is chosen. This particular coefficient illustrates the effects on utility of attributes not included in the choice specific protection program.

Based on the fact that the choice experiment methodology is consistent with utility maximization and demand theory, it is safe to assume that if a cost attribute (representing the marginal utility of income) is included in the choice set, we can derive estimates on welfare. Therefore, the WTP value for a marginal change in each attribute level can be estimated by dividing the coefficient of this attribute by the coefficient of the cost attribute, as depicted by the linear utility function (Eq.(3)).

Studies have shown that information campaigns targeting environmental goods or ecosystem services may have a positive effect on residents' WTP for the selected at each time ecosystem services (van der Wal et al., 2014; Szabó and Ujhelyi, 2015; Latinopoulos et al., 2018). The main hypothesis for this is based on the fact that respondents who become more informed: (i) have increased awareness in relation to the content and what precisely they are being asked to pay for

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(Brouwer et al., 2016), (ii) can be more willing to take action (i.e. willing to change their preferences), and (iii) can be more willing to pay for suggested environmental protection programs. Nevertheless, a certain decline in WTP values is often anticipated as they may be negatively affected by memory capacities (working memory, long-term memory), therefore, implying the existence of a decay effect with the passage of time, moving further away from the dates when the information campaign was conducted. This deterioration associated effect, in terms of memory capacity and WTP, can be attributed to possible memory lapses or negligence regarding information acquired during the campaign, particularly in cases where this information is not frequently applied in practice by individuals (Wickelgren, 1972; Tisdell et al., 2008).

Exploring the value of information and hypotheses tests

The main objective of this choice experiment conducted in Syros Island, beyond added benefits such as promoting the protection of the local marine and coastal ecosystems, is to explore and validate whether information campaigns can effectively be applied as a tool of environmental policy on the basis of influencing participants' preferences and environmental values toward the greater good in accordance with scientific data and based on objectivity. One of the most conventional measures of economic appraisal regarding environmental values is the willingness to pay (WTP), determined as the sum of money depicting the difference in consumer surplus before and after any improvements made in environmental quality. For this purpose, information regarding the contemporary state and/or future state of certain environmental assets (e.g. current issues, future environmental risks) along with objective quality evidently may affect this perceived environmental quality for each individual (Blomquist and Whitehead, 1998). In this context, public information campaign, as in the case of Syros Island, are indeed crucial in relation to the perceived quality of marine and coastal ecosystem services currently and for the future, in addition to any perceived risks regarding future degradation (i.e. on the significance of mitigating these risks) (Latinopoulos et al., 2018).

In particular, a respondent having acquired the “ideal” (on the basis of both quality and quantity) amount of information regarding the local marine and coastal ecosystem services is assumed not

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to be influenced by the information campaign. On the contrary, respondents with insufficient and/or poor quality information may be predominantly affected in two ways: (a) the information campaign could increase their stated WTP value (toward the true WTP), if prior to participating in the campaign, their perceived quality/risk was lower than the objective quality/risk; (b) the information campaign could decrease their stated WTP values, if prior to participating in the campaign, their perceived quality/risk was higher than the objective quality/risk. Thus, it is deemed important for objectivity purposes to assume that the effects of participating in the information campaign on WTP values can be positive, but also zero or negative as well.

In the case of Syros, one of the primary objectives of our research was to investigate the information effect of the campaigns and their milestones (Plastic Bag Free Weeks) performed in the island during 2016-2018. In addition, we intended to examine the intertemporal effects of the information effect bearing in mind the effectiveness of the information campaigns in economic terms with regard to environmental values in the short-run as well as for longer time periods (i.e. after approximately two years of information provision). Furthermore, we also thoroughly examined the citizens' commitment to take individual action by means of accepting the proposed policy measures aiming at regulating plastic bag consumption.

The potential impact of the information campaigns and their milestones on citizens' preferences in association with ecosystem values was investigated on the basis of three hypotheses adapted from Loomis and Keske (2012). In particular, the first hypothesis examines the possible impact information may have on the coefficients of the selected attributes via the application of a log-likelihood test in order to determine whether there is equality of the β -coefficients among the various samples (participants versus non-participants) in the conditional logit regression models. The null hypothesis is presented in the following equation:

$$H_0: \beta'_{Inf} = \beta'_{NI} \quad (4)$$

where β'_{Inf} represents the vector of coefficients resulting from the sample which was informed during the information campaign and β'_{NI} is the vector of coefficients generated from the sample

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which was collected before the information campaign (thus, they are not-informed/non-participants). The null hypothesis was tested through the use of a likelihood ratio test for coefficient equality. This likelihood ratio test compares the sum of log-likelihoods of the two individual models (i.e. the unrestricted coefficient models) to the loglikelihood of a pooled model (i.e. a model that restricts the coefficients to be the same in the samples compared). The premise is that unless this restriction is rejected, then there is coefficient equality in the samples compared, and thus the information campaign has no effect on residents' preferences.

The second hypothesis tested whether the WTP magnitudes are equal across the samples compared, on the basis of the following null hypothesis:

$$H_0: WTP_{Inf} = WTP_{NI} \quad (5)$$

Specifically, the second hypothesis was examined in two ways: (a) estimation of the confidence intervals of the WTP values in the samples compared, and subsequently by; (b) comparing the generated sets of results in order to test whether they overlap (Creel and Loomis, 1991; Latinopoulos et al., 2018). At this point, it should be noted that for reasons of simplicity both hypotheses (1 and 2) were tested exclusively for the main-effect models (i.e. for models that exclusively include the selected set of attributes, as depicted in Eq. (3)).

The third and last hypothesis tests if participation in the information campaign can be an important predictor choice behaviour. To this effect, a pooled model was incorporated to test if a dummy variable, associated with the information campaign (which is equal to one for the participants), was statistically different from zero when it interacted with either individual attributes or with the ASC variable. Within this particular framework, it is important to use a utility function where individual choice may also be influenced by a set of individual socio-economic characteristics of the respondent i (S_i) and participation in the information campaign (I_i). Taking into account the fact that these characteristics are presumed constant across choices for any given individual, they are entered either as interaction terms with specific attributes or as interaction terms with the alternative specific constant (Hanley et al., 2001; Morrison et al., 1999). In this sense, Eqs. (1) and (3) from previously transform into Eqs. (6) and (7) as follows:

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$$U_{ij} = V_{ij}(Z_{ij}, S_i, I_i) + e_{ij} \quad (6)$$

$$V_{ij} = \beta_{ASC}ASC + \sum_k \beta_k Z_{j,k} + \sum_m \gamma_h S'_h + \sum_p \delta_l I'_l + \quad (7)$$

where γ represent the coefficients of the interactions (S'_h) of the individual specific socio-economic characteristics with the choice specific attributes (including the ASC variable), and δ are the coefficients of the interactions (I'_l) between the information dummy variable and the choice specific attributes (including the ASC variable as well).

In this case, the null hypothesis was that δ -coefficients are equal to zero, which translates to the fact that having participated in the information campaign was not a significant determinant of choice:

$$H_0: \delta_l = 0, \forall l \in 1, \dots, p \quad (8)$$

These hypotheses were investigated on the basis of four identical surveys which were implemented in Syros during the period May 2016 - December 2017. In particular, the first survey was conducted before the 1st milestone (*Plastic Bag Free Week 2016*) of the information campaign during May 2016, while the second survey was conducted after the 1st milestone, between May and June 2016. The penultimate survey was conducted one month after the 2nd milestone (*Plastic Bag Free Week 2017*) of the campaign during June 2017 and the last survey six months after the 2nd milestone in December 2017.

In the context of this survey, utility and WTP are considered as dynamic processes directly associated with the provision of information. As depicted in Figure 7-14, there is a theoretical framework based on which a dynamic WTP function is formed regarding the preservation of the

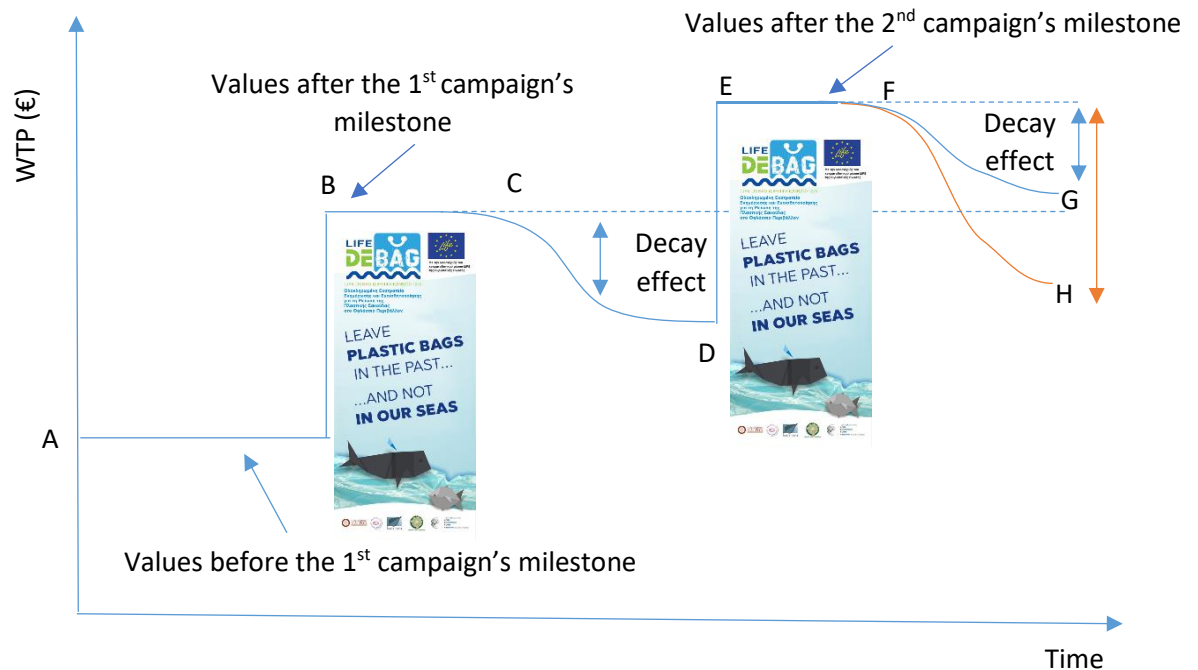
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selected local marine and coastal ecosystem services, resulting from the provision of information in connection with the associated campaign. Thus, and in reference to legitimate expectations based on data acquired during the surveys, further exposure to and/or provision of information from a milestone campaign is expected to increase the WTP values. However, it should be also noted that WTP values may decrease in the long-run as a result of the aforementioned decay effect, due to longer time periods elapsing after the intensive milestones of the information campaigns. For this reason, it is rather complicated to accurately estimate the extent of this decay effect in terms of WTP decline rate.

Consequently, two alternative trajectory paths were formed, as better illustrated in Figure 7-14. In particular, the first trajectory presents a certain direction where the provision of information affects more vigorously WTP values compared to memory capacity (trajectory FG), whilst the second trajectory depicts a substantially negative rate resulting from the decay effect, which may ultimately (in the long-term) minimize the positive result of the information provision (trajectory FH). The main objective of our analysis was to properly identify these dynamic changes in relation to the WTP values, deriving from the provision of information, in addition to determining which of the two trajectories depicted in Figure 7-14 essentially prevail in association with the WTP values for each ecosystem service under examination along with the aggregate WTP.

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Figure 7-14: A theoretical framework in terms of a dynamic WTP function influenced by the information campaigns



Source: Bithas et al., 2022

7.2.3 Survey design and implementation

The survey was designed and conducted on the basis of the stated preference methodology via the implementation of a choice experiment in order to explore and clarify to the greatest extent possible the environmental and social preferences of the citizens of Syros Island with regard to ecosystem services in the local marine and coastal environment (Hensher et al., 1998; Louviere et al., 2000; Latinopoulos et al., 2018). In particular, a discrete choice experiment was formed and implemented in different time periods aiming at evaluating the WTP of the citizens regarding the preservation of certain selected and representative for the local marine and coastal environment ecosystem services, which are most liable to be impacted by plastic pollution. Within this framework, the residents of Syros were asked to choose among various alternative programs for

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coastal protection (i.e. regarding plastic waste management, etc.), characterized by different costs and different patterns, thus, generating different performance levels regarding the selected ecosystem services that originate from their respective marine/coastal ecosystems.

The survey was based on the following steps which were carried out in chronological order:

- Identification of the environmental good to be valued (i.e. ecosystem services).
- Identification of the associated attributes and specification of their respective levels.
- Application of experimental design techniques to efficiently combine the attribute levels into multi-attribute profiles, which were subsequently merged for the formation of choice sets (choice cards).
- Creation of a pilot design suitable for the selected attributes and levels. A pilot study (30 questionnaires) was conducted during April 2016 in order to improve the selected attributes and their levels.
- Implementation of the survey to the selected target groups via personal face-to-face interviews.
- Statistical/econometric data analysis via the use of the conditional logit model on the basis of the three aforementioned hypothesis tests.

Selection of attributes and attribute levels

As mentioned above, after the identification of the environmental goods to be valued, which in our case refer to certain aspects of the local marine and coastal environment of Syros Island (i.e. associated ecosystem services), the next step within the choice experiment design is to select an appropriate set of attributes in order to evaluate a public program (suggested to the respondents), aiming at protecting the local marine and coastal environment of Syros from plastic waste pollution.

This particular selection was made based on the following key factors in relation to the attributes: (i) they should be policy relevant to marine/coastal environment protection, (ii) they should properly represent the ecosystem services affected by plastic waste, and (iii) they should be easily

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communicable and explicable to the general public (the respondents). Regarding the first two key factors, we took into consideration the most prominent and frequent types of damage induced by marine litter and plastic waste, that is ecological damages (e.g. negative impacts on marine biodiversity, etc.), economic damages (e.g. elevated cost for tourism, damage to fisheries, etc.), and social damages (e.g. losses in aesthetic value landscape quality degradation, public safety implications, etc.) (Galgani et al., 2010). In addition, the initial choice of attributes was based on the feedback provided by earlier studies and experts as well, along with the small-scale pilot study performed in April 2016, which further contributed to the refinement of the selected attributes and their respective levels.

As a result of this process, four attributes were identified as most relevant regarding the associated marine and coastal ecosystem services within the interest of efficiently describing the potential benefits from the proposed to the local residents (respondents) programs, whilst investigating their preferences and possible trade-offs made with regard to these ecosystem services.

These four attribute categories are the following:

- Recreational activities which can be used either as attributes on an individual level (regarding a particular level of an activity or revenue) or as attributes representing aggregate recreational utility (Doherty et al., 2014), regarded as direct use value. In our applied model the attribute of recreation is properly designated to denote the quality of recreational activities, which is potentially affected by plastic litter/waste concentration on beaches. High concentrations of plastic litter/waste on beaches are associated with progressively higher (negative) impacts on recreational experiences and opportunities accordingly, thus, affecting the recreational values of local residents. This particular attribute is closely related to one of the most prominent among the cultural ecosystem services, recreation and (eco)tourism, defined as *“the recreational pleasure that people derive from natural or cultivated ecosystems”* (MEA, 2005; Sukhdev et al., 2010). The recreational activities mainly include bathing, water sports, sunbathing, etc.

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- Landscape quality, in terms of the perceived by visitors landscape and the beach image in general, which is significantly affected by the presence of plastic litter/waste, while it is considered as a highly rated attribute in visitors' choice (of beach) and an important attribute with regard to residents' quality of life. A clean coastal environment forms aesthetically attractive landscapes which are subsequently appreciated by tourists and residents alike. This attribute targets the aesthetic (indirect use) value of marine/coastal ecosystems. In this sense, the main goal is to evaluate residents' preferences regarding beaches and shorelines, which are aesthetically attractive and not "impaired" or degraded by plastic litter/waste.
- Biodiversity, representing important aspects in terms of regulating and habitat ecosystem services for marine and coastal ecosystems. Plastic litter/waste constitutes an increasingly severe threat to marine and coastal biodiversity on a global level. In the case of the Mediterranean Sea, plastics are considered the most common litter items on the deep sea floors (Pham et al., 2014; Ioakeimidis et al., 2017), accounting for 82% of all man-made floating items (Suaria and Aliani, 2014). Numerous marine species and organisms (approximately 267) have been found to be negatively affected by plastic debris, while the implications are even worse if we take into consideration smaller organisms as well (Moore, 2008; Mrosovsky et al., 2009; Rochman et al., 2013; Campani et al., 2013). A plethora of studies has already delineated the harmful effects of plastic debris and waste in sea turtles, sea birds, and marine mammals (Carr, 1987; Spear et al., 1995; Campani et al., 2013; Mrosovsky et al., 2009; Kühn et al., 2015). The biodiversity attribute is, thus, used to account for the intrinsic (non-use) value of the marine/coastal ecosystems. This attribute was communicated to the general public on the basis of the habitat protection/provision ecosystem service (De Groot et al., 2002), though it is not specifically categorized as an ecosystem service within the MEA (2005) framework, but its importance is nevertheless acknowledged (TEEB, 2010, EEA, 2013, Liqueste et al., 2013; Hattam et al., 2015). This particular attribute was communicated on the basis of exclusively emphasizing on the ecologically important species/areas, which along with the

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customized selection of the other three attributes, eliminates the risk (bias) of overlap.

- Commercial fishing activity in reference to the significance of fishing and seafood provisioning for a marine/coastal region and specifically an island as in the case of Syros. High concentrations of plastics in the marine environment may negatively affect fishing activities due to impacts: (i) on fish populations, and fish catch (Anastasopoulou et al., 2013; Romeo et al., 2015), (ii) on the food chain via the process of biomagnification, potentially affecting human health in a negative way (Meeker et al., 2009; Romeo et al., 2015). Within the context of the survey, this attribute was communicated in accordance with the associated direct use values, namely the induced risks to the revenue of local fishermen, and the impaired by plastics seafood quality and safety in relation to humans.

At this point it is deemed important to denote that qualitative levels were applied for all the aforementioned attributes in order to minimize confusion while describing the potential environmental benefits in association with the suggested waste management programs in terms of impact (risk) reduction. In addition, effects coding was applied to appropriately code these qualitative variables (particularly the ones with more than two levels), being more suitable for this kind of analysis compared to the dummy coding (Adamowicz et al., 1994; Latinopoulos et al., 2018).

These levels were described on the basis of both textual and visual representations. In this context, a policy tool was also incorporated as an instrument in order to investigate citizens' preferences with regard to potential alternative future policies supplementing the plastic waste management program suggested at each time. In particular, a control policy attribute in relation to plastic pollution was used, representing residents' willingness to accept a total ban or a constraint (partial ban) on the use of plastic bags within the study area. This attribute was constructed as a way of examining the capacity of these policy instruments in relation to the acceptability of the proposed programs, whilst investigating the effectiveness of information campaigns in encouraging action on an individual level (based on the assumption that any ban (partial or total) on plastic bags would alter the current consumption choices). However, there

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was no a priori expectation as to whether this particular policy attribute would affect preferences or, in what direction this could be achieved (i.e. if it would generate utility or disutility to residents).

A cost attribute was included as well in order to allow the estimation of the marginal WTP values for each ecosystem service. The payment vehicle used for this survey was a bi-monthly municipal levy, in the form of an additional cost someone would pay which is embedded in their municipal taxes, on the basis of both plausibility and familiarity in relation to the surveyed population. We used four different price levels, ranging from €3 to €15 to efficiently represent this attribute. In Table 7-1, the selected attributes, the associated ecosystem services (if relevant), their levels and variables used within the context of the choice experiment surveys are presented. This set of attributes was subsequently merged into different choice sets on the basis of an orthogonal design.

