VRIJE UNIVERSITEIT BRUSSEL

SOCIAL AND ECOLOGICAL SYSTEMS DYNAMICS OF THE GALAPAGOS ISLANDS:

Participatory methodological approaches to support sustainability, conservation science and management.

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SOCIAL AND ECOLOGICAL SYSTEMS DYNAMICS OF THE GALAPAGOS ISLANDS:

Participatory methodological approaches to support sustainability,

conservation science and management.

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by

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Cover picture from Francisco Benitez Capistros © - Galapagos giant tortoise (*Chelonoidis nigrita)* foraging together with cows in the highlands of a farm in Santa Cruz Island, Galapagos, Ecuador.

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Pour vous et grâce à vous, mam, pap et Ric

“They circle; now dense like a polished roof; now disseminated like a mesh of some vast all-heaven-sweeping net…. wheeling, rending, tearing, darting, crossing, and piercing one another – a madness in the sky”

- Edmund Selous on starlings, biologist, 1905 -

"Today this ‘madness’ is understood in individual birds using standard sense of sight, sound, pressure and odour to respond to their nearest neighbours, forming a network of nonlinear interactions where information can pass from one another to permit adaptive collective responses to what is going on in the environment.

The world is complex, and now science shows us that so too should be our representations of it…. if we want to make sense of the complexity that we find in nature"

- Sandra D. Mitchell, philosopher of science and historian of ideas, 2009-

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SUMMARY (EN)

Sustainability and biodiversity conservation aim at the protection and maintenance of natural ecosystems. Although both are inherently related concepts, practical differences in their conceptualization and implementation carry the risk of discrepancies between conservation and sustainability objectives. This is related to the multi-dimensional understanding of the sustainability concept and the bio-centric approaches to conservation that have tended to disconnect human systems instead of considering these as an integral part of natural systems. Overcoming these challenges requires the understanding of the linkages between the social and ecological systems. However, these linkages are complex and interact at different interconnected levels from social to ecological and government processes which are at the same time interacting at several scales, ranging from local to global. Understanding these linkages requires the exchange and generation of cohesive and actionable knowledge that is relevant across scientific disciplines, as well as for society, so that practical solutions contribute to the transition towards sustainability and biodiversity conservation. Consequently, inter and transdisciplinary approaches are required to yield and aggregate knowledge, in particular to bridge the gap between the often-disconnected insights generated by natural and social sciences.

I therefore consider it adequate to have a transdisciplinary approach to study biodiversity conservation and the sustainability of social ecological systems. This thesis builds on three empirical case studies to study conservation and sustainability challenges on the Galapagos Islands. In doing so, I used three different participatory methodologies (Delphi-Q-PRA) that either synthesised and/or generated knowledge from a wide variety of Galapagos societal actors. Thus, in **Chapter 3**, we first characterised the general dynamic inter-linkages and causal relationships of the Galapagos social-ecological system that generates environmental impacts and the responses in the form of policy and management actions that are required to mitigate these impacts.

In **Chapter 4** we subsequently focused on exploring conservation discourses to explain a range of conservation issues by identifying conflicts, values, and relations of power and how

these discourses are related to different conservation governance approaches and conflicts with other species. In **Chapter 5**, we characterise a practical and emergent conservation conflict between giant tortoises (*Chelonoidis* spp.) and farmers in the rural area of Santa Cruz Island. In this chapter we assess the relationship of several social and ecological inter-linked variables and how these can be used to improve conservation and sustainability strategies.