Table 7-1: Attributes, associated ecosystem services, levels and variables used in the choice experiment surveys

Attribute	Associated Ecosystem Services	Attribute levels	Variable
Recreational activities ¹	Recreation, leisure and tourism	Plastic waste has a significant impact on recreation enjoyment*	
		Plastic waste has a relatively small impact on recreational enjoyment (RECREAT1)	RECREAT1 (small impact)
		No-impact on recreation (RECREAT2)	RECREAT2 (no-impact)
Landscape quality	Aesthetic values and experience	Significant aesthetic degradation due to plastic waste*	

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		No degradation	LANDSCAPE
Biodiversity	Habitat services (provision of habitat, gene pool protection)	Plastic waste is a major threat to marine/coastal biodiversity*	
		Plastic waste is a minor threat to marine/coastal biodiversity	BIODIVERSITY
Fisheries	Food provision (wild capture seafood, farmed seafood)	Plastic waste is a major threat to local fisheries*	
		Plastic waste is a minor threat to local fisheries	FISHERIES
Policy tool¹	-	No measures taken*	
		Constraints on the use of plastic bags (BAN1)	BAGS1 (partial ban)
		Complete ban on plastic bags (BAN2)	BAGS2 (complete ban)
Expected bi-monthly cost (€)	-	0*,3, 6, 10, 15	COST

Note:* Current attribute levels (status quo)

¹ Effects coding was used to represent these attributes

Source: Bithas et al., 2022.

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Designing the questionnaire and choice cards

The next step after the identification of the attributes and their respective levels was to shape a set of alternative policy options on the basis of differentiating the attribute levels (profiles) and subsequently form the choice sets in accordance with these profiles, thus, generating the choice cards, which are to be presented to the survey participants. Taking into consideration that in order to incorporate every possible combination of the five selected attributes (see Table 7-1) it would require a factorial design of 288 possible policy combinations (i.e. the options provided), we used a subset of these combinations to form a more manageable number. This process was performed via the SPSS Orthoplan procedure (SPSS Inc., version 20.0, Chicago, IL, USA) based on an orthogonal design, which generated a set of 16 optimal choice profiles that corresponded to the first (unlabeled) option on the choice card (Latinopoulos et al., 2018). Afterwards, the profiles for the second option were formed manually on the basis of a rotating design by reason of rotating each attribute level one place to the right.

Through consecutive repetitions, 16 choice cards characterized by two alternative marine/coastal protection programs, and a status quo option (i.e. the zero-cost option without further improvements in environmental protection), were ultimately produced. However, 16 cards would prove to many or “tiresome” for an individual to properly evaluate, hence, they were subsequently randomly divided into four separate versions in order to eventually provide each survey respondent with four choice cards. Figure 7-15 delineates an example of these choice cards which was used within the framework of the questionnaire surveys (translated in English).

The questionnaire was comprised of four sections characterized by specific themes within the context of the survey. In particular, the first section consisted of general knowledge, inclinations, and opinions regarding local environmental issues, but predominantly with regard to plastic waste pollution in the coastal environment of the island. In this sense, a subset of questions in relation to professional as well as recreational activities relevant to the issue under examination within the marine/coastal area was included, along with a group of questions regarding potential affiliations to local environmental related actions (i.e. participation in NGOs, discussion fora, beach cleaning activities, etc.), and/or prior knowledge with respect to the issue at hand. The second section presented the coastal protection programs both graphically and in a narrative form, subsequently described the selected attributes and elucidated on the chosen payment

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vehicle while introducing the four choice cards. The next section, the third one, was based on follow-up questions for reexamination purposes in relation to potential difficulties in answering the choice cards, it included the justifications for refusing to pay in any suggested option in order to discriminate among the true zero-bidders and the protest voters and concluded with the primary reason (motivation) based on which respondents were willing to pay for the coastal protection programs suggested to them. A last section (fourth one) acquired all the necessary information with respect to the demographic and socio-economic characteristics of the respondents.

Figure 7-15: An illustration based on a template of a choice card used in the questionnaire surveys

	Option A	Option B	Option C (Status quo)
Recreational activities (e.g. bathing, sunbathing, etc)	No impact 	Small impact 	Large impact 
Aesthetics quality	Significant degradation 	No degradation 	Significant degradation 
Biodiversity	Minor threat 	Major threat 	Major threat 
Fisheries	Minor threat 	Major threat 	Major threat 
Policy tool	Partial ban/restriction of plastic bags 	Complete ban of plastic bags 	No restrictions 
Expected bi-monthly cost	€15 	€3 	€0 
Choice	☐	☐	☐

Source: Latinopoulos et al., 2018.

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Survey implementation and sample consistency

Four identical questionnaire surveys were conducted on the island of Syros, all of which offered the same choices to different respondent groups, during a period of approximately 2 years. Each survey was administered by trained interviewers via face-to-face interviews through the use of a structured questionnaire (Latinopoulos et al., 2018). The target population was consisted of the general public as well as the resident population of Syros. The samples taken were proportionally stratified based on age, sex and education, as these variables were initially considered significant in shaping people's choices. In this sense, each sample can be considered to be representative of the population to certain reasonable degree.

At this point, it should be pointed out that two critical assumptions were made: (i) respondents characterized by the same socio-demographic characteristics, who also reside in the same local environment (i.e. the island of Syros), would follow similar social norms with comparable values (preferences) in relation to the local marine and coastal environment and their respective ecosystem services, (ii) during the over the one-and-a-half year period (approximately two years) the WTP estimates were influenced exclusively by the relevant information provided via the information campaigns, due to the fact that there were not any significant changes in the study area during this specific period (i.e. no changes regarding the socio-economic status of residents and/or the local environmental conditions).

The first questionnaire survey was conducted before the 1st milestone of the environmental information campaign ("*Plastic Bag Free Week 2016*")¹, with 185 completed and useful questionnaires being collected. Afterwards, the second questionnaire survey followed during and within a few days after this 1st milestone (27 May-5 June 2016), resulting in 156 questionnaires in total. The third questionnaire survey was conducted during 15-24 of June 2017, immediately after the 2nd milestone of the information campaign ("*Plastic Bag Free Week 2017*"), in which 200 completed and useful questionnaires were collected. The last questionnaire survey, the fourth one, was conducted six months after the 2nd milestone of the campaign during 7-15 of December 2017, with a total of 191 questionnaires being collected. The risk of biased non-participation can be characterized as very low, as the response rate in all four questionnaire surveys was very high, at approximately 86%.

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For classifications purposed with regard to the zero-bid responses we applied a debriefing question in relation to the reasons for rejecting any improvement scenario (i.e. not willing to pay any amount of money for a proposed waste management program) by choosing the status quo option on every choice cards. In particular, the goal was to differentiate between the zero-bid (opt-out) responses that were either true-zero or protest votes. The protest votes were associated with individuals choosing the: *“It is the state’s/municipality’s responsibility to pay for the proposed program”* reason (justification) for their choice. In this context, we identified a declining trend in the course of time regarding the percentage of protesters that were considerably different among the four questionnaire surveys.

Notably, in the 1st questionnaire survey the protester’s percentage was 34%, while in the 2nd questionnaire survey it decreased to 22.7%, further decreasing to 15.5% for the 3rd questionnaire survey and finally to 12.6% for the 4th and final questionnaire survey. This result could be interpreted on the basis of the axiom stating that the protest rate tends to decline as information becomes more available and improves in quality (Borzykowski et al., 2015). In addition, it may be contributed to the reinforcing effects of the information campaigns which swayed the residents of Syros (respondents) toward the preservation and protection of the local marine/coastal environment on the basis of a more ethical responsibility and a moral obligation. The subsequent analysis does not contain any of these protest responses.

According to Table 7-2, all four samples appear quite similar to each other regarding the key characteristics of the respondents with reference to their main socio-economic attributes along with their main perceptions, attitudes, and opinions in relation to the local marine and coastal environment. The primary difference among the samples is associated with income distribution, taking into account that the higher income groups increased significantly during 2017, especially in the case of the 4th questionnaire survey’s sample. This outcome could be attributed to the lower percentage of respondents employed in the tourism industry during that particular period, as the majority of both employers and employees in this sector do not reside in the island during wintertime. In this sense, the last questionnaire survey may be considered an example of the population of Syros Island during the winter months. In conclusion, it is fair to say that all four samples are sufficiently similar in accordance with every predictor of interest, and thus sampling biases can be ruled out.

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Table 7-2: Descriptive statistics of respondent characteristics for all samples

Variables	Description	1 st survey 4–6 May 2016 Before the 1 st milestone (n=121)	2 nd survey 27 May–5 June 2016 Directly after the 1 st milestone (n=119)	3 rd survey 15–24 June 2017 Directly after the 2 nd milestone (n=200)	4 th survey 7-15 December 2017 6 months after the 2 nd milestone (n=191)
AGE	Age of respondent	46.86 (11.49)	48.89 (11.99)	45.23 (13.20)	44.34 (13.02)
SEX	Sex [1=male, 0 =female]	52.1%	53.7%	51.00%	52.3%
EDU	Education level: 1 = Primary education 2 = Lower secondary education 3 = Upper secondary education 4 = University education 5 = Post-graduate studies	6.6% 9.1% 33.9% 43.0% 7.4%	7.6% 9.2% 37.0% 40.3% 5.9%	3.0% 5.0% 41.5% 43.5% 7.0%	5.2% 8.9% 38.7% 41.4% 5.8%
INCOME	Annual household income: 1 = up to €5,000 2 = €5,001-10,000 3 = €10,001- 15,000 4 = €15,001- 20,000 5 = €20,001-25,000 6 = more than €25,000	10.2% 17.8% 34.8% 16.9% 16.1% 4.2%	11.1% 22.2% 35.0% 12.8% 11.1% 7.7%	17.0% 23.5% 35.0% 13.0% 8.0% 3.5%	20.4% 23.5% 36.1% 16.8% 3.1% 0.0%
FAM_SIZE	Number of household members	2.71 (1.22)	2.81 (1.24)	2.60 (1.14)	2.43 (1.19)
MAR_ENV	Necessity of further measures to protect the marine/coastal environment [Likert scale 0=not important, 5= Very important]	4.4 (0.82)	4.1 (1.00)	4.3 (0.86)	4.29 (0.75)

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RECYCLE	Households recycling	91.2%	90.8%	96.5%	92.7%
BEACH_VIS	Frequency of visits to the beach (during the summer): [1= never, 2=less than once a month, 3= once or twice a month, 4=once or twice a week, 5= three or four times per week, 6=every day]	5.24 (0.82)	4.71 (1.39)	4.94 (1.10)	5.02 (0.98)
WOR_TOUR	Respondents working in tourism	38.8%	43.7%	31.0%	23.9%
SEAVIEW	Houses with a sea view	61.9%	63.8%	55.0%	57.6%
FISH_CONS	Frequency of local fish consumption: [1=never, 2=once or twice a month, 3=once or twice a week, 4=three or four times per week, 5=five to seven times per week]	2.53 (0.84)	2.41 (0.71)	2.45 (0.72)	2.40 (0.69)

Source: Bithas et al., 2022.

7.2.4 Results

7.2.4.1 The intertemporal effect of an information campaign on the environmental preferences of the local population of Syros Island

In the interest of exploring the inter-temporal effect of extensive and recurrent information provision on the individual preferences of the citizens of Syros Island, on the basis of intensive information campaigns, we compare the results of the four discrete choice experiment (DCE) questionnaire surveys that were conducted during the time period starting from May 2016 to December 2017. At this point, it is essential to denote that certain assumptions have been made in relation to the information effect of the information campaigns, and in particular with regard

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to its homogeneity and its milestones for the whole sample taken. In Table 7-3, the regression results of the conditional logit model for every DCE questionnaire surveys are presented, based on a main-effects-only specification, therefore, no interactions were considered at the moment.

Based on the econometric analysis presented in Bithas et al. (2021), it is shown that even if the overall fit of the first two models (assessed via McFadden's R^2) is not very high, it is still well within the range of acceptability (Louviere et al., 2000). In addition, the overall fit of both the 3rd and 4th models has been significantly improved and may, thus, be considered very good based on the conventional standards applied to judge probabilistic discrete choice models. Furthermore, the majority of the coefficients were found significant (in model 3 all coefficients are considered significant) and the signs were as expected a priori.

Table 7-3: Results of the conditional logit model for all DCE questionnaire surveys (main-effects-only specification)

Variables	4–6 May 2016 Before the 1 st milestone (n=121)	27/5 – 5/6 2016 Directly after the 1 st milestone (n=119)	15/6 –24/6 2017 Directly after the 2 nd milestone (n=169)	7/12 –15/12 2017 6 months after the 2 nd milestone (n=167)
Attributes				
Constant (ASC)	0.557 (0.274)**	0.536 (0.298)*	-0.001 (0.285)	-0.650 (0.252)**
RECREAT 1	0.202 (0.100)**	-0.092 (0.088)	0.176 (0.069)**	0.126 (0.069)*
RECREAT 2	0.238 (0.090)***	0.207 (0.097)**	0.400 (0.089)***	0.072 (0.083)
LANDSCAPE	0.170 (0.122)	0.347 (0.125)***	0.436 (0.100)***	0.232 (0.098)**
BIODIVERSITY	0.514 (0.134)***	0.343 (0.131)***	0.512 (0.106)***	0.675 (0.101)***
FISHERIES	0.152 (0.129)	0.306 (0.128)**	0.718 (0.100)***	0.613 (0.102)***

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BAGS1	0.303 (0.089)***	0.189 (0.088)**	0.447 (0.077)***	0.189 (0.074)**
BAGS2	0.160 (0.102)	0.037 (0.104)	0.231 (0.086)**	0.248 (0.087)***
COST	-0.098 (0.016)***	-0.065 (0.016)***	-0.069 (0.013)***	-0.111 (0.014)***
Number of observations (choice sets)	484	476	676	668
-2Log(likelihood)	976.02	995.82	1070.8	1138.11
AIC	994	1014	1088.8	1156.10
Pseudo R ²	0.119	0.107	0.359	0.289

Note: *** = Significant at 1% level; ** = Significant at 5% level; * = Significant at 10% level

^a Numbers in parentheses are standard errors

Source: Bithas et al., 2022.

Stability of preferences in the course of time

In the interest of examining the inter-temporal impact of the information campaigns on the preferences of the citizens of Syros Island, we applied a log-likelihood test assessing the equality of the estimated preference parameters between two different samples (i.e. two different questionnaire surveys). The null hypothesis is the following:

$$H_0: \beta'F = \beta'L \quad (1)$$

with $\beta'F$ being the vector of b-coefficients from the former (in time) sample (questionnaire survey) and $\beta'L$ being the vector of coefficients which is derived from the latter sample (questionnaire

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survey), in which we are based on the assumption that respondents are better informed and more aware regarding the environmental as well as health impacts of plastic waste. The null hypothesis was tested on the basis of a Likelihood Ratio (LR) test for coefficient equality, therefore, comparing the sum of log-likelihoods of the two individual models to the log-likelihood of a pooled model (i.e. a model which restricts the coefficients to be equal for the two samples) (Swait and Louviere, 1993). In this sense, unless this restriction is rejected, it may well be argued that there is coefficient equality in the two samples, and thus the information campaign has no effect on residents' preferences regarding the corresponding time period (i.e. the period between the two samples under examination).

As presented in Table 7.4, the results of this procedure indicate that all the estimated LR tests (i.e. the tests of global goodness of fit, following a chi-square distribution with degrees of freedom equal to the number of parameters in the utility model) exceed the 5% critical value. For this reason, the estimated models have been found to differ significantly, therefore, suggesting that the underlying preference structure has been modified over the time interval between the pairs of surveys evaluated (Schaafsma et al., 2014). As a result, the initial hypothesis that the information campaigns had no effect on participants' preferences and behaviour, is rejected. By contrast, the information effect in all likelihood is significant in either relatively short (1-6 months) or longer time periods (12-18 months).

Table 7-4: Likelihood Ratio (LR) tests results regarding the equal preferences between the choice models at various time periods

Sample F	Sample L	Time period	LL _F	LL _R	LL _{pooled}	LR-test	x ² Critical value (P≤0.05, df=9)
1 st survey	2 nd survey	1 month	-488.01	-497.91	-996.6	21.36	16.92
2 nd survey	3 rd survey	12 months	-497.91	-535.25	-1056.6	46.88	
3 rd survey	4 th survey	6 months	-535.25	-569.055	-1120.16	31.71	
2 nd survey	4 th survey		-497.91	-569.055	-1090.78	47.63	

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		18 months					

Source: Bithas et al., 2022.

Information campaign effects on the significance and ecosystem services hierarchy

In the interest of recognizing any temporal changes in citizens' preferences induced by intensive information campaigns, it is vital to examine the significance and ecosystem services hierarchy, as presented in Table 7-3. Within this context, the BIODIVERSITY attribute is positive and statistically significant at the 5% level in all four questionnaire surveys. The FISHERIES and LANDSCAPE attributes were both found positive and statistically significant at the 5% level in the three questionnaire surveys conducted after the 1st milestone (indicating intensive information provision) of the information campaign. At the same time, the RECREAT2 attribute (i.e. optimal protection of marine/coastal recreational activities), which was characterized as a priority for the participants (in terms of preferences) before the 1st milestone (i.e. in the 1st questionnaire survey), seems to bear no significance on participants' choices in the last questionnaire survey. This result can be justified on grounds of seasonal variations, as this last questionnaire survey was conducted during wintertime, therefore, introducing a seasonal-sensitive effect, taking into account that coastal-based recreational activities are extremely limited during winter, thus, affecting citizens' preferences toward these activities.

The hierarchy of the environmental attributes among questionnaire surveys varies, as depicted in Table 7-3, in view of the fact that the BIODIVERSITY attribute was the most important in the first and the last questionnaire survey, while during the third one participants ranked higher the FISHERIES attribute (i.e. the impact of plastic waste on the provisional service of fish production). At this point, it should be pointed out that the positive value on all ecosystem services corresponded with the a priori expectations, thus, implying that the local residents of Syros Island are more inclined to choose alternatives which would reduce the impacts of plastic pollution on the selected ecosystem services. In addition, the price coefficient was found negative and highly significant in all models, suggesting that the preference for a program decreases as the cost of this program increases.

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Nevertheless, only in the case of the 3rd questionnaire survey (in June 2017), every ecosystem service (all four of them) was found statistically significant (though recreational activities are considered statistically significant only if p-values for both RECREAT1 and RECREAT2 are below the threshold level). During the 2nd and 4th questionnaire surveys three ecosystem services were found statistically significant, while in the case of the 1st questionnaire survey (i.e. the survey conducted before the first intensive information week, the 1st milestone) only two ecosystem services. Based on these results, it is revealed that the information campaigns had a positive effect in terms of acknowledging the multidimensionality of certain environmental functions and threats, together with a “decay” effect regarding information and participants’ preferences/values as time passed by, from their last participation in the information campaign (see Figure 7-14).

Information campaign effects on the preferences regarding policy instruments (bag constraints/bag bans)

As presented in Table 7-3, the BAGS1 attribute (i.e. a policy action of a partial bag-constraint) is characterized by a positive and statistically significant value at the 5% level in all four questionnaire surveys, thus, suggesting that participants were in favour of implementing this policy, whilst this predisposition (of theirs) is not significantly influenced by activities in relation to the information campaigns. However, the marginal utility associated with the BAGS2 attribute (i.e. the complete ban of plastic bags) tends to increase through time. Citizens’ preferences were found statistically insignificant in the first two questionnaire surveys as participants were characterized by a neutral attitude regarding this policy action, whilst during the 3rd and 4th questionnaire surveys this attitude became positive and statistically significant as well.

This particular transformation is justified on the basis two main factors: (i) the recurrent and focused provision of information, and/or (ii) the relatively extensive mass media exposure and information provision in relation to the forthcoming plastic bag levy, which was to be introduced in Greece on 01/01/2018, only a few days after the end of the 4th and final questionnaire survey. As a result, it may well be argued that despite the existing difficulties in accurately assessing the

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effectiveness of information campaigns, their impact on the citizens of Syros Island is evident in terms of encouraging people to change their attitudes in favour of environmental policies aiming at reducing plastic bag use and improper disposal.

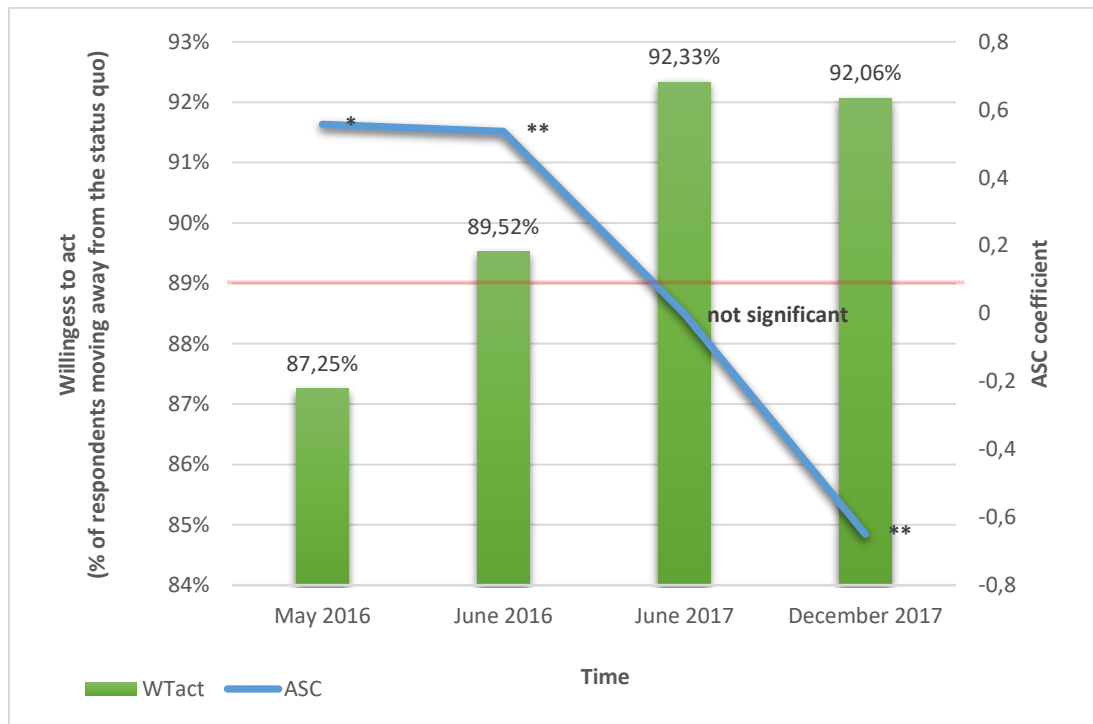
Information campaign effects on pro-environmental behaviour

The ASC (alternative specific constant) coefficient of the four questionnaire surveys (Table 7-3), represents the variation in choices which cannot be explained by the attributes or the socio-economic variables (Bennet and Adamowicz, 2001). Within the context of our research, the ASC was coded in order to denote a positive marginal utility though the negative values as the status quo situation alters for the better (i.e. adoption of measures for environmental protection). In this sense, this specific term is related to a certain will or desire for preserving the existing situation (status quo), where no measures or management actions are taken, therefore, excluding the selected ecosystem services from improvements. However, the reasons behind this desire are not reflected by the selected attributes. Based on Table 7-3, it is clear that this variable gradually changes through time, thus, revealing a negative trend as information increases.

In Figure 7-16, the respondents' willingness to act (i.e. pay for improved ecosystem services) as well as the ASC coefficient and the percentage of respondents who did not always choose the opt-out (status quo) alternative are illustrated, as they are progressively influenced by the information campaigns conducted. With regard to this representation, it is fair to say that the provision of information via information campaigns as policy tool, alters the ASC from a positive and statistically significant in the 1st questionnaire survey status, toward a negative and statistically significant status during the final questionnaire survey. On the contrary, the opt-out option is shown relatively more increased during the 1st and 2nd questionnaire surveys in comparison with the 3rd and 4th ones. Consequently, it is estimated that respondents gradually become more willing to pay, aiming at protecting/preserving the local marine/coastal environment (due to reasons other than the attributes presented in the choice questions), therefore, distancing themselves from the status quo, as their access to information and awareness increases. The ASC is statistically not significant only in the 3rd questionnaire survey, conducted after the 2nd milestone of the information campaign, thus, indicating that the attributes in the model account for every factor influencing respondents while forming their opinions and choosing accordingly.

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Figure 7-16: The respondents' willingness to act (i.e. pay for improved ecosystem services) as influenced by the information campaigns



Source: Bithas et al., 2022.

Based on these results, it is deduced that the provision of environmental information and/or formation of environmental awareness contribute to better communicating the adequacy, efficacy, and specific relevance of the marine/coastal protection program in addition to stimulate and motivate individuals (Daudi, 2008). Hence, a pro-environmental behaviour motivation is in place via the formation of a certain willingness to act on environmental issues. In this particular case, it is fair to say that respondents willing to pay money for improving a number of ecosystem services are the ones willing to take action in favour of environmental protection and improvement. In this sense, WTP from this point forward will be regarded as a measure of tendencies to act for an individual with regard to the intended environmental protection/improvement appraised in monetary terms (Ramdas and Mohamed, 2014).

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Information campaign effects on the WTP for the protection of ecosystem services

A critical part of our survey was to assess if and to what extent the information campaigns actually influenced the values of the selected ecosystem services via estimating the WTP values for all their related environmental attributes in all four questionnaire surveys. Table 7-5 presents the mean WTP values for every attribute in all four questionnaire surveys on an annual basis, as generated by the four main effects (conditional logit) models. The formula applied to produce these annual WTP values was the following:

$$WTP = -w_i \frac{b_{ESi}}{b_{cost}}$$

where b_{ESi} represent the b-coefficients of environmental attributes (see Table 7-5), b_{cost} the b-coefficient of the cost attribute and w_i , a constant in accordance with the attribute's i coding (i.e. $w=1$ for continuous and dummy variables, $w=2$ for effects-coded variables). The 95% confidence interval, presented in brackets in Table 7-5, were generated via the application of the Delta method in LIMDEP 8, NLOGIT 3.0 (Greene, 2007).

As shown in Table 7-5, the WTP values regarding the 1st, 2nd and 3rd questionnaire surveys tend to increase for all ecosystem services except for the RECREAT1 attribute (i.e. partial control of plastic on recreational enjoyment). However, between the 3rd and 4th questionnaire surveys a certain decreasing trend emerges once more for all ecosystem services, while the confidence intervals regarding the mean WTP estimates of the LANDSCAPE and BIODIVERSITY attributes overlap in all cases, even though their values tend to fluctuate among surveys noticeably differentiating from each other. In this context, it is safe to argue that the effect of both information campaigns' milestones was limited with regard to participants' preferences and values for biodiversity, a particular ecosystem service regarded as significant prior to information campaigns as well. On the other hand, the WTP value for the FISHERIES attribute may be characterized as the most probable to be influenced by the provision of information, taking into account that it is substantially different in the case of the 1st and 3rd questionnaire surveys, being considerably higher, as well as in the 3rd and 4th questionnaire surveys, being considerably lower. In addition,

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as presented in Table 7-5, the confidence intervals for the RECREAT2 attribute do not overlap between the 3rd and the 4th questionnaire survey, therefore, denoting an important change in WTP estimates for this particular time period.

Table 7-5: WTP estimates (€/year) for every questionnaire survey

Attributes	4–6 May 2016 Before the 1 st milestone (n=121)	27/5–5/6 2016 Directly after the 1 st milestone (n=119)	15/6–24/6 2017 Directly after the 2 nd milestone (n=169)	7/12–15/12 2017 6 months after the 2 nd milestone (n=167)
RECREAT1	24.786 [-0.96 , 50.53] ^a	-16.902 [-34.08 , 17.15] ^b	30.465 [7.05 , 53.87]	13.589 [-1.09 , 28.28]
RECREAT2	29.124 [6.83, 51.41]	38.232 [-2.42 , 78.90]	69.281 [38.78 , 99.78] [⌘]	7.820 [-9.69 , 25.33] ^b
LANDSCAPE	10.446 [-4.28 , 25.17] ^b	31.992 [5.90 , 58.08]	37.784 [20.80 , 54.77]	12.508 [2.11 , 22.90]
BIODIVERSITY	31.494 [13.16 , 49.83]	31.632 [4.30, 58.96]	44.384 [26.41 , 62.35]	36.423 [25.71 , 47.14]
FISHERIES	9.342 [-6.30 , 24.97] ^b	28.260 [0.64, 55.88]	62.254 [45.20 , 79.31]	33.103 [22.33 , 43.88]
WTP for best case scenario:	€60.6 [19.99 , 101.24]	€130.1 [8.42 , 251.82]	€213.7 [131.19 , 296.21]	€95.62 [50.15, 113.92]

^a in brackets: 95% Confidence Intervals

^b statistically insignificant Ecosystem Service: not included in the best case scenario evaluation

[⌘] Highlighted cells represent confidence intervals that do not overlap (i.e. indicating ES or WTP scenarios that differ significantly across two or more surveys)

Source: Bithas et al., 2022.

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In total, taking into consideration the results of the aforementioned analysis, it may be said with confidence that the provision of information via information campaigns (as a policy tool) may potentially increase WTP values. This assertion is further corroborated based on the results depicted in the last row of Table 7-5, presenting the aggregate expected welfare, as a function of an aggregate WTP, for implementing the best-case scenario, thus, signifying a transition from the status quo to another situation where the provision of all ecosystem services is optimized, focusing on their protection/preservation. In this sense, taking into consideration these values, the WTP in relation to the best-case scenario increases by 114% or alternatively €70 in absolute terms from the 1st to the 2nd questionnaire survey, whilst it also increases by 64% or alternatively €83.7 in absolute terms from the 2nd and 3rd questionnaire survey. On the other hand, after the last milestone of the information campaign (i.e. after 6 months) and granted that this 4th questionnaire survey was conducted during wintertime, the WTP decreased to a level lower than the one estimated in the 2nd questionnaire survey, though it remained significantly higher when compared to its counterpart from the 1st questionnaire survey (i.e. it was 58% higher than the mean WTP before the information campaign).

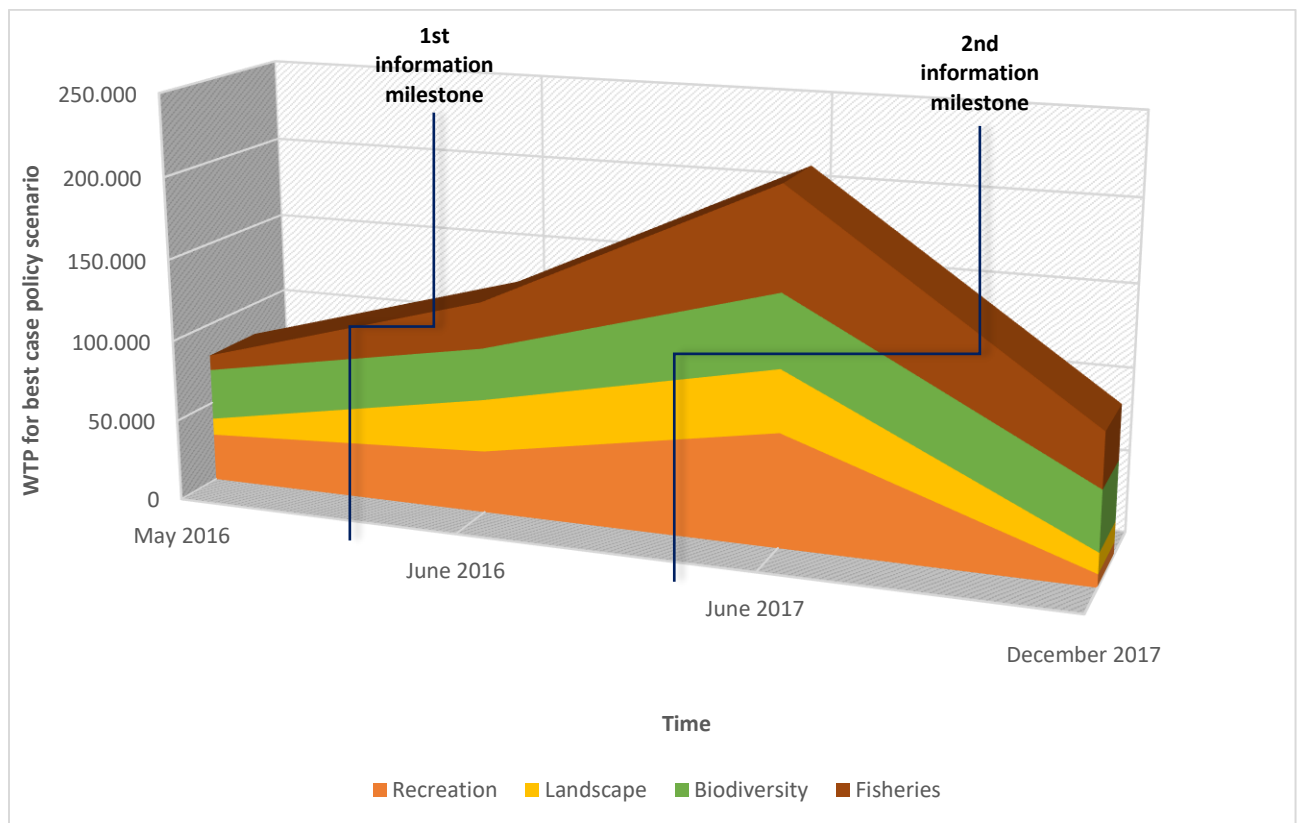
Figure 7-17 graphically illustrates the aggregate as well as the estimates for the per ES (ecosystem service) WTP through the four questionnaire surveys for a time period slightly longer than one and a half years. The time evolution regarding the aggregate WTP better approximates the second trajectory path, previously presented in Figure 7-14. The ongoing provision of information via the recurring information campaigns may have positively affected the WTP values, though this effect seems to be temporary as justified by the 6-month time interval from the final information campaign and its effects on the WTP values.

Nevertheless, the lower WTP for the 4th questionnaire survey should not be completely credited to the time decay effect, as the aforementioned substantially lower recreation values ought to be taken into consideration, on the grounds that this final questionnaire survey (4th one) was conducted during the “non-popular” in terms of tourism winter period. In particular, for an island as in the case of Syros, recreational activities such as the ones assimilated in our survey are not widespread and rarely occur. In addition, the percentage of individuals representing the sector of tourism is significantly lower for the 4th questionnaire survey’s sample in contrast to the previous ones. Certain ecosystem services (especially the ones related to recreational activities) are time-

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relevant, as they may be predominantly provided during summertime, thus, decreasing their value and importance during wintertime, a fact which is further corroborated by the results of similar studies with regard to temporal variations and recreational ecosystem services. In particular cases, variations in a use-value may emulate variations in the use of an ecosystem service, further delineated in terms of analysis with reference to values attached to recreational ecosystem services, therefore, suggesting that recreation values may increase over time (Rolfe and Dyack, 2019).

Figure 7-17: Aggregate and per ES willingness to pay through the surveys for the best-case scenario



Source: Adapted from Bithas et al., 2022.

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7.2.4.2 Investigating the effectiveness of information campaigns as a policy tool

It is considered a matter of paramount importance to appropriately test the effectiveness of a certain tool of environmental policy during the decision-making process and before incorporating it in the environmental policy agenda. In this context, it is critical to explore whether information campaigns can prove to be effective in influencing people's preferences and behavioural patterns along with the duration of their effects and efficiency over time. In essence, to pinpoint the exact optimal number (or at least a close approximation of it) as well as the ideal frequency. In this context, a pooled model was generated through the combination of data from the four questionnaire surveys together with the integration of two new variables accounting for: (i) the number of information campaigns' milestones in which each respondent directly participated (i.e. the variable CAMPAIGN, taking values within the range [0-2]), and (ii) the time interval (expressed in months) between the moment (day) of the particular questionnaire survey in which each respondent took part and the date of the last information campaign milestone in which this individual participated (i.e. the variable MONTHS, taking values in the range [1-18]).

This pooled model differentiates from the analysis above in one crucial aspect, the precise participation of the respondents in the information campaigns' milestones. In particular, the preceding analysis examined the effectiveness of the information campaigns, in terms of influence on Syros citizens' values and preferences, regardless of the participation of each individual in more than one milestone of the information campaigns. In this sense, an assumption has been made on the basis of the homogeneity of the information effect of the campaigns for the entire sample, the residents of Syros Island. By contrast, the pooled model analysis focuses on the effectiveness of information campaigns based upon their recurrence over time, whilst also bearing in mind the active participation of every respondent in both milestones of the information campaigns.

The variables CAMPAIGNS and MONTHS were tested in relation to every possible interaction with respect to the selected attributes with the main purpose of determining whether they can be characterized as important predictors of preferences or behaviour, and if so to evaluate their impact on the WTP estimates. In addition, a number of interactions between the ASC and the respondent-specific characteristics was incorporated aiming at checking for observed individual

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heterogeneity. These specific characteristics involve socio-demographic variables such as education level, income, age, etc., as well as behavioural variables such as recycling behaviour, the need to take additional measures to protect the marine and coastal environment, etc.).

In Table 7-5 the results of the statistically best-fit pooled model are presented, including three interactions with the ASC and six interactions with the selected attributes. From these interaction terms, five out of nine (being statistically significant) were associated in terms of interactions with the variables CAMPAIGNS and MONTHS of the information campaigns. However, characteristics such as age, income, recycling behaviour, sea-view and frequency of visits to the local beaches did not influence participants' choices to a large extent, though the exact opposite was expected. The R^2 (overall model fit) was estimated at 0.29, over the 0.2 value, therefore, suggesting a good model fit (Louviere et al., 2000). Furthermore, the statistically significant and negative value of the coefficient ASC*CAMPAGNS denotes that as the number of information events in which an individual attends increases, so does the possibility of financially contributing to a marine/coastal protection program (i.e. he/she will give money, thus, rejecting the status-quo alternative). To this effect, the interactions terms ASC*EDU (higher education) and ASC*MAR_ENV (i.e. citizens' attitudes regarding the importance of protecting the local marine/coastal environment) also considerably influenced respondents to reject the status-quo alternative.

The majority of the attributes, except RECREAT1, FISHERIES, and BAGS2, were found statistically significant at the 1% level and were characterized by the same (anticipated) signs, as presented in Table 7-5. Based on the results of Table 7-6, we see that the cost coefficient is significant and negative, hence, the derivation of welfare estimates is permitted. A statistically and negative significant interaction occurred in the case of the COST*MONTHS, which delineates the cost attribute and the time interval in relation to the survey and the most recent milestone of the information campaign. In this sense, it is deduced that the greater the interval of time from the last milestone of the information campaign, the lower the desire (willingness) to pay a higher cost for protecting the marine/coastal environment. This particular effect appears to apply for all welfare estimates, therefore, indicating a linear decay effect (taking into account our model specification) on all WTP values with regard to the protection and/or restoration of ecosystem services.

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Table 7-6: Pooled model and interaction terms

Attributes	
Constant (ASC)	5.315 (0.518)***
RECREAT 1	-0.289 (0.181)
RECREAT 2	0.240 (0.078)***
LANDSCAPE	0.339 (0.060)***
BIODIVERSITY	0.535 (0.063)***
FISHERIES	-0.135 (0.215)
COST	-0.064 (0.011)***
BAGS1	0.288 (0.045)***
BAGS2	-0.296 (0.194)
Interaction terms	
ASC*CAMPAIGNS	-1.219 (0.206)***
ASC *EDU	-0.558 (0.072)***
ASC *MAR_ENV	-0.350 (0.074)***
FISHERIES*FISH_CONS	0.299 (0.085)***
COST*MONTHS	-0.007 (0.003)**

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RECREAT2*MONTHS	-0.035 (0.018)**
RECREAT2*WORK_TOUR	0.271 (0.082)***
RECREAT1*CAMPAGNS	0.221 (0.099)**
BAGS2* CAMPAGNS	0.277 (0.105)***
Number of observations (choice sets)	5460
-2Log(likelihood)	3102.5
AIC	3138.5
Pseudo R ²	0.290

Note: *** = Significant at 1% level; ** = Significant at 5% level; * = Significant at 10% level

Source: Bithas et al., 2022.

The RECREAT2 environmental attribute, which refers to the optimal protection of recreation activities, is the only attribute that also interacts with the variable MONTHS. This particular interaction is characterized by a substantially negative effect which is mostly attributed to the combination of the time interval between the final questionnaire survey (during wintertime), the two milestones of the information campaigns (6 to 18 months) and the effect of the “wintertime” questionnaire survey on recreational (use) values. In order to neutralize any potential bias resulting from the under-representation of professionals in the sector of tourism regarding the last sample (wintertime questionnaire survey), the RECREAT2*WORK_TOUR interaction term was also integrated in the model. Based on this term, it is deduced that residents currently employed in the sector of tourism are more likely to choose alternatives aiming at completely resolving/mitigating the negative impact of plastic pollution (waste) on recreational activities. As a result, the ecosystem services associated with recreational activities are valued higher by those individuals who take part in leisure activities (individually), and benefit from tourism as well.

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The FISHERIES attribute (seafood provision) did not provide any statistically significant interaction effect with regard to this attribute, on the basis of choices aiming at reducing the impact of plastic waste on local fisheries and the profession of fisherman, though several tests were performed. However, the opposite was true regarding RECREAT2*WORK_TOUR, the recreational ecosystem service and the professionals in the sector of tourism. Nevertheless, a statistically significant and very robust relationship occurred between FISHERIES and FISHERIES*FISH_CONS (consumption of local fish). In this sense, residents who tend to consume local fish are more likely to choose alternatives aiming at reducing the negative health impact of plastic pollution on local fisheries. Consequently, taking into account the data from Table 7-5 and Figure 7-17, we conclude that the positive effect of the information campaigns on the WTP values for the protection of FISHERIES is for the most part attributed to considerations regarding human health (i.e. improved awareness regarding the effect of plastic waste via the biomagnification process) instead of fisheries' contribution to the local economy.

It is important to denote that the number of information campaigns (CAMPAIGNS) in which each respondent actively participated proved to be a critical factor in choosing/agreeing (or not) to take certain measures, thus, rejecting the status-quo situation. Despite that, there was no particular effect between the CAMPAIGNS variable and the attributes associated with the ecosystem services, with the only exception of RECREAT1 (partially improving recreational activity) which was characterized by a positive association with regard to number of campaigns. Therefore, systematic motives, apart from the attribute values, do exist, thus, influencing the more informed respondents to reject the status-quo situation. The number of information campaign events appears to positively influence respondents regarding the acceptance of policies/programs associated with the implementation of a complete ban on plastic bag use. Hence, it would be reasonable to assume that the provision of information on a recurring basis via information campaigns (policy tool) may considerably encourage individual action for the reduction of plastic bag use.

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7.2.4.3 Critical aspects

The provision of information appears to be a useful tool within the context of influencing environmental awareness and shaping environmental preferences. Information campaigns emerge as a potentially beneficial non-economic instrument of environmental policy promoting goals associated with sustainable development while they do not necessitate substantial economic sacrifices. In addition, citizens and policy makers seem to favor these type of measures as they seem less “crude”, whilst also engaging the general public without any added cost (in monetary terms). Therefore, it is deemed important to determine the most crucial aspects of this promising tool and test its effectiveness on the environmental preferences of people within the framework of a content, intensive and long-term information provision. The identification of any temporal effects on citizens’ preferences is also essential, taking into account seasonal variations in relation to the experience with ecosystem services and certain environmental assets.

In this context, we examined four major parameters in order to properly determine the temporal changes associated with people’s environmental preferences induced by information provision resulting from the implemented information campaigns, bearing in mind the sensitivity in seasonal experience with ecosystems. These parameters appertain to:

- Effects on the relative importance of the ecosystem services
- Effects on preferences with regard to various policy instruments
- Effects of the information campaigns on public perception in relation to environmental protection
- Effects on the willingness to pay for protecting/ preserving ecosystem services

For these reasons, the analysis emphasized on existing trends regarding changes among the 1st, 2nd and 3rd questionnaire surveys, as they are related with the intertemporal effects of recurring provision of information, whilst any changes between the 3rd and 4th questionnaire surveys reveal the decay effect over time and on account of seasonal changes in the experience with the

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ecosystems. Consequently, changes between the 1st and 4th questionnaire surveys refer to the overall outcome of the information campaigns.

The provision of information via information campaigns effectively contributed to making citizens (participants) aware of certain ecosystem services associated with the marine and coastal environment, while also increasing their interest in them. The information campaigns revealed a series of critical aspects in relation to marine and coastal ecosystems, thus, indicating a certain lack of awareness and inexperience with respect to the provision of ecosystem services and the overall functioning of these ecosystems. Most people may be characterized as relatively unaware regarding several ecosystem services, ecosystem functions and their significance in sustaining human life and generating welfare for human beings. In this sense, the provision of information associated with environmental issues can contribute to the minimization of this environmental inexperience and lack of knowledge. This effect can be affected by seasonal experience with ecosystem services (Bithas et al., 2022).

The provision of information can amplify people's interest regarding environmental properties which directly affect their utility in terms of recreational activities during summertime and attention to amenities associated with landscape quality. Nevertheless, this particular "amplification" effect tends to decrease as the seasonal experience comes to an end, though in the case of landscape quality the levels remained higher compared to the ones before any information campaign. Information provision also highlighted specific provisioning and regulatory ecosystem services, whilst assigning interest and values to them. In particular, the "fisheries" and "biodiversity" ecosystem services are not affected by seasonal variations, therefore, the interest and values assigned to them were influenced by the provision of information. Notably, this effect was significantly stronger in proportion for the provisioning ecosystem service of "fisheries". The time decay effect is evident in these services, but it is relatively lower when compared to its counterpart regarding the recreational activities.

In view of the fact that citizens acknowledge the utility generated from the provisioning and regulatory services in time, variations in seasonal experience are removed while the impact induced by the information campaigns endures and may be characterized as relatively stronger. This is more apparent in the case of the "biodiversity" regulatory service, as it has the lowest increase in terms of value gained as a result of the provision of information, whilst it also presents

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the lowest decay effect following the culmination of the information campaigns. In this sense, “biodiversity”, being a significant regulatory service is closely associated with essential environmental properties, gradually and smoothly increases its allure while preserving proportionally more of this increase after the information campaigns have ended. On the contrary, aesthetics (e.g. Landscape), being a part of the cultural services, as well as recreational values demonstrate a certain pattern regarding influence, corresponding to a high sensitivity on actual experience with the relevant ecosystems.

The notion of actual experience with ecosystem services also affects seasonal variation, which in turn significantly affects individual preferences and cannot be counterbalanced by the provision of information. People will most probably value more the ecosystem services that directly contribute to their utility, as they are influenced by the utilization of these services. If this particular “utilization” is interrupted, the relevant preferences will in all likelihood be compromised. This statement is demonstrated in the classification (ranking) of the relevant to recreation (as an activity) ecosystem services before any information provision and after rigorous provision, during a period characterized by the minimal recreational activities available. On the other hand, “biodiversity” which represents a regulatory ecosystem service of non-use value, is highly emphasized before any provision of information and stays that way even after the provision, following the termination of the seasonal experience with recreational activities (Bithas et al., 2022).

Another important aspect of our analysis pertains to the sensitivity of individual opinions in relation to certain policy actions aiming at controlling plastic waste. The provision of information enabled citizens (participants) to better and more comprehensively approve and adopt policies which targeted plastic waste and aimed at reducing plastic use (consumption). At this point, it should be noted that that our results may have also been affected by the information provision within the framework of the state in order to promote the forthcoming (at the time) environmental levy on plastic bags, a mass-media campaign which was initiated during the 3rd and 4th questionnaire surveys during the last months of 2017. However, since both these information campaigns, that is the ones conducted in Syros Island and the mass-media campaign conducted at national level, represent information-based tools, our results centralized the overall effect of information provision in this particular survey area for the respective time period.

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In essence, the ultimate goal of the research was to determine and assess the efficiency of a promising policy tool such as the information campaign over time and on the basis of seasonal variations, an endeavour which has not yet been scientifically achieved, especially with regard to Mediterranean ecosystems. The provision of information is currently gaining a lot of momentum and has often become the preferred choice for government agencies, public authorities, NGOs, and intergovernmental bodies, as in the cases of IPCC and IPBES. In accordance with our results, the provision of information may contribute to the mitigation of environmental threats via actively engaging citizens, whilst appropriately influencing their environmental preferences. Nevertheless, although the impact on environmental preferences is deemed pivotal in successfully alleviating a major environmental issue such as plastic pollution, it should be noted that seasonal experience and time decay may considerably affect these efforts.

In addition, information provision highlights the value in use associated with certain ecosystem services or environmental assets in general, prompting individuals to be more aware regarding the utility they attain via experiencing these assets. Therefore, they become more willing to make sacrifices for the protection of these environmental assets and ecosystem services. However, as soon as their utility experience is interrupted, their preferences tend to moderate and their willingness to sacrifice (or contribute) gradually decreases. This particular process of decay is amplified as time passes from the last information provision effort (Bithas et al., 2022). Furthermore, the provision of information can enhance the environmental preferences associated with non-use values as well, taking into account such type of values affiliated with regulatory ecosystem services. Despite the fact that their impact is significantly lower, as opposed to its counterpart regarding use values, the subsequent increase in interest with regard to regulating ecosystem services is more persistent and durable, while it is not affected by the seasonal variation of experience and is characterized by comparatively lower decay following the conclusion of the information campaigns.

In conclusion, the aforementioned information campaigns which were conducted in Syros Island demonstrated definite signs of inducing environmental awareness to the residents of the island, thus, affecting their environmental preferences. Taking into account the fact that non-economic instruments, such as information campaigns, are often popular and well received by policy makers since they do not necessitate major economic sacrifices, their integration in the environmental

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policy arsenal as an effective tool seems appropriate. The case study of Syros Island exemplifies the significance of information provision in shaping environmental preferences, at least for a respective amount of time. Use values along with primary environmental assets tend to be more sensitive to information, as people are keener to perceive information relevant to their direct utility sources.

The decay effect associated with information provision may diminish the influence information has on use values, especially when combined with seasonal variation. Nevertheless, information provision may increase the interest and corresponding values regarding certain major provisioning and regulating ecosystem services along with an attitude toward the preservation of the integrity of marine and coastal ecosystems (i.e. the pro-environmental behaviour/attitudes), an effect which endures through time. In this sense, information provision via information campaigns can be a vital tool, though not entirely sufficient without supplementary resources (additional instruments). Although information provision raises environmental awareness and reveals important environmental properties and their respective sources of utility to individuals, thus, enabling them to make more informed decisions, sustainable environmental protection requires additional and more permanent measures in order to properly mainstream public interest toward sustainable ecosystem management.

7.3 The stakeholders

7.3.1 Case study and survey design

For the purpose of exploring the environmental preferences of specific groups of people, namely stakeholders, regarding the reduction of plastic waste in the marine and coastal environment of Syros Island, an additional survey was conducted aiming at assessing their attitudes and inclination with respect to this contemporary environmental issue. During this survey, a contingent valuation technique was applied, emphasizing on the stakeholders, a specific target group referring to hotel and room rental facilities owners of the island.

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The study area once again pertained to the island of Syros with respect to its marine and coastal ecosystems, as they directly affect the livelihood of the aforementioned stakeholders, being an integral part of the sector of tourism. Within the context of this study, the main goal was to investigate stakeholders' preferences and willingness to pay (WTP) for the reduction of plastic waste, and especially plastic bags, in the marine and coastal environment of the island. This particular survey was conducted during May 2017 and it was administered by trained interviewers via face-to-face interviews by means of a structured questionnaire. As mentioned above, a contingent valuation technique was applied targeting explicitly the selected target group (hotel/room rental facilities owners) during the 2nd milestone of the information campaigns (Plastic Bag Free Week 2017), resulting in the collection of 40 useful questionnaires in total, a fairly satisfactory sample size, taking into account the total number of hotel/room rental facilities owners in the study area at that time.

The survey questionnaire applied was constructed on the basis of the inherent characteristics of the target group consisting of four sections in total. The main focus of the first section was on the general knowledge, attitudes and opinions regarding local environmental issues, mostly related to the issue of plastic waste and pollution within the coastal area of the island, whilst the second section was set to collect information regarding existing or environmental practices which are to be utilized by these enterprises. The third section introduced the proposed marine and coastal protection policy as well as certain preventive measures which would be applied and explained the payment vehicle. In this context, the exact amount of money the enterprise was willingness to pay was elicited or alternatively the reason(s) an individual was not willing to pay as well as the main motivation for this particular choice. The last section (fourth one) was dedicated to retrieving all the necessary information regarding the demographic and socio-economic characteristics of the respondents.

7.3.2 Results

Table 7-7 depicts the main socio-economic characteristics, environmental practices, and attitudes of the respondents with reference to the relatively satisfactory sample (n=40) representing the operational at that time hotels and room rental facilities. The majority of the respondents were

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predominately middle-aged males with upper secondary education or university education, employed in businesses of approximately over 90% annual occupancy rates, which apply recycling policies, are quite aware of the negative impacts of plastic waste and also willing to further reduce plastic use within the framework of their enterprises.

Table 7-7: Socio-economic characteristics, environmental practices, and attitudes regarding the stakeholder's sample of Syros

Variables	Description	(n=40)
AGE	Age of respondents	50.08 (13.91)
SEX	Sex [1=male, 0 =female]	65%
EDU	Education level 1 = Primary education 2 = Lower level secondary education 3 = Upper secondary education 4 = University education 5 = Post-graduate studies	2.5% 5.0% 47.5% 40.0% 5.0%
EMP	Number of employees	4.52 (2.97)
OCCUPANCY	Annual hotel/rental rooms occupancy rate	91.2%
RECYCLE	Hotel/rental rooms recycling [1=Yes, 0=No]	85.0%
(EU) 2015/720	Awareness regarding Directive (EU) 2015/720 a= Very much aware	

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	b= Somewhat aware c= Not aware	67.5% 32.5% 0.0%
REDUCE_PLASTIC	Likelihood of future reduction in overall plastic use a= Most Probably b= Probably c= Probably Not d= I don't use such products	52.5% 45.0% 2.5% 0.0%

Source: Mentis et al., 2018.

It may well be argued that the respondents regarding the sample of stakeholders can be defined as environmentally responsible and rather eco-sensitive in regard to plastic waste (Table 7-8). In particular, as far as certain variables denoting important ecosystem services and functions are concerned, such as the importance of protecting the fishery population in the marine/coastal ecosystems (FISHERIES), the importance of protecting the landscape quality (LANDSCAPE), and the importance of protecting species diversity in the marine/coastal ecosystems (SPECIES_DIV) their position is firmly in favour of environmental protection and preservation regarding these particular services.

In addition, they acknowledge the hazards associated with the excessive everyday use of plastic (DANG_ENV) in terms of the induced negative impacts for the marine and coastal environment and are positively inclined toward promoting environmental information/education (ENV_EDU) as an environmental policy tool in an effort to alleviate this environmental threat. It is also important to denote that this particular stakeholder's sample of Syros Island, representing the crucial sector of tourism associated with hotels and room rental facilities, believe that plastic litter bears a deterrent effect in beach preference (PLASTIC_FREE), while a clean and plastic free beach is clearly the optimal choice. Furthermore, they regard plastic recycling as a significant factor in tourist decision making (RECYCLE_PLASTIC), with reference to specific choices regarding accommodation and lodging.

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Table 7-8: Variables and environmental preferences regarding the stakeholder's sample of Syros

Variables	Description	mean	sd	var
FISHERIES	Importance of protecting fishery population in the coastal/marine ecosystems of Syros [1=Not at all important, 5=Very Important]	4.95	0.22	0.04
LANDSCAPE	Importance of protecting landscape quality in the coastal/marine ecosystems of Syros [1=Not at all important, 5=Very Important]	4.97	0.15	0.02
SPECIES_DIV	Importance of protecting species diversity in the marine/coastal ecosystems of Syros [1=Not at all important, 5=Very Important]	4.97	0.15	0.02
DANG_ENV	Significance of the excessive everyday use of plastic as an environmental danger (negative impacts on marine/coastal environment) [1= Not at all important, 5=Very Important]	4.62	0.49	0.24
ENV_EDU	Importance of promoting environmental information/ education [1=Not at all important, 5=Very Important]	4.97	0.15	0.02

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PLASTIC FREE	Relevance of plastic free attribute in beach preference [1=Not at all relevant, 5=Very relevant]	4.7	0.56	0.31
RECYCLE_PLASTIC	Plastic recycling as a factor that influences tourist decision making [1=Not at all important, 5=Very Important]	3.94	0.72	0.52

Source: Mentis et al., 2018.

The estimated WTP values for the stakeholders, as presented in Table 7-9, fall within the range of €130 characterized by a mean value of €90 on an annual basis, taking into account the imposed by the economic crisis financial restrictions, as stated by the majority of the stakeholder's sample respondents.

Table 7-9: WTP estimates regarding the stakeholder's sample of Syros (€/year)

Variables	€/year
Min	30.00
Max	200.00
Median	90.00
Mean	94.33
Sd	53.41

Source: Mentis et al., 2018.

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According to the aforementioned valuation results of the structured questionnaire survey, a significant percentage of the hotel owners of Syros Island would and already do support policies aiming at protecting and conserving the local marine and coastal environment of the island. Based on their stated preferences regarding the impacts of plastic waste pollution on the coastal and marine ecosystems of Syros Island, stakeholders are willing to financially support the reduction of the risks (negative effects) associated with plastic litter and waste on critical marine and coastal ecosystem services such as biodiversity, aesthetic amenities, recreational activities, and fish production. Stakeholders tend to assign a high economic value to the overall (marine/coastal) ecosystem services which directly or indirectly affect the sector of tourism. In addition, it appears that the adoption and integration of environmental-friendly processes and strategies in terms of “good practices” within the framework of their respective enterprises is encouraged (from stakeholders) and may prove to be beneficial to them on a financial basis as well.

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Chapter 7: The Case Studies

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This final chapter is dedicated to the presentation of the main conclusions deduced on the basis of the PhD thesis by means of presenting the key aspects and most important recommendations for each chapter. The purpose of this thesis was to adequately investigate the concept of sustainable development in association with ecosystem services and examine this relationship within the framework of operational criteria which may be validated by a specific case study in relation to selected Mediterranean ecosystems. Subsequently, the primary goal is to provide a contemporary perspective in terms of sustainable development taking into consideration all the relevant theoretical approaches in regard to this issue, whilst exploring a major environmental threat as in the case of plastic pollution in the marine environment.

In each separate chapter of this PhD thesis, specific research questions were investigated in an effort to advance from one chapter to another consistently and comprehensively, while sufficiently addressing all the research questions posed. This research process has resulted in interesting and original insights, though several aspects require further exploration in order to facilitate future requirements.

The notion of sustainable development has evolved throughout the years in an effort to fulfil human needs via a socio-economic framework characterized by certain restrictions imposed by our planet's limitations on grounds of natural resources and realized under specific decision-making processes. The ultimate goal is to improve the aggregate human well-being for current as well as future generations based on a value-based "ethos". Thus, there are certain principal parameters ought to be satisfied, which can be traced back to the initial and most cited delineation of sustainable development, that is in the context of the Brundtland Report. In particular, sustainable development assures long-term environmental and ecological sustainability, whilst fulfilling fundamental human needs, and advocating in favour of intragenerational and intergenerational equity.

In addition, the preservation of nature's intrinsic value is of outmost importance, predicated on environmental conservation through citizen and stakeholder participation along with substantial

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public engagement, so as to improve and enhance the quality of life. These parameters are interdependent and necessitate the effective implementation of environmental policies and measures built upon global cooperation and coordination to mitigate environmental threats, whilst achieving sustainable development. In order to achieve this objective, precise and definite maximum and minimum level threshold values should be set and subsequently respected (not exceeded) in consideration of the nine planetary boundaries.

The 17 SDGs constitute a proposed blueprint for sustainability, based on specific targets and indicators on a global level, to be fulfilled within a relatively reasonable amount of time bearing in mind the importance and urgency regarding several of the environmental threats under consideration. These policy implications are to be put into practise by both national and international policy makers during the decision-making processes in reference to issues appertaining to sustainable development. The need for a practical and operational approach which integrates the aforementioned crucial ecological thresholds is at present quite compelling.

At this point it is essential to denote the significance of accomplishing certain goals and meeting a particular threshold value without compromising another. Trade-offs or potential offsets are not always effective on an aggregate level. Furthermore, democratic and egalitarian principles should be adequately appreciated, bearing in mind that sustainable development may be achieved more efficiently within the framework of these axioms. Despite the fact that effective intervention is usually more robust on a national level, sustainable development depends on global partnerships across countries in order to reinforce the means of implementation whilst contributing to the overall planetary and human welfare.

In the following section the main conclusions and recommendations for each chapter will be presented in an effort to concisely provide the most important aspects of the PhD thesis.

Chapter 1

Contemporary and critical threats to sustainable development during this current, though unofficial, Anthropocene epoch necessitate urgent mitigating actions as crucial planetary processes are under substantial threat. Overpopulation, climate change, increasingly demanding

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development pressures, the anthropogenic ecosystem crisis, chemical pollution (especially plastic pollution) are among the most prominent of a series of global environmental issues setting the Earth system under tremendous strain, while at the same time compromising certain irreplaceable functions and processes within the context of our natural environment (Rockström and Karlberg, 2010). The need for a sustainable type of society operating on the basis of Earth's biophysical limits has now become a prerequisite for planetary and human well-being. The repercussions from neglecting or inadequately mitigating these major environmental threats may be detrimental for both our planet as well as the various human economic processes sustained by it. Several theoretical approaches advocate in favour of restoring natural capital, revising environmental management toward more efficient strategies, and safeguarding ecosystems and, thus ecosystem services.

In this context, the weak and strong sustainability approaches insist on climate stabilization (halt climate change) along with promoting a steady-state condition in regard to human population and our planet's ecosystems (prevent further deterioration). Strong sustainability, being for the most part influenced by the axioms of ecological resilience, promotes the transformation of industrial and governmental policies regarding environmental management based on the sustainable use of natural resources. Ecosystems are not static or straightforward, not even in a relative manner, therefore, the implementation of "quick measures" to rectify an unfortunate situation may eventually leave ecosystems more vulnerable to cascading changes characterized by unfavourable results, whilst undermining the Earth's system integrity (Caradonna, 2014). Achieving resilience should be the primary objective in conjunction with working in alignment with vital natural processes and safeguarding critical ecosystem services. In this way, the healthy functioning of Earth's natural environment may ensure socio-economic stability for human beings.

Global resilience, for its part, is dependent on respecting the nine planetary boundaries which allow Earth to remain in the desired and conducive to human welfare current state. The ever-growing socio-ecological pressure on the key earth system processes will result in environmental turmoil, thus, derailing human development and progress. For this purpose, contemporary approaches promote the adoption of the safe operating space paradigm, based on which the most important social and planetary boundaries are taken into account and should under no

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circumstances be exceeded. To this end, applicable frameworks, measures, and indicators are currently in existence, derived from international agreements in accordance with minimum standards for human well-being, as in the case of the 17 Sustainable Development Goals established in 2015 and adopted by every UN member state (Rockström and Karlberg, 2010; Raworth, 2017).

Nevertheless, actions and policies in terms of intergovernmental bodies, national administrations, stakeholders, and resource managers in general, should strive for more than the preservation and sustainable consumption, but also restoration of the natural capital. In this sense, effective environmental policy is critical and should, therefore, be more applicable and highly adaptable.

Chapter 2

Ecosystems services refer to particular functions, structures, and processes which directly or indirectly provide benefits to human beings and increase their well-being (MEA, 2005). The concept of ecosystem services has proven instrumental within the framework of accomplishing sustainable development both on an inter- and intragenerational level, attracting attention from various academic disciplines, thus, fostering multidisciplinary. In this respect, ecosystem services have the potential to be a transformative tool, embedding important parameters in regard to human-nature interactions. The development of a proper and scientifically based information and knowledge management system in addition to the utilization of the appropriate policy mechanisms during the decision-making process may prove to be very productive (Daily et al., 2009; Wainger et al., 2010; Bateman et al., 2013; Abson et al., 2014).

The connection or “translation” of this transformative knowledge, whilst replacing conservative and anachronistic methodologies, to actions (measures, policies) along with the integration of aspects from various scientific disciplines as well as non-scientists, may greatly contribute to achieving the desired societal goals and ultimately sustainable development (Reyers et al., 2010). The advanced comprehension of the concept of ecosystem services is essential in forming genuinely sustainable human-nature interactions. The adoption of a holistic approach based on transdisciplinarity may balance all the related parties involved in this process, from citizens to stakeholders and administrative bodies (Jax et al., 2013).

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Ecosystem services as a concept are capable of producing operational criteria when corresponding to sustainable development goals and provided that they are predicated on effective assessment techniques. The integration of research results throughout the design of sustainable management policies would substantially aid in the effective interpretation of correlations existing between ecosystems and the surrounding socio-economic activities. Nevertheless, the notion of ecosystem services generates better outcomes when engaging different practices with regard to governance, communication, motivation, and education thematics in an effort to consolidate fragmented information domains within a holistic and universal framework with practical applications.

Chapter 3

The valuation process regarding ecosystem services has evolved throughout the years whilst integrating more contemporary and advanced techniques, such as the use of advanced software programs or satellite functions in order to incorporate massive land territories, which are subsequently registered and analyzed. The need for ecosystem services valuation is derived from the robust association existing between ecosystem services and human welfare. The ecosystem services concept integrates major aspects from every form of capital (human, natural, built) within the framework of the ongoing socio-economic and ecological changes.

In this sense, it is deemed most efficient to adequately comprehend the fundamental principles of both market-based and non-market-based valuation methods that are most frequently applied for estimating values associated with ecosystem services. Consequently, the next step should be the assiduous investigation of the advantages and disadvantages of each valuation method, while clarifying the data requirements regarding these valuation methods as well. In this sense, the selection of the most appropriate and suitable method for the valuation of the particular ecosystem under examination, aiming at generating a proper assessment, is essential. In the interest of better facilitating the decision-making process for implementing optimal policy measures, the valuation of ecosystem services constitutes an integral part, as it provides the

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necessary representative values based on which environmental policy decisions are made (Koetse et al., 2015).

Therefore, with a focus on efficiency as well as sufficiency the valuation process should incorporate all forms of value emerging from the interactions between the natural environment and the beneficiaries of ecosystem services. Human welfare is consisted of intrinsic values as well, in addition to its purely utilitarian factors, thus, necessitating an amalgamation of estimating both material and non-material benefits generated on the basis of ecosystem services. The ultimate objective of ecosystem services conservation depends on stirring all relevant policy measures toward the proper direction. Hence, the future for ecosystem services valuation lies within joint collaboration in systematically assembling and aligning socio-economic and environmental databases with reference to ecosystem services.

To this end, the most prominent components that ought to be taken under serious consideration pertain to the overall contribution of ecosystem services to human well-being, the motivations shaping the decisions of both policymakers and stakeholders regarding ecosystem management, weighing the implications when facilitating certain agendas and courses of action, and the particular requirements and necessities existing not only at a central, but also at a regional and local level.

Chapter 4

Ecosystem services represent a plethora of different interactions performed within the context of the natural environment, and thus they are not limited to the terrestrial space. Fish are the primary protein source for approximately one billion people at a global scale, while marine and coastal ecosystems accommodate numerous plant and animal species, all of which contribute to providing valuable services for human welfare.

The variety of marine and coastal ecosystem services ranges from supporting or intermediate services, as in the case of life-cycle maintenance and nutrient cycling, provisioning services such as fisheries and raw elements, regulating services such as carbon sequestration and storage, moderation of extreme events, and waste-water treatment to cultural services in regard to

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recreational activities, tourism as well as generating aesthetic and spiritual benefits (MEA, 2005). Taking into account contemporary and major environmental threats, climate change in particular, the significance of the planet's oceans in climate regulation and ocean acidification is immense. Based on recent study results, it is deduced that the seas absorb approximately 1/3 of the overall carbon dioxide emitted on an annual basis worldwide (Ocean and Climate Platform, 2020).

The plankton existing in the oceans represents over 95% of all marine biomass including fish larvae, microalgae, micro-crustaceans, reproductive cells, etc., along with the phytoplankton which absorbs carbon dioxide and produces over 50% of the vital for human beings oxygen via the process of photosynthesis. There are thousands of different species of algae and planktonic animals in existence contributing to our planet's gene pool and biodiversity status, a planetary boundary which has been severely surpassed (i.e. biosphere integrity), while in terms of the marine food chain the importance of sustaining healthy levels with respect to the genetic and functional diversity is tremendous.

The aggregate value of the services provided by marine and coastal ecosystems has been estimated to approximately USD\$ 29.5 trillion on an annual basis worldwide. Marine and coastal ecosystem services constitute vital resources for coastal communities at a regional scale, but also on a national level and in terms of international trade as well (Lau et al., 2010). The value generated by fishery enterprises for the global economy is substantial, but it strongly depends on the resilience and conservation of the associated marine ecosystems. In particular, any further degradation to these ecosystems may result in a series of cascading negative effects, therefore, reducing both the quantity and quality of the ecosystem services delivered. In this sense, it is deemed necessary to adequately comprehend and acknowledge this plethora of benefits provided by marine and coastal ecosystems, which have proven to be essential for human well-being within the framework of achieving sustainable development (Lopes and Videira, 2013).

Nevertheless, policy makers along with the general public have still relatively limited knowledge regarding the biological and economic significance of marine and coastal ecosystem services. Therefore, the selection of the most suitable and appropriate method of economic valuation with regard to marine and coastal ecosystem services is of paramount importance. Subsequently, the practical use originating from the proper selection is evident across all levels, policy-planning, decision making, and communication. The applicability of any valuation method regarding marine

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and coastal ecosystem services is mainly based on their capacity to acknowledge and properly assess any occurring changes with reference to marine/coastal ecosystem services.

The effective marine and coastal ecosystem services valuation may offer the means to adequately measure the anticipated costs and benefits for a certain policy which is to be implemented during the decision-making process, while also contributing to raising awareness in regard to the value and benefits generated and delivered to humans by healthy marine/coastal ecosystems.

Chapter 5

Plastic pollution is currently considered to be among the most urgent environmental threats on a global level, as production tends to increase at overwhelming rates, whilst the majority of the plastic products are often single-use and easily discarded. In cases when waste management proves inadequate or the recycling systems insufficient, the results are far bleaker. More than 300 million tons of plastic are produced on an annual basis worldwide to be used in a wide range of applications, from which a minimum of approximately 8 million tons is estimated to end up in marine environments across the globe, thus, forming marine debris and litter.

Marine plastic pollution (MPP) has been exacerbated due to the accelerating rate of plastic waste inputs originating from both land and sea-based sources, taking into consideration that nowadays man-made litter (particularly plastic debris) has been found in almost every marine environment. Shoreline and recreational activities, dumping, and smoking account for approximately 80% of land-based marine pollution worldwide. Microplastics and nanoplastics pose a serious threat for marine and human organisms alike. Marine litter and plastic debris are present in every marine habitat, being very pervasive, but also within marine organisms, secluded beaches, the seafloor, submarine canyons, seamounts, mounds, banks, continental shelves and ocean ridges, therefore, negatively affecting each habitat and ecosystem.

The most frequent among the negative repercussions they induce to marine wildlife refer to ingestion, suffocation, entanglement, and debilitation in general. As a result, the impacts are detrimental ranging from simple injuries or death for marine organisms to adverse effects for the

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associated marine and coastal environment, negative effects for the global/local economy as well as unfavourable effects on human health.

The economic costs linked to marine plastic pollution refer to certain types of expenditure, losses in revenue or output along with welfare losses. These costs, either direct or indirect, are related to the foregone benefits of industries or corresponding economic activities in general (e.g. fishing vessels, commercial shipping, leisure craft, tourism, etc.), together with non-market assets, as in the case of various ecological processes performed by marine and coastal ecosystems that positively influence social welfare. In addition, marine plastic pollution is associated with diminished recreational values (e.g. coastal tourism) as well as with costs of actions in regard to measures which have to be taken for mitigating the negative impacts linked to the presence of plastic waste. The removal of plastic litter from vessels or facilities, the need for replacements or repairs to damaged equipment by plastic waste together with losses in revenue due to diminished catches or contamination constitute a significant economic burden to all the relevant industries involved.

Furthermore, marine plastic pollution threatens both food safety and quality, thus, bearing serious negative implications for human health. The abundance of potential pathways of human exposure to plastics, particularly in relation to microplastics, via food consumption (biomagnification process) or even ventilation is strongly connected to a series of health risks (Wright and Kelly, 2017). Taking into account the fact that based on certain estimations an average person could ingest up to 5 grams of plastic on a weekly basis, depending on his/hers consumption habits, chronic exposure may result to oxidative stress, inflammatory lesions, and translocation (WWF, 2019). The human immune system cannot efficiently remove synthetic particles (microplastics, nanoplastics, etc.) which in turn contribute to inducing immunotoxicity, immunosuppression or abnormal inflammatory responses.

In this context, plastic bags are considered to be prominent among the plastic waste composite, being in wide circulation all over the world and produced/consumed at accelerating rates. Plastic bag waste along with plastic packaging waste are strongly linked to all the negative impacts plastic litter and debris induce to the marine and coastal environment, as they are easily discarded (especially single-use items) and tend to promptly break down into smaller parts, thus, forming microplastics. The overall economic cost they generate for governments and businesses alike is

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substantial, while it is most commonly comprised of certain procedures such as waste collection, removal, transportation, disposal, and recycling.

In terms of policy measures as well as governance solutions it is imperative to explore the use of the existing and legally binding international agreements along with the formation of potentially additional ones, aiming at preventing and reducing plastic waste in order to effectively address marine plastic pollution. The tenets of sustainable development urge for adequate governance and managing interventions with regard to this issue, whilst at the same time properly integrating the economic value of marine plastic waste impacts. The most notable and effective among the various policy measures implemented toward this goal assume the form of environmental regulations, bans, and fees, for the most part, to reduce the consumption of single-use plastics. In addition, there is a variety of supplementary means on the basis of market-based instruments, voluntary actions, distributive, regulatory, redistributive, and constituent policies. Reusing and recycling plastic products may also prove to be rather practical, while the necessity for further funding in research and innovation toward developing new environmentally friendlier products for replacing single-use plastics is immense.

Plastic pollution requires immediate mitigation actions and initiatives, as its negative impacts are not only limited to the marine and coastal environment worldwide, but in consideration of the accelerated global plastic production, the exacerbation of climate change on account of the subsequent and increasingly higher GHG emissions is imminent.

Chapter 6

The impact incurred by the effective use of information on people's preferences and choices constitutes an intriguing thematic which has recently drawn significant attention from various scientific disciplines, particularly with regard to environmental behaviour. The notion of successfully combining certain aspects of communication policy and information (facts) with other policies is strongly encouraged, as it may also prove to be productive. Information may contribute to empowering individuals whilst allowing them to be more cognizant of crucial environmental issues which affect their well-being and social welfare in general, bearing in mind

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the high level of concern within the context of modern society along with the need for improved awareness (Møller Rasmussen, 2001).

Information provision may affect both the perceptions and knowledge of the recipients, while it may also increase the sense of individual responsibility in regard to specific environmental threats as well as the level of commitment toward being an active part of the solution. To this end, environmental education may also influence environmental preferences, even compensating for the lack of personal experiences (Lang and Cavanagh, 2018; Chen and Cho, 2019). Within the framework of environmental policy the tactic of influencing environmental awareness has frequently been applied as a tool often combined with more conventional measures as in the cases of taxation, standards, etc., for optimal results.

In this context, information campaigns emerged as a promising policy tool detached from the customary strategies of implementing command and control measures or providing incentives and disincentives respectively, being the most conventional economic instruments (Weiss and Tschihart, 1994). The principal objective of a successful information campaign lies in delivering the appropriate environmental message which may ultimately affect the target audience. For this purpose, several sociological and psychological theoretical approaches exist in the matter of social influence, mainly concentrating on topics regarding the adequate provision of information, inducing social norms, enhancing awareness, and influencing/altering inherent values and preferences.

Information campaigns maybe applied as awareness raising measures or educational tools aiming at enhancing individuals' ability to make informed decisions and form responsible behaviour with regard to environmental issues. The integration of information campaigns in the environmental policy design could prove to be productive, though certain parameters ought to be taken under consideration. In particular, the use of information campaigns as policy instruments depends on its effectiveness and capacity to seize public interest as well as the attention of the selected target audience. In addition, it is critical to present as clearly as possible the intended message, whilst influencing the understanding of the recipients, and thus forming the framework for the social outcome that is sought. Although awareness raising activities, as in the case of information campaigns, can be cost-effective they do not necessarily guarantee changes in behaviour, so it is

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important to make use of different approaches as well, while systematically evaluating these activities and tools in order to better understand their potential benefits.

Information provision may bear a substantial impact on sustainable development thematics, thus, prompting for further research on the investigation of reliable and accurate methods of measurement. Information campaigns are characterized by their capacity to inform, educate, and mobilize people when applied accordingly and on the basis of adequate research. They tend to be effective in generating the intended policy outcomes, though they require further exploration in regard to developing suitable methods toward mitigating their disadvantages.

Chapter 7

In an attempt to properly examine the effectiveness of information campaigns as a non-economic policy instrument that contributes toward raising environmental awareness, an intensive in content and relatively extended in time study was conducted at Syros Island. This study was designed with the intention to investigate in situ the effects of information provision on the environmental preferences of the citizens of Syros Island via the application of a DCE, thus, linking their preferences on the basis of decisions characterized as more or less informed.

Taking into account the results of our analysis we have reached the conclusion that information provision and enhanced environmental awareness affect environmental preferences. Providing people with additional information regarding a crucial and contemporary environmental issue, as in the case of marine plastic pollution, may indeed affect their environmental values, even in the case of short time periods. Based on our findings, the citizens of Syros Island became more aware and interested regarding certain marine and coastal ecosystem services within the context of their island after the information provision. However, this effect can also be subjected to seasonal variations and particularly “experience” regarding the specific ecosystem services under examination. In the case of Syros Island the provision of information intensified citizens’ interest for certain environmental properties which have direct impacts on their utility, as for example recreational activities during summertime, though this effect gradually decreases as soon as the seasonal experience is discontinued.

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Information provision via information campaigns can effectively convey the utility gains people experience on account of the benefits provided to them through the environment and ecosystem services, therefore, encouraging them to be more willing to sacrifice for the conservation of these services. Nevertheless, a decay effect takes place once the experience of these services is interrupted, subsequently affecting (lowering) their respective preferences and their willingness to sacrifice (or contribute) diminishes accordingly. This particular decay effect can be influenced by the amount of time passed since the information provision process ended.

According to our results, information provision “improved” the preferences regarding non-use values as well, such as the ones relating to regulatory ecosystem services. Their impact was significantly lower when compared to their corresponding use values, but this increased interest in preferences regarding regulating ecosystem services was more consistent and permanent, while it was also characterized by relatively lower decay once the information campaign ended and was neutral to the seasonal variation of experience as well.

Since information provision is considered to be a reliable policy instrument, and thus is frequently utilized by several public authorities, NGOs, and international bodies (e.g. IPCC), our study investigated the sensitivity of individual opinions in relation to policy actions aiming at controlling plastic waste. Based on our results, the provision of information may enable people to be better prepared to accept and adopt any relevant policies and policy measures with the purpose of mitigating the plastic waste problem. In this sense, their framework of environmental preferences is reshaped, aspiring toward an enhanced or/and improved ecosystem services protection and preservation.

Information campaigns based on the structured provision of information have proven to be a promising non-economic environmental policy tool which may greatly contribute to promoting the environmental protection agenda, but not a sufficient one as they are liable to seasonal experience and time decay. A more stable instrument is also required to adequately stir individual choices toward sustainable ecosystem management and environmental conservation. Nevertheless, information provision enhances environmental awareness, therefore, providing insights to individuals regarding certain environmental properties along with the associated utility derived from them in order to make informed decisions with respect to crucial environmental issues.

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Innovation, originality and contributions of the PhD thesis

This PhD thesis attempts to explore contemporary and crucial environmental thematic within the framework of sustainable development, thus, contributing to the scientific dialogue in regard to this objective. The first main contribution and novelty lies in the thorough investigation of the existing associations between sustainable development and ecosystem services, whilst focusing on marine and coastal ecosystem services which have received relatively little attention when compared to other categories of ecosystem services (terrestrial, estuarine, etc.). In addition, a critical environmental threat currently in progress at a global scale, in particular plastic pollution (chemical pollution), is meticulously examined in association with its effects and impacts on marine and coastal ecosystems. In this context, potential tools and measures of effective mitigation are explored in terms of environmental policy instruments, particularly information campaigns. In order to test these notions and assumptions certain practical applications have taken place to verify the legitimacy as well as efficiency of the theoretical framework of the PhD thesis.

Sustainable development and sustainability as concepts have already been examined, predominantly in relation to economic growth and on the basis of restrictions set due to insufficient natural resources. The importance of healthy ecosystem functioning for human well-being has been denoted since the classical era in Ancient Greece. Major reports as in the case of the Millennium Ecosystem Assessments (MEA) effectively demonstrate the human impact on the environment and the urgent necessity for ecosystem services conservation. The benefits represented in both market and non-market values (use and non-use values) significantly exceed the required “limits to growth”.

It is, therefore, essential to properly investigate the current trends, approaches and hypotheses aiming at achieving sustainable development by means of adequate ecosystem services management and preservation. The concept of ecosystem services was formed in an effort to acknowledge and quantify every relevant and beneficial interaction existing among humans and our planet’s ecosystems across the globe. Marine and coastal ecosystem services offer a variety of highly valuable benefits to human beings ranging from climate regulation to habitat provision

Innovation, Originality and Contributions of the PhD thesis

for numerous plant and animal species. However, in order for these services and benefits to be efficiently delivered by marine and coastal ecosystems, certain thresholds (breakpoints) must be respected. If these “boundaries” are exceeded, there is a very strong possibility for regime shifts to take over along with all the cascading deleterious repercussions, thus, signaling a transition to an alternative state characterized by inhibited resilience to environmental pressures, but increased susceptibility to unnecessary changes.

Marine plastic pollution constitutes an environmental threat currently ranking high in terms of prioritization on the environmental policy agenda, and thus scientific debate at a global scale. There is a strong need for additional research, data and information regarding this issue, particularly in the case of specific regions such as the Mediterranean area and its associated ecosystems. However, it is also vital to provide an adequate framework in order to transition from theory to practice. In particular, to suggest the appropriate tools and instruments within the environmental policy context for successfully mitigating marine plastic pollution as well as other similar environmental threats. For this purpose, the provision of information on the basis of information campaigns was thoroughly examined as a promising tool within the arsenal of environmental policy.

The costs in human welfare resulting from ecosystem degradation tend to be severe, therefore, necessitating their inclusion within the context of environmental assessments and management. In this direction the preservation of healthy marine and coastal ecosystems along with the reduction to a minimum of the human impact on ecosystem functions is essential. Consequently, the PhD thesis adheres to the primary principles of sustainable development, whilst organically integrating the most significant aspects of the ecosystem services concept with regard to marine and coastal ecosystems and the currently widespread environmental problem of plastic pollution. In addition, an attempt is being made toward exploring the potency of a promising policy instrument (i.e. information provision/information campaigns). Hence, the PhD thesis lays the scientific foundation for further research in regard to utterly confirming the efficiency of information provision as a strategy and information campaigns as an adequate instrument.

The practical novelty of the PhD thesis is related to the respective case studies examining the legitimacy of this tool in reference to the critical ecological threat of marine plastic pollution for a Mediterranean ecosystem as in the case of Syros Island, Greece. The research process consisted

Innovation, Originality and Contributions of the PhD thesis

of three main steps. Firstly, a baseline regarding public awareness on the most significant aspects of plastic pollution was sought and subsequently the proposed environmental policy instrument (i.e. information campaigns) was tested in the case of Syros Island. This experimental study, involving multiple questionnaire surveys and interviews with regard to the general public as well as specific stakeholders of Syros Island, was intensive in content and extended in time, therefore, producing valuable results, especially when compared to the limited published research pertaining to this issue on a global level.

The econometric analysis of these results delivered insights for a particular region of Greece for the first time worldwide. Within the framework of the PhD thesis an attempt was made to comprehensively investigate the tenets of sustainable development in association with the ecosystem services concept, taking into consideration a contemporary and critical environmental threat referring to a Mediterranean ecosystem. It is deemed of outmost importance to provide the proper link between theory and practice and practically test the efficiency of a promising policy instrument such as information provision.

With the aforementioned stated, the PhD thesis could be considered among the first scientific endeavours to offer theoretical and practical insights regarding an intricate theme, thus, advocating in favour of the realisation of the research and investigation.

Annexes

I. Questionnaire distributed in the residents of Syros Island (in Greek)



LIFE DEBAG

Ολοκληρωμένη εκστρατεία ενημέρωσης και ευαισθητοποίησης για τη μείωση της πλαστικής σακούλας στο θαλάσσιο περιβάλλον

(LIFE14 GIE/GR/001127)"

Ερευνά αποτίμησης του ιδιωτικού οφέλους από την λήψη διαχειριστικών μέτρων προστασίας του παράκτιου περιβάλλοντος από τα πλαστικά απορρίμματα

Το παρόν ερωτηματολόγιο γίνεται στο πλαίσιο του έργου LIFE DEBAG το οποίο έχει ως κεντρικό άξονα την προστασία του παράκτιου και θαλάσσιου περιβάλλοντος της Σύρου. Έχετε επιλεγεί τυχαία μαζί μ' ένα μεγάλο αριθμό κατοίκων της Σύρου που επίσης συμμετέχουν στη έρευνα αυτή. Σκοπός της έρευνας είναι να διερευνήσουμε τις προτιμήσεις σας αναφορικά με τα μέτρα προστασίας του παράκτιου και θαλάσσιου περιβάλλοντος από τα πλαστικά απορρίμματα. Οι απαντήσεις είναι εμπιστευτικές και θα χρησιμοποιηθούν αποκλειστικά για ερευνητικούς σκοπούς.

A. Ερωτήσεις γνώσης/αξιολόγησης του προβλήματος των πλαστικών απορριμμάτων στον παράκτιο χώρο.

1. Ποιοι είναι κατά τη γνώμη σας οι τρεις σημαντικότεροι κίνδυνοι για το παράκτιο και το θαλάσσιο περιβάλλον της Σύρου;

1. _____

2. _____

3. _____

2. Σε μια κλίμακα από το 1 ως το 5, όπου 1=διαφωνώ απόλυτα και 5=συμφωνώ απόλυτα, ποια είναι η γνώμη σας για τις παρακάτω φράσεις:

- ☐ Το παράκτιο περιβάλλον της Σύρου υποβαθμίζεται διαρκώς από ανθρώπινες δραστηριότητες
- ☐ Το παράκτιο περιβάλλον της Σύρου χρειάζεται περαιτέρω μέτρα προστασίας

3. Σε μια κλίμακα από το 1 ως το 5, όπου 1=καθόλου σημαντικός και 5=εξαιρετικά σημαντικός, πόσο σημαντικούς θεωρείτε τους παρακάτω κινδύνους για το παράκτιο και θαλάσσιο περιβάλλον της Σύρου.

- ☐ Αστική οικιστική ανάπτυξη στον παράκτιο χώρο.
- ☐ Τουριστική ανάπτυξη στον παράκτιο χώρο (υποδομές ξενοδοχείων, ενοικιαζόμενων, οργανωμένες παραλίες, κτλ.)
- ☐ Κεντρική διαχείριση στερεών απορριμμάτων (πλαστικού, γυαλιού, κτλ.) – λειτουργία ΧΥΤΑ και Ανακύκλωσης.
- ☐ Χρήση σκαφών και μηχανοκίνητων σπορ (jet ski, water ski, κτλ.) στη θάλασσα – ρύπανση των υδάτων.
- ☐ Υπερβολική χρήση πλαστικού στην καθημερινή ή/και την τουριστική δραστηριότητα, μεγάλες ποσότητες του οποίου καταλήγουν στις ακτές και τη θάλασσα.
- ☐ Υπερβολική αλίευση.
- ☐ Κλιματική αλλαγή και άνοδος της στάθμης της θάλασσας

4. Σε μια κλίμακα από το 1 ως το 5, όπου 1=καθόλου σημαντική και 5=εξαιρετικά σημαντική, πώς θα χαρακτηρίζατε τους παρακάτω στόχους διαχείρισης για την παράκτια/θαλάσσια περιοχή της Σύρου;

- ☐ Προστασία της βιοποικιλότητας και των σπάνιων ειδών (ζώων ή φυτών) του παράκτιου χώρου
- ☐ Προστασία των ειδών που αποτελούν μέρος της τροφικής αλυσίδας του ανθρώπου (ψάρια, οστρακοειδή, κτλ.)
- ☐ Προστασία της αισθητικής και της καθαριότητας των ακτών και των θαλασσών.
- ☐ Λήψη κατάλληλων περιβαλλοντικών μέτρων που δεν θα περιορίζουν την ανθρώπινη δραστηριότητα στον παράκτιο χώρο και δεν θα έχουν επιπτώσεις στην τοπική ανάπτυξη
- ☐ Αυξημένη περιβαλλοντική ενημέρωση και περιβαλλοντική εκπαίδευση των κατοίκων της Σύρου

5. Έχετε πραγματοποιήσει κάποια από τις παρακάτω δραστηριότητες τον τελευταίο χρόνο;

		ΝΑΙ	ΟΧΙ
1	Αναζήτηση περιβαλλοντικών πληροφοριών (στην τηλεόραση, την εφημερίδα, το διαδίκτυο, κτλ.)		
2	Συμμετοχή σε κάποια εκστρατεία καθαρισμού των ακτών		
3	Συμμετοχή σε κάποια δημόσια συζήτηση για την προστασία της θάλασσας/των ακτών;		
4	Ενημέρωση στο πλαίσιο της καμπάνιας του προγράμματος LIFE DEBAG για τις επιπτώσεις της πλαστικής σακούλας στο παράκτιο/θαλάσσιο περιβάλλον.		
5	Ανακύκλωση πλαστικού και άλλων συσκευασιών στους μπλε κάδους		
6	Μέλος σε κάποια περιβαλλοντική ΜΚΟ Αν ναι διευκρινίστε: _____		
7	Δωρεά χρημάτων για κάποια περιβαλλοντική δράση/σκοπό. Αν ναι διευκρινίστε: _____		

6. Κατά την καλοκαιρινή περίοδο πόσο συχνά επισκέπτεστε τις παραλίες του νησιού;

α. Καθημερινά	β. 3-4 φορές την εβδομάδα
γ. 1-2 φορές την εβδομάδα	δ. 1-2 φορές το μήνα
ε. σπανιότερα	στ. ποτέ

7. Τι είδους δραστηριότητες πραγματοποιείτε συνήθως στην παραλία (μπορείτε να επιλέξετε περισσότερες από μία):

α. Κολύμπι,	β. Ηλιοθεραπεία
γ. Περπάτημα στην παραλία και παιχνίδια παραλίας (beach volley, ρακέτες, κτλ.)	
δ. Ερασιτεχνικό ψάρεμα	ε. Υποβρύχιο ψάρεμα/καταδύσεις (scuba diving)
στ. Σπορ θαλάσσης (wind-surfing, canoe, θαλάσσιο σκι, ιστιοπλοΐα, jet-ski, κτλ.)	

8. Σε μια κλίμακα από το 1 ως το 5, όπου 1=καθόλου πιθανό και 5=εξαιρετικά πιθανό, πόσο πιθανό θα ήταν τα παρακάτω χαρακτηριστικά να σας οδηγήσουν στο να επιλέξετε μια παραλία για τις δραστηριότητες αυτές:

- ☐ Η παραλία διαθέτει όλες τις απαραίτητες οργανωμένες υποδομές (ομπρέλες, ξαπλώστρες, καντίνες, WC)
- ☐ Η παραλία είναι καθαρή από πλαστικά και άλλα στερεά απορρίμματα
- ☐ Η παραλία διαθέτει μεγάλη ποικιλία από προσφερόμενα θαλάσσια σπορ
- ☐ Η ακτή διαθέτει γαλάζια σημαία και έχει εξαιρετική ποιότητα νερών κολύμβησης
- ☐ Η παραλία διαθέτει δωρεάν υποδομές (WC, ντουζιέρες)
- ☐ Η παραλία είναι κοσμοπολίτικη
- ☐ Η παραλία είναι ήσυχη χωρίς πολλούς τουρίστες

9. Το επάγγελμά σας συνδέεται άμεσα ή έμμεσα με:

α. Τον Τουρισμό: ☐ ΝΑΙ ☐ ΟΧΙ

Αν «ΝΑΙ» διευκρινίστε: _____

β. Την αλιεία: ☐ ΝΑΙ ☐ ΟΧΙ

Αν «ΝΑΙ» διευκρινίστε: _____

γ. Το περιβάλλον: ☐ ΝΑΙ ☐ ΟΧΙ

Αν «ΝΑΙ» διευκρινίστε: _____

10. Πόσο συχνά καταναλώνετε ψάρια και θαλασσινά τα οποία προέρχονται από την ευρύτερη περιοχή της Σύρου;

α. Ποτέ β. 1-2 φορές το μήνα γ. 1-2 φορές την εβδομάδα

δ. 3-4 φορές την εβδομάδα ε. 5-7 φορές την εβδομάδα

11. Γνωρίζετε ότι το πλαστικό και ειδικότερα οι πλαστικές σακούλες έχουν αρνητικές επιπτώσεις στο περιβάλλον και ιδιαίτερα τα θαλάσσια οικοσυστήματα;

α. Ναι, το γνωρίζω πολύ καλά β. Κάτι έχω ακούσει γ. Δεν το γνωρίζω

12. Γνωρίζετε ότι η Ε.Ε., βάσει της Οδηγίας 720/2015, επιδιώκει την εφαρμογή πολιτικών αντιμετώπισης της υπερβολικής χρήσης πλαστικής σακούλας;

α. Ναι, το γνωρίζω πολύ καλά β. Κάτι έχω ακούσει γ. Δεν το γνωρίζω

13. Σε μια κλίμακα από το 1 ως το 5, όπου 1=διαφωνώ απόλυτα και 5=συμφωνώ απόλυτα, ποια είναι η γνώμη σας για τις παρακάτω φράσεις: «Θα πρέπει να λάβουμε μέτρα προστασίας των παράκτιων και θαλάσσιων οικοσυστημάτων της Σύρου»

α. Παρά την οικονομική κρίση της χώρας ☐

β. Ακόμα και αν αυτό επηρεάσει την καθημερινότητά μου (απαγόρευση χρήσης πλαστικής σακούλας, τιμολόγηση σακούλας, κτλ.) ☐

B. Μέθοδος αποτίμησης: περιγραφή – κάρτες επιλογής

Καλείστε τώρα να επιλέξετε μεταξύ διαφορετικών σεναρίων για τη μελλοντική διαχείριση του παράκτιου περιβάλλοντος της Σύρου και την προστασία του από τα πλαστικά απορρίμματα. Τα εναλλακτικά σενάρια αντιστοιχούν σε διαφορετικά μέτρα προστασίας της θάλασσας και των ακτών (π.χ. πολιτικές καθαρισμού των ακτών, πολιτικές ελέγχου της παράνομης διάθεσης απορριμμάτων, πολιτικές ενημέρωσης/ευαισθητοποίησης, κτλ.), τα οποία θα διαφέρουν ως προς τα παρακάτω χαρακτηριστικά:

- I. **Δραστηριότητες αναψυχής στην παραλία/θάλασσα:** Η μεγάλη συγκέντρωση πλαστικών απορριμμάτων (σακούλες, μπουκάλια, κτλ.) στις ακτές και τη θάλασσα επιδρά αρνητικά στις διάφορες δραστηριότητες που μπορεί να πραγματοποιήσετε (κολύμπι, θαλάσσια σπορ, βόλτα στην παραλία, κτλ.).
 - 1) Μεγάλη ενόχληση** από τα πλαστικά απορρίμματα στις διάφορες δραστηριότητες.
 - 2) Μικρή ενόχληση** από τα πλαστικά απορρίμματα στις διάφορες δραστηριότητες.
 - 3) Καμία ενόχληση** από τα πλαστικά απορρίμματα στις διάφορες δραστηριότητες.
- II. **Αισθητική υποβάθμιση.** Η συγκέντρωση πλαστικών απορριμμάτων στις ακτές και τη θάλασσα υποβαθμίζει το τοπίο όχι μόνο των ακτών κολύμβησης αλλά ολόκληρου του παράκτιου χώρου. Η υποβάθμιση αυτή δεν αφορά μόνο την καλοκαιρινή περίοδο (οπότε και γίνονται συνήθως οι καθαρισμοί) αλλά όλη τη διάρκεια του χρόνου.

4) Σημαντική υποβάθμιση του τοπίου

5) Καμία υποβάθμιση του τοπίου: Το θαλάσσιο/παράκτιο τοπίο της περιοχής δεν δέχεται καμία σημαντική επίδραση από τα πλαστικά απορρίμματα

III. Υποβάθμιση θαλάσσιου/παράκτιου οικοσυστήματος: Η συσσώρευση πλαστικού επηρεάζει τους ζωικούς και φυτικούς οργανισμούς που διαβιώνουν στο παράκτιο-θαλάσσιο οικοσύστημα (βιοποικιλότητα). Ως αποτέλεσμα ενδέχεται – αν δεν ληφθούν περαιτέρω μέτρα - να προκληθεί στο μέλλον σημαντικός κίνδυνος για τη διατήρηση των πληθυσμών αυτών αλλά και για την ίδια την ισορροπία του οικοσυστήματος:

- **Μεγάλη πιθανότητα σημαντικής υποβάθμισης του οικοσυστήματος:** Σημαντικός κίνδυνος στη βιοποικιλότητα
- **Μικρή πιθανότητα σημαντικής υποβάθμισης του οικοσυστήματος:** Μικρός κίνδυνος στη βιοποικιλότητα

IV. Υποβάθμιση των αλιευμάτων. Σύμφωνα με τους ειδικούς επιστήμονες η αύξηση της συγκέντρωσης πλαστικού στους ωκεανούς ενδέχεται να επηρεάσει τα αλιεύματα της περιοχής, τόσο εξαιτίας της μείωσης του πληθυσμού των ψαριών, όσο και μέσα από την αύξηση των κινδύνων στην υγεία των ανθρώπων από την επιβάρυνση της τροφικής αλυσίδας (λόγω συσσώρευσης πλαστικού σε διάφορους θαλάσσιους οργανισμούς).

- **Μεγάλη πιθανότητα σημαντικής υποβάθμισης των αλιευμάτων:** Σημαντικός κίνδυνος στους πληθυσμούς των αλιευμάτων ή/και στην τροφική αλυσίδα
- **Μικρή πιθανότητα σημαντικής υποβάθμισης των αλιευμάτων:** Μικρός κίνδυνος στους πληθυσμούς των αλιευμάτων ή/και στην τροφική αλυσίδα

V. Ανάγκη λήψης ειδικών μέτρων προστασίας. Για την αποτελεσματικότερη εφαρμογή ενός προγράμματος προστασίας, πέρα από τις ενέργειες που αναμένεται να κάνει η τοπική αυτοδιοίκηση μπορεί να ληφθούν και επιπλέον μέτρα σχετικά με τη χρήση της πλαστικής σακούλας που ενδέχεται να επηρεάσουν την καθημερινότητά σας:

- **Καθολική απαγόρευση:** Απαγόρευση χρήσης και αγοράς πλαστικής σακούλας σε όλα τα εμπορικά καταστήματα (επιτρέπονται μόνο οι μεγάλες μαύρες σακούλες για τους κάδους σκουπιδιών)

- **Μερική απαγόρευση:** Απαγόρευση χρήσης πλαστικής σακούλας μόνο στα super-markets με στόχο την εναρμόνιση στην Ευρωπαϊκή Οδηγία η οποία προβλέπει πολιτικές μείωσης της κατανάλωσης σακούλας ως το 2019.
- **Καμία απαγόρευση:** Δεν εφαρμόζεται κανένα μέτρο για την πλαστική σακούλα.

VI. Κόστος εφαρμογής του προγράμματος περιβαλλοντικής προστασίας. Την ευθύνη της υλοποίησης των πολιτικών προστασίας του θαλάσσιου/παράκτιου περιβάλλοντος θα την έχει η Τοπική Αυτοδιοίκηση (Δήμος Σύρου-Ερμούπολης). Για να μπορέσει ωστόσο ο Δήμος να καλύψει το κόστος των μέτρων/προγραμμάτων απαιτούνται χρήματα που θα επιβαρύνουν τα δημοτικά τέλη που πληρώνετε ανά δόμηνο στη ΔΕΗ.

Στη συνέχεια θα σας δείξουμε 4 καρτέλες. Σε κάθε καρτέλα θα υπάρχουν 3 διαφορετικά σενάρια τα οποία θα διαφέρουν ως προς τα χαρακτηριστικά που μόλις σας περιγράψαμε και από τα οποία θα κληθείτε να διαλέξετε αυτό που κάθε φορά θεωρείτε καλύτερο. Θα θέλαμε να σας επισημάνουμε ότι σ' όλες τις περιπτώσεις, η τρίτη εναλλακτική δεν θα σας επιβαρύνει περαιτέρω οικονομικά αλλά σύμφωνα μ' αυτή δε θα προκύψουν τα απαραίτητα έσοδα για τη χρηματοδότηση κάποιου νέου προγράμματος προστασίας των παράκτιου περιβάλλοντος της Σύρου. Παρακαλείστε να σημειώσετε σε κάθε έναν από τους παρακάτω πίνακες την επιλογή που προτιμάτε, λαμβάνοντας υπόψη ότι το κόστος προστασίας θα επιβαρύνει το οικογενειακό σας εισόδημα. Τονίζεται ότι κάθε κάρτα επιλογής είναι ανεξάρτητη από τις προηγούμενες και ότι δεν υπάρχουν σωστές απαντήσεις, καθώς σκοπός της έρευνας είναι να καταγράψουμε τις ατομικές σας προτιμήσεις.

ΕΔΩ ΚΑΤΑΓΡΑΦΟΝΤΑΙ ΟΙ ΑΠΑΝΤΗΣΕΙΣ:

	Επιλογή Α	Επιλογή Β	

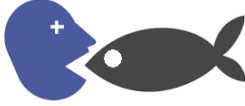
Annexes

			Επιλογή Γ (Status quo)
1 ^η Κάρτα επιλογής			
2 ^η Κάρτα επιλογής			
3 ^η Κάρτα επιλογής			
4 ^η Κάρτα επιλογής			

1^η κάρτα επιλογής

	Επιλογή Α	Επιλογή Β	Αναμενόμενη μελλοντική κατάσταση χωρίς επιπλέον μέτρα προστασίας
Αναψυχή	Καμία ενόχληση 	Μικρή ενόχληση 	Μεγάλη ενόχληση 
Τοπίο	Σημαντική Υποβάθμιση 	Καμία Υποβάθμιση 	Σημαντική Υποβάθμιση 
Βιοποικιλότητα	Μικρός κίνδυνος	Μεγάλος κίνδυνος	Μεγάλος κίνδυνος

Annexes

			
Αλιεία	Μικρός κίνδυνος 	Μεγάλος κίνδυνος 	Μεγάλος κίνδυνος 
Απαγόρευση πλαστικής σακούλας	Καμία απαγόρευση 	Μερική απαγόρευση 	Καμία απαγόρευση 
Αύξηση δημοτικών εισφορών ανά νοικοκυριό	15€ 	3€ 	0 € 
Επιλογή	☐	☐	☐

2^η κάρτα επιλογής

	Επιλογή Α	Επιλογή Β	Αναμενόμενη μελλοντική κατάσταση χωρίς επιπλέον μέτρα προστασίας

Annexes

Αναψυχή	Μεγάλη ενόχληση 	Καμία ενόχληση 	Μεγάλη ενόχληση 
Τοπίο	Καμία Υποβάθμιση 	Σημαντική Υποβάθμιση 	Σημαντική Υποβάθμιση 
Βιοποικιλότητα	Μικρός κίνδυνος 	Μεγάλος κίνδυνος 	Μεγάλος κίνδυνος 
Αλιεία	Μικρός κίνδυνος 	Μεγάλος κίνδυνος 	Μεγάλος κίνδυνος 
Απαγόρευση πλαστικής σακούλας	Καθολική απαγόρευση 	Καμία απαγόρευση 	Καμία απαγόρευση 
Αύξηση δημοτικών εισφορών ανά νοικοκυριό	10€ 	15€ 	0 € 

Annexes

Επιλογή	☐	☐	☐

3^η κάρτα επιλογής

	Επιλογή Α	Επιλογή Β	Αναμενόμενη μελλοντική κατάσταση χωρίς επιπλέον μέτρα προστασίας
Αναψυχή	Μικρή ενόχληση 	Μεγάλη ενόχληση 	Μεγάλη ενόχληση 
Τοπίο	Σημαντική Υποβάθμιση 	Καμία Υποβάθμιση 	Σημαντική Υποβάθμιση 
Βιοποικιλότητα	Μικρός κίνδυνος 	Μεγάλος κίνδυνος 	Μεγάλος κίνδυνος 
Αλιεία	Μεγάλος κίνδυνος	Μικρός κίνδυνος 	Μεγάλος κίνδυνος 

Annexes

			
Απαγόρευση πλαστικής σακούλας	Καθολική απαγόρευση 	Καμία απαγόρευση 	Καμία απαγόρευση 
Αύξηση δημοτικών εισφορών ανά νοικοκυριό	3€ 	6€ 	0 € 
Επιλογή	☐	☐	☐

4^η κάρτα επιλογής

	Επιλογή Α	Επιλογή Β	Αναμενόμενη μελλοντική κατάσταση χωρίς επιπλέον μέτρα προστασίας
Αναψυχή	Καμία ενόχληση 	Μικρή ενόχληση 	Μεγάλη ενόχληση 

Annexes

Τοπίο	Καμία Υποβάθμιση 	Σημαντική Υποβάθμιση 	Σημαντική Υποβάθμιση 
Βιοποικιλότητα	Μικρός κίνδυνος 	Μεγάλος κίνδυνος 	Μεγάλος κίνδυνος 
Αλιεία	Μεγάλος κίνδυνος 	Μικρός κίνδυνος 	Μεγάλος κίνδυνος 
Απαγόρευση πλαστικής σακούλας	Καμία απαγόρευση 	Μερική απαγόρευση 	Καμία απαγόρευση 
Αύξηση δημοτικών εισφορών ανά νοικοκυριό	6€ 	10€ 	0 € 
Επιλογή	☐	☐	☐

Γ. Κατανόηση των προτεινόμενων σεναρίων – Κριτήρια επιλογής

1. Σε μια κλίμακα από το 1 ως το 5, όπου 1= καθόλου σίγουρος και 5=απόλυτα σίγουρος πόσο σίγουροι είστε για τις επιλογές που κάνετε στις παραπάνω κάρτες επιλογές: ____
2. Αν επιλέξατε την διατήρηση της υφιστάμενης κατάστασης (3^η στήλη) σε όλες τις καρτέλες για ποιο λόγο το κάνετε;
 - α. Το εισόδημά μου είναι περιορισμένο
 - β. Δεν θεωρώ τον εαυτό μου υπεύθυνο για την περιβαλλοντική υποβάθμιση
 - γ. Πιστεύω ότι η συνετή ατομική χρήση πλαστικού αρκεί για την καταπολέμηση
 - δ. Δεν θεωρώ σημαντικό το πρόβλημα της ρύπανσης του θαλάσσιου περιβάλλοντος από τα πλαστικά απορρίμματα.
 - ε. Πρέπει να επιβαρυνθεί ο Δήμος ή η Περιφέρεια το κόστος αυτό
 - στ. Θεωρώ ότι τα χρήματα δεν θα χρησιμοποιηθούν για το σκοπό αυτό
 - η. Δεν πιστεύω ότι ένα νέο πρόγραμμα μπορεί να βοηθήσει πιο αποτελεσματικά στην προστασία του θαλάσσιου/παράκτιου περιβάλλοντος
 - ζ. Δεν μπορούσα να καταλάβω τα υπόλοιπα σενάρια/δύσκολο να επιλέξω
 - η. Άλλος λόγος: _____

3. Κατά την επιλογή σας, πόσο σημαντικά ήταν τα παρακάτω κριτήρια για σας:

	Καθόλου σημαντικά ← → Πολύ σημαντικά				
	1	2	3	4	5
Ποιότητα ακτών και νερών κολύμβησης					
Αλλοίωση του τοπίου					
Κίνδυνος στη βιοποικιλότητα					
Κίνδυνος στα αλιεύματα					
Μη απαγόρευση της σακούλας					

Επιβάρυνση στο εισόδημά μου					

4. Πώς θα επηρεάσει την καθημερινότητά σας μια ενδεχόμενη κατάργηση της χρήσης πλαστικής σακούλας στα εμπορικά καταστήματα;

α. Καθόλου, καθώς χρησιμοποιώ ήδη εναλλακτικά μέσα (χάρτινη σακούλα, ψάθινη σακούλα, καρότσι, δίχτυ, καλάθι).

β. Αρκετά, διότι το έχω συνηθίσει ως μέσο μεταφοράς.

γ. Πολύ, διότι θεωρώ ότι η πλαστική σακούλα διευκολύνει την καθημερινότητά μου, όχι μόνο στα ψώνια αλλά και σε άλλες χρήσεις (αποθήκευση τροφίμων, επαναχρησιμοποίηση για μεταφορά ειδών, συγκέντρωση απορριμμάτων, κτλ.).

Δ. Προσωπικές πληροφορίες

1. Φύλο του ερωτώμενου: Άνδρας ☐ Γυναίκα ☐

2. Ηλικία του ερωτώμενου (έτος γέννησης): _____

3. Διεύθυνση μόνιμης κατοικίας: _____

4. Η κατοικία σας έχει θέα στη θάλασσα; Ναι ☐ Όχι ☐

5. Μορφωτικό επίπεδο του ερωτώμενου:

α. Απόφοιτος Δημοτικού

β. Απόφοιτος Γυμνασίου

γ. Απόφοιτος Λυκείου

δ. Ανώτερη/Ανώτατη Εκπαίδευση

ε. Μεταπτυχιακός/Διδακτορικός τίτλος

6. Επάγγελμα του ερωτώμενου:

α. Ιδιωτικός Υπάλληλος	β. Δημόσιος Υπάλληλος
γ. Ελεύθερος Επαγγελματίας	δ. Συνταξιούχος
ε. Άνεργος	στ. Οικοκυρικά
η. Άλλο (διευκρινίστε): _____	

7. Αριθμός μελών νοικοκυριού: _____

8. Αριθμός μελών κάτω 18 ετών: _____

9. Ετήσιο οικογενειακό εισόδημα του ερωτώμενου:

α. Έως 5.000€	ε. 20.000€ - 25.000€
β. 5.000€ - 10.000€	στ. 25.000€ - 30.000€
γ. 10.000€ - 15.000€	η. Πάνω από 30.000€
δ. 15.000€ - 20.000€	

10. Θα είχατε την πρόθεση να ξανασυμμετέχετε σε παρόμοια έρευνα έπειτα από ένα έτος (5/2017); Αν ναι, θα μπορούσατε να μας δώσετε τον αριθμό επικοινωνίας σας;

II. Questionnaire distributed in the stakeholders (hotel and room rental facilities owners) of Syros Island (in Greek)



LIFE DEBAG

Ολοκληρωμένη εκστρατεία ενημέρωσης και ευαισθητοποίησης για τη μείωση της πλαστικής σακούλας στο θαλάσσιο περιβάλλον

(LIFE14 GIE/GR/001127)

Έρευνα αποτίμησης του οφέλους των ξενοδοχείων και ενοικιαζόμενων δωματίων από την λήψη διαχειριστικών μέτρων προστασίας του παράκτιου περιβάλλοντος αναφορικά με τα πλαστικά απορρίμματα

Το παρόν ερωτηματολόγιο γίνεται στο πλαίσιο του έργου LIFE DEBAG το οποίο έχει ως κεντρικό άξονα την προστασία του παράκτιου και θαλάσσιου περιβάλλοντος της Σύρου. Η παρούσα έρευνα αφορά αποκλειστικά τους ιδιοκτήτες ξενοδοχείων και τουριστικών καταλυμάτων της Σύρου. Σκοπός της έρευνας είναι να διερευνήσουμε τα πιθανά οφέλη της επιχείρησής σας από τη λήψη μέτρων προστασίας του παράκτιου και θαλάσσιου περιβάλλοντος από τα πλαστικά απορρίμματα. Οι απαντήσεις είναι εμπιστευτικές και θα χρησιμοποιηθούν αποκλειστικά για ερευνητικούς σκοπούς.

A. Ερωτήσεις αξιολόγησης του προβλήματος των πλαστικών απορριμμάτων στον παράκτιο χώρο.

1. Σε μια κλίμακα από το 1 ως το 5, όπου 1=καθόλου σημαντικός και 5=εξαιρετικά σημαντικός, πόσο σημαντικούς θεωρείτε για τον κλάδο του τουρισμού και για την επιχείρησή σας τους παρακάτω περιβαλλοντικούς κινδύνους;

- ☐ Κίνδυνοι που προκύπτουν από την κεντρική διαχείριση στερεών απορριμμάτων (πλαστικού, γυαλιού, κτλ.) - λειτουργία ΧΥΤΑ - Ανακύκλωσης.
- ☐ Χρήση σκαφών και μηχανοκίνητων σπορ (jet ski, water ski, κτλ.) στη θάλασσα – ρύπανση των υδάτων.
- ☐ Υπερβολική χρήση πλαστικού στις καθημερινές ανθρώπινες δραστηριότητες, μεγάλες ποσότητες του οποίου καταλήγουν στις ακτές και τη θάλασσα.

- ☐ Υπερβολική αλίευση.
- ☐ Κλιματική αλλαγή και άνοδος της στάθμης της θάλασσας.

2. Σε μια κλίμακα από το 1 ως το 5, όπου 1=καθόλου σημαντική και 5=εξαιρετικά σημαντική, πόσο σημαντικούς θεωρείτε για τον κλάδο του τουρισμού και την επιχείρησή σας τους παρακάτω στόχους διαχείρισης για την παράκτια/θαλάσσια περιοχή της Σύρου;

- ☐ Προστασία της βιοποικιλότητας και των σπάνιων ειδών (ζώων ή φυτών) του παράκτιου χώρου
- ☐ Προστασία των ειδών που αποτελούν μέρος της τροφικής αλυσίδας του ανθρώπου (ψάρια, οστρακοειδή, κτλ.)
- ☐ Προστασία της αισθητικής και της καθαριότητας των ακτών και των θαλασσών.
- ☐ Λήψη κατάλληλων περιβαλλοντικών μέτρων που δεν θα περιορίζουν την ανθρώπινη δραστηριότητα στον παράκτιο χώρο και δεν θα έχουν επιπτώσεις στην τοπική ανάπτυξη
- ☐ Αυξημένη περιβαλλοντική ενημέρωση και περιβαλλοντική εκπαίδευση των κατοίκων της Σύρου
- ☐ Αυξημένη περιβαλλοντική ενημέρωση και οδηγίες καλών (περιβαλλοντικών) πρακτικών για τους τουρίστες της Σύρου

3. Γνωρίζετε ότι το πλαστικό και ειδικότερα οι πλαστικές σακούλες έχουν αρνητικές επιπτώσεις στο περιβάλλον και ιδιαίτερα τα θαλάσσια οικοσυστήματα;

α. Ναι, το γνωρίζω πολύ καλά β. Κάτι έχω ακούσει γ. Δεν το γνωρίζω

4. Γνωρίζετε ότι η Ε.Ε., βάσει της Οδηγίας 720/2015, επιδιώκει την εφαρμογή πολιτικών αντιμετώπισης της υπερβολικής χρήσης πλαστικής σακούλας;

α. Ναι, το γνωρίζω πολύ καλά β. Κάτι έχω ακούσει γ. Δεν το γνωρίζω

5. Σε μια κλίμακα από το 1 ως το 5, όπου 1=καθόλου πιθανό και 5=εξαιρετικά πιθανό, πόσο πιθανό θεωρείτε τα παρακάτω χαρακτηριστικά να επιδρούν στις επιλογές που κάνουν οι τουρίστες ως προς τις παραλίες που θα επισκεφθούν;

- ☐ Η παραλία διαθέτει όλες τις απαραίτητες οργανωμένες υποδομές (ομπρέλες, ξαπλώστρες, καντίνες, WC)
- ☐ Η παραλία είναι καθαρή από πλαστικά και άλλα στερεά απορρίμματα
- ☐ Η παραλία διαθέτει μεγάλη ποικιλία από προσφερόμενα θαλάσσια σπορ
- ☐ Η ακτή διαθέτει γαλάζια σημαία και έχει εξαιρετική ποιότητα νερών κολύμβησης
- ☐ Η παραλία διαθέτει δωρεάν υποδομές (WC, ντουζιέρες)
- ☐ Η παραλία είναι κοσμοπολίτικη
- ☐ Η παραλία είναι ήσυχη χωρίς πολλούς τουρίστες
- ☐ Η παραλία βρίσκεται σε κοντινή απόσταση από το κατάλυμα διαμονής τους
- ☐ Άλλος

λόγος:

B. Ερωτήσεις περιβαλλοντικών πρακτικών που εφαρμόζει η επιχείρηση

1. Η επιχείρησή σας πραγματοποιεί/λαμβάνει σήμερα κάποια από τα παρακάτω μέτρα περιβαλλοντικής διαχείρισης;

		ΝΑΙ	ΟΧΙ
1	Μέτρα εξοικονόμησης (ηλεκτρικής) ενέργειας: Αν ΝΑΙ αναφέρετε ενδεικτικά: α. _____ β. _____ γ. _____		
2	Μέτρα για τη μείωση της κατανάλωσης νερού: Αν ΝΑΙ αναφέρετε ενδεικτικά: α. _____ β. _____		

	Υ. _____		
3	Μέτρα ανακύκλωσης ή/και μείωσης των στερεών απορριμμάτων: Αν ΝΑΙ αναφέρετε ενδεικτικά: α. _____ β. _____ γ. _____		
4	Μέτρα καθαρισμού της παραλίας για τη χρήσης της από τους πελάτες του ξενοδοχείου;		
5	Χρηματοδότηση τοπικών οργανώσεων/φορέων/ΜΚΟ που ασχολούνται με την προστασία του παράκτιου & θαλάσσιου περιβάλλοντος;		

2. Σε μια κλίμακα από το 1 ως το 5, όπου 1=καθόλου και 5=πάρα πολύ, εκτιμάτε ότι η εφαρμογή των παρακάτω φιλο-περιβαλλοντικών (πράσινων) δράσεων από τη μονάδα σας ενδέχεται να επηρεάσει (επηρεάζει) θετικά την επιλογή της από τους τουρίστες της Σύρου:

- ☐ Εφαρμογή μέτρων εξοικονόμησης ενέργειας
- ☐ Εφαρμογή μέτρων μείωσης της κατανάλωσης νερού
- ☐ Εφαρμογή μεθόδων ανακύκλωσης και μείωσης της χρήσης πλαστικού
- ☐ Εφαρμογή μέτρων καθαρισμού της γειτονικής παραλίας
- ☐ Παροχή περιβαλλοντικής ενημέρωσης για ορθές περιβαλλοντικές πρακτικές εκ μέρους των τουριστών

3. Πόσο πιθανό θεωρείτε να εφαρμόσετε στο μέλλον ένα από τα παρακάτω μέτρα:

3.1 Μείωση της υφιστάμενης χρήσης πλαστικού στα μπάνια (πλαστικά σαμπουάν, πλαστικά περιτυλίγματα στα σαπούνια, καπελάκια μπάνιου, οδοντόβουρτσες, κτλ.)

α. Πολύ πιθανό, β. Λίγο πιθανό, γ. Καθόλου πιθανό, δ. Δεν χρησιμοποιούνται αυτά τα προϊόντα στην επιχείρησή μου

Annexes

3.2 Μείωση της υφιστάμενης χρήσης πλαστικού στην κουζίνα (μπουκάλια εμφιαλωμένου νερού, πλαστικά πιάτα, ποτήρια, μαχαιροπίρουνα, κτλ.)

α. Πολύ πιθανό, β. Λίγο πιθανό, γ. Καθόλου πιθανό, δ. Δεν χρησιμοποιούνται αυτά τα προϊόντα στην επιχείρησή μου

3.3 Εφαρμογή συστήματος ανακύκλωσης (διαλογής πλαστικού) στα δωμάτια ή/και τους κοινόχρηστους χώρους

α. Πολύ πιθανό, β. Λίγο πιθανό, γ. Καθόλου πιθανό

3.4 Συνολική μείωση της χρήσης πλαστικής σακούλας σε δωμάτια (π.χ. κάδοι απορριμμάτων) και υπηρεσίες (π.χ. σακούλες ρούχων από το καθαριστήριο)

α. Πολύ πιθανό, β. Λίγο πιθανό, γ. Καθόλου πιθανό δ. Δεν χρησιμοποιούνται αυτά τα προϊόντα στην επιχείρησή μου

3.5 Παροχή ενημερωτικών φυλλαδίων στα δωμάτια ή/και τους κοινόχρηστους χώρους για τις βέλτιστες πρακτικές των πελατών ως προς τα πλαστικά απορρίμματα και τις πλαστικές σακούλες

α. Πολύ πιθανό, β. Λίγο πιθανό, γ. Καθόλου πιθανό

4. Σε μια κλίμακα από το 1 ως το 5, όπου 1=καθόλου και 5=εξαιρετικά, εκτιμάτε ότι θα πληγεί ο κλάδος δραστηριοποίησης της επιχείρησής σας από μια ενδεχόμενη τιμολόγηση της πλαστικής σακούλας;

Καθόλου ← → Εξαιρετικά				
1	2	3	4	5

Γ. Μέθοδος αποτίμησης

Για την μελλοντική προστασία της θάλασσας και των ακτών της Σύρου, εξετάζεται το ενδεχόμενο της εφαρμογής ενός ολοκληρωμένου προγράμματος διαχείρισης των στερεών αποβλήτων και κυρίως των πλαστικών απορριμμάτων το οποίο θα περιλαμβάνει: (α) μέτρα καθαρισμού των ακτών, (β) μέτρα ελέγχου της παράνομης διάθεσης των απορριμμάτων, (γ) πολιτικές ενημέρωσης, ευαισθητοποίησης και παροχής οικονομικών κινήτρων για τον περιορισμό της χρήσης της πλαστικής σακούλας τόσο από τους κατοίκους όσο και από τους τουρίστες του νησιού. Στόχος αυτού του προγράμματος είναι η προστασία της βιοποικιλότητας και του θαλάσσιου/παράκτιου οικοσυστήματος, η προστασία του τοπίου και της αισθητικής των ακτών και η μείωση του κινδύνου υποβάθμισης των τοπικών αλιευμάτων (με επιπτώσεις τόσο στον κλάδο της αλιείας όσο και στην υγεία των ανθρώπων).

Για την εφαρμογή των μέτρων αυτών θα χρειαστούν επιπλέον πόροι. Οι πόροι αυτοί θα μπορούσαν να αντληθούν – μεταξύ άλλων – από χορηγίες των τοπικών επιχειρήσεων στο πλαίσιο της οικειοθελούς συμμετοχής τους σε δράσεις εταιρικής κοινωνικής (περιβαλλοντικής) ευθύνης. Οι δράσεις αυτές ενδέχεται να επηρεάσουν θετικά την εικόνα των επιχειρήσεων που θα συμμετάσχουν.

1. **Στο πλαίσιο αυτού του προγράμματος, θα επιθυμούσατε η επιχείρησή σας να πληρώσει (μέσω χορηγίας) κάποιο ποσό ετησίως έτσι ώστε να συμβάλει στην προστασία του παράκτιου και θαλάσσιου περιβάλλοντος της Σύρου;**

ΝΑΙ ____

ΟΧΙ ____

2. **Αν ναι**, ποιο θα ήταν το μέγιστο ποσό που θα ήσασταν διατεθειμένος να πληρώσετε το χρόνο μέσω χορηγίας για το σκοπό αυτό;
_____€

3. **Αν όχι**, αιτιολογήστε την απάντησή σας

α. Τα έσοδα της επιχείρησης είναι περιορισμένα και δεν είμαι σε θέση να πληρώσω

- β. Δεν θεωρώ σημαντικό το πρόβλημα της ρύπανσης του θαλάσσιου περιβάλλοντος από τα πλαστικά απορρίμματα.
- γ. Δεν πιστεύω ότι ένα νέο πρόγραμμα μπορεί να βοηθήσει πιο αποτελεσματικά στην προστασία του θαλάσσιου/παράκτιου περιβάλλοντος
- δ. Πρέπει να επιβαρυνθεί ο Δήμος ή η Περιφέρεια το κόστος αυτό
- ε. Θεωρώ ότι τα χρήματα δεν θα χρησιμοποιηθούν για το σκοπό αυτό
- στ. Άλλος λόγος: _____

Δ. Προσωπικές/Εταιρικές πληροφορίες

1. Επωνυμία της επιχείρησης: _____

2. Διεύθυνση έδρας της
επιχείρησης: _____

3. Αναφέρετε το είδος (ξενοδοχείο/ ενοικιαζόμενα δωμάτια) και την κατηγορία κατάταξης (αστέρια) της επιχείρησής σας

4. Αναφέρετε τον αριθμό δωματίων και κλινών της επιχείρησής σας

5. Αριθμός εργαζομένων στην επιχείρηση: _____

6. Μέση πληρότητα της μονάδας σας κατά την τουριστική περίοδο (%):

2014 _____ %

2015 _____ %

2016 _____ %

Annexes

7. Φύλο του ερωτώμενου: Άνδρας ☐ Γυναίκα ☐

8. Ηλικία του ερωτώμενου (έτος γέννησης): _____

9. Μορφωτικό επίπεδο του ερωτώμενου:

α. Απόφοιτος Δημοτικού

β. Απόφοιτος Γυμνασίου

γ. Απόφοιτος Λυκείου

δ. Ανώτερη/Ανώτατη Εκπαίδευση

ε. Μεταπτυχιακός/Διδακτορικός τίτλος

10. Θα είχατε την πρόθεση να ξανασυμμετέχετε σε παρόμοια έρευνα; Αν ναι, θα μπορούσατε να μας δώσετε τον αριθμό επικοινωνίας σας;

III. Web-Based Questionnaire distributed in Greece (in Greek)

<https://goo.gl/forms/khOzAPaz1x4t0Qln2>

Απόψεις και Εκτιμήσεις των Πολιτών σχετικά με τις Πλαστικές Σακούλες Μεταφοράς Προϊόντων

Αγαπητοί Συμμετέχοντες,

Η παρούσα έρευνα διενεργείται στο πλαίσιο του Ευρωπαϊκού Έργου LIFE DEBAG (LIFE14 GIE/GR/001127), το οποίο στοχεύει στην ανάπτυξη και εφαρμογή μιας ολοκληρωμένης εκστρατείας ενημέρωσης και ευαισθητοποίησης για την πρόληψη και μείωση της ρύπανσης που προκαλούν οι πλαστικές σακούλες στο θαλάσσιο περιβάλλον.

Μας ενδιαφέρει να καταγράψουμε τις απόψεις και εκτιμήσεις σας σχετικά με τη χρήση της λεπτής πλαστικής σακούλας μεταφοράς προϊόντων («μιας χρήσης») κατά την διάρκεια του 2017.

Για τη συμπλήρωση του ερωτηματολογίου απαιτούνται περίπου 2 λεπτά. Η συμμετοχή στην έρευνα είναι εθελοντική, τα δεδομένα που συλλέγονται ανώνυμα και οι απαντήσεις σας θα χρησιμοποιηθούν αποκλειστικά για τους σκοπούς της έρευνας του Ευρωπαϊκού προγράμματος LIFE DEBAG.

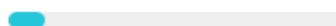
Ευχαριστούμε πολύ για τη συμμετοχή και το χρόνο σας!



With the contribution of the LIFE financial instrument of the European Community



ΕΠΟΜΕΝΟ



Σελίδα 1 από 9

1. Γνωρίζετε ότι οι πλαστικές σακούλες έχουν αρνητικές επιπτώσεις στο περιβάλλον και ιδιαίτερα στη θαλάσσια ζωή και στα θαλάσσια οικοσυστήματα; *

(Επιλέξτε μία μόνο απάντηση)

- ☐ Ναι το γνωρίζω πολύ καλά
- ☐ Κάτι έχω ακούσει
- ☐ Δεν το γνωρίζω

2. Γνωρίζετε ότι η Ε.Ε., με στόχο την αντιμετώπιση των σημαντικών επιπτώσεων των πλαστικών σακουλών στα θαλάσσια οικοσυστήματα, επιδιώκει την εφαρμογή πολιτικών δραστηκής μείωσης της χρήσης τους; *

(Επιλέξτε μία μόνο απάντηση)

- ☐ Ναι το γνωρίζω πολύ καλά
- ☐ Κάτι έχω ακούσει
- ☐ Δεν το γνωρίζω

3. Γνωρίζετε ότι το κόστος των πλαστικών σακουλών στα καταστήματα μέχρι σήμερα, ενσωματώνεται στις τιμές των προϊόντων που αγοράζουμε ως καταναλωτές; *

(Επιλέξτε μία μόνο απάντηση)

- ☐ Ναι το γνωρίζω πολύ καλά
- ☐ Κάτι έχω ακούσει
- ☐ Δεν το γνωρίζω

4. Σούπερ μάρκετ (για αγορά κάθε είδους προϊόντων) *

	0	1	2	3	4	5	6	7	8
Πόσες λεπτές πλαστικές σακούλες μεταφοράς παίρνει, κατά μέσο όρο, κάποιο μέλος της οικογένειάς σας σε κάθε επίσκεψη;	☐	☐	☐	☐	☐	☐	☐	☐	☐
Πόσες φορές, κατά μέσο όρο την εβδομάδα, πηγαίνουν συνολικά τα μέλη της οικογένειάς σας για ψώνια;	☐	☐	☐	☐	☐	☐	☐	☐	☐

5. Λαϊκή αγορά / μανάβικο (για αγορά κυρίως φρούτων και λαχανικών) *

	0	1	2	3	4	5	6-10	11-15	16 και πάνω
Πόσες λεπτές πλαστικές σακούλες μεταφοράς παίρνει, κατά μέσο όρο, κάποιο μέλος της οικογένειάς σας; (Εάν δεν πηγαίνετε σε λαϊκές αγορές ή μανάβικα επιλέξτε το «0»)	☐	☐	☐	☐	☐	☐	☐	☐	☐
Πόσες φορές την εβδομάδα, κατά μέσο όρο, πηγαίνουν συνολικά τα μέλη της οικογένειάς σας; (Εάν δεν πηγαίνετε σε λαϊκές αγορές ή μανάβικα επιλέξτε το «0»)	☐	☐	☐	☐	☐	☐	☐	☐	☐

6. Καθημερινά ψώνια (για αγορά καθημερινών προϊόντων όπως ψωμί, γάλα, τυριά κ.α.) *

	0	1	2	3	4	5	6	7 και πάνω
Πόσες λεπτές πλαστικές σακούλες μεταφοράς παίρνει, κατά μέσο όρο ημερησίως, κάποιο μέλος της οικογένειάς σας (για ψωμί, γάλα, τυριά κ.α.);	☐	☐	☐	☐	☐	☐	☐	☐
Πόσες φορές την εβδομάδα, κατά μέσο όρο, κάνουν τα μέλη της οικογένειάς σας συνολικά, καθημερινά ψώνια;	☐	☐	☐	☐	☐	☐	☐	☐

7. Λοιπές αγορές (για αγορά ειδών ρουχισμού, οικιακών ειδών, ηλεκτρικών συσκευών κ.α.) *

	0	1	2	3	4	5	6-10	11-15	16 ή πάνω
Πόσες λεπτές πλαστικές σακούλες μεταφοράς παίρνει, κατά μέσο όρο το μήνα σε μία έξοδο αγοράς, κάποιο μέλος της οικογένειάς σας ;	☐	☐	☐	☐	☐	☐	☐	☐	☐
Πόσες φορές συνολικά το μήνα, κατά μέσο όρο, τα μέλη της οικογένειάς σας πραγματοποιούν λοιπές αγορές;	☐	☐	☐	☐	☐	☐	☐	☐	☐

Σελίδα 4 από 9

ΠΙΣΩ

ΕΠΩΜΕΝΟ

8. Εφόσον θα επιβάλλεται πλέον από 1η Ιανουαρίου 2018 περιβαλλοντικό τέλος 3.72 λεπτά του ευρώ (με Φ.Π.Α.) ανά πλαστική σακούλα και από 1η Ιανουαρίου 2019 το τέλος γίνεται 8.68 λεπτά του ευρώ (με Φ.Π.Α.), ποια είναι η πιο πιθανή επίπτωση που νομίζετε ότι θα έχει αυτό στην συμπεριφορά σας;

*

(Επιλέξτε μία μόνο απάντηση)

- ☐ Θα συνεχίζω να χρησιμοποιώ τον ίδιο αριθμό πλαστικών σακουλών και ως πληρώνω το σχετικό αντίτιμο ανά πλαστική σακούλα.
- ☐ Θα προσπαθήσω να μειώσω τον αριθμό των πλαστικών σακουλών που χρησιμοποιώ (τοποθετώντας περισσότερα προϊόντα στις πλαστικές σακούλες) δεδομένου του χρηματικού αντιτίμου που έχει επιβληθεί.
- ☐ Θα χρησιμοποιήσω/αγοράσω εναλλακτικό μέσο μεταφοράς προϊόντων (π.χ. καρότσι, υφασμάτινη τσάντα, άλλη τσάντα πολλών χρήσεων, δίχτυ, κτλ).

9. Συμφωνείτε να επιβληθεί το περιβαλλοντικό τέλος και σε περίπτερα και υπαίθριο εμπόριο (λαϊκές αγορές κτλ.), τα οποία εξαιρούνται της εφαρμογής του; *

(Επιλέξτε μία μόνο απάντηση)

- ☐ Ναι, συμφωνώ να επιβληθεί το περιβαλλοντικό τέλος και σε περίπτερα και υπαίθριο εμπόριο (λαϊκές αγορές κτλ.).
- ☐ Όχι, δεν συμφωνώ να επιβληθεί το περιβαλλοντικό τέλος και σε περίπτερα και υπαίθριο εμπόριο (λαϊκές αγορές κτλ.).

10. Επιθυμείτε να καταργηθεί στο μέλλον η χρήση πλαστικής σακούλας στα εμπορικά καταστήματα ; *

(Επιλέξτε μία μόνο απάντηση)

- ☐ Ναι, επιθυμώ στο μέλλον να καταργηθεί η χρήση πλαστικής σακούλας στα εμπορικά καταστήματα.
- ☐ Όχι, δεν επιθυμώ στο μέλλον να καταργηθεί η χρήση πλαστικής σακούλας στα εμπορικά καταστήματα.

Φύλο *

- ☐ ΑΝΤΡΑΣ
- ☐ ΓΥΝΑΙΚΑ

Ηλικία *

- ☐ <18
- ☐ 18-30
- ☐ 31-40
- ☐ 41-50
- ☐ 51-65
- ☐ >65

Περιοχή κατοικίας *

(Επιλέξτε την Περιφέρειά σας)

Επιλογή



Σελίδα 7 από 9

ΠΙΣΩ

ΕΠΟΜΕΝΟ

Δήμος κατοικίας

(Συμπληρώστε τον Δήμο σας)

Η απάντησή σας

Μορφωτικό επίπεδο του ερωτώμενου/ης *

- ☐ Απόφοιτος Δημοτικού
- ☐ Απόφοιτος Γυμνασίου
- ☐ Απόφοιτος Λυκείου
- ☐ Ανώτερη/Ανώτατη Εκπαίδευση
- ☐ Μεταπτυχιακός/Διδακτορικός τίτλος

Ετήσιο οικογενειακό εισόδημα του ερωτώμενου/ης: *

- ☐ Έως 5.000€
- ☐ 5.000€ - 10.000€
- ☐ 10.000€ - 15.000€
- ☐ 15.000€ - 20.000€
- ☐ 20.000€ - 25.000€
- ☐ 25.000€ - 30.000€
- ☐ Πάνω από 30.000€

Σελίδα 8 από 9

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[ΕΠΟΜΕΝΟ](#)

Απόψεις και Εκτιμήσεις των Πολιτών σχετικά με τις Πλαστικές Σακούλες Μεταφοράς Προϊόντων