In the general discussion in **Chapter 6**, I provide an analysis of the different insights of this work by explaining the usefulness of transdisciplinary and participatory processes to co-create knowledge, to delineate the specific system problems and to further find novel solutions to aid policy and decision makers in the transitions towards sustainability and biodiversity conservation. Furthermore, I include a thorough analysis and cross-comparison of the results between the used methodologies, and how transfer of knowledge was achieved through transdisciplinarity and participation. Lastly, I provide an analysis of the insights of this work and how they can be used in other contexts and to operationalize other international conservation and sustainability policy frameworks. In **Chapter 7**, I provide a series of conclusions that refer to: i) the relevance of consensus building to integrate knowledge in complex conservation settings and where conflicts of evidence are common, ii) the importance of discourse analysis to understand the past and current human-nature relationships to address future conservation and sustainability challenges. Similarly, the relevance of discourse analysis in social-ecological systems to capture and expose different relations of power so that specific conservation and sustainability rules are perceived as fair and legitimate by all the actors that are involved in process. iii) The significant use of a transdisciplinary and participatory approach to involve varied stakeholders in conservation issues, to integrate knowledge and to increase interpersonal and inter-institutional trust between stakeholders where conservation conflicts occur.

New scientific approaches that combine local knowledge, science and policies to produce adequate, persisting and sustainable results are urgent to achieve an adequate transition to sustainability and biodiversity conservation as part thereof. This work is a contribution to bridge the gap between different natural and social sciences, methods, science and policies, and scientists and society in general.

SAMENVATTING (NL)

Duurzaamheid en biodiversiteitsbehoud zijn twee concepten die streven naar een betere bescherming van natuurlijke ecosystemen. Ondanks de gelijklopende doelstellingen, zijn er duidelijke verschillen merkbaar in interpretatie en praktische implementatie. Het negeren van die verschillen kan leiden tot risicovolle tegenstellingen en tot het niet-behalen van beoogde beleidsdoelstellingen. Het multi-dimensionele karakter van het duurzaamheidsconcept en de bio-centrische interpretatie van biodiversiteitsbehoud leiden tot een ontkoppeling van menselijke systemen en natuurlijke systemen, en tot een miskenning van het geïntegreerde karakter van sociaal-ecologische systemen. Het begrijpen en analyseren van de links tussen sociale en ecologische variabelen is een complexe taak, aangezien beleidsvariabelen ook een belangrijke spelen. Al deze processen interageren bovendien op verschillende schaalniveaus (van lokaal tot globaal). Het begrijpen van deze links vereist de uitwisseling en creatie van coherente en actie-genererende kennis, die idealiter relevant is voor verschillende disciplines, en voor de maatschappij als geheel. Enkel zo kunnen praktische oplossingen gegenereerd worden die bijdragen aan de maatschappelijke transitie tot duurzaamheid en biodiversiteitsbehoud. Inter- en transdisciplinaire benaderingen zijn dus noodzakelijk om dergelijke kennis te genereren, en om de kloof te overbruggen tussen de vaak ontkoppelde inzichten die voortvloeien uit de natuur- en sociale wetenschappen.

In deze thesis volgen we dus een en transdisciplinaire aanpak om biodiversiteitsbehoud en duurzaamheid te bestuderen in social-ecoligische systemen. Deze thesis focust op drie empirische case studies om biodiversiteitsbehoud en duurzaamheidsuitdagingen te analyseren in de Galapagos eilanden. We gebruikten drie participatieve methodologieën (Delphi, Q, PRA) die hetzij kennis synthetiseerden, hetzij nieuwe kennis genereerden, samen met een brede waaier aan belanghebbenden in de Galapagos eilanden. In **Hoofdstuk 3** beschreven we eerst de dynamische links en de causale verbanden die het sociaal-ecologische systeem op de Galapagos vormgeven, en die zowel milieu-effecten genereren als het kader creëren waarbinnen beleids- en beheers-acties vormgegeven worden die deze effecten kunnen verzachten. Vervolgens focussen we in **Hoofdstuk 4** op het verkennen van verschillende biodiversiteitsbehoud-discours om zo inzicht te verkrijgen in een reeks natuurbehouds-issues. Dit gebeurt via de identificatie van conflicten, waarden, machtsverhoudingen, en via het linken van de geïdentificeerde discours met verschillende governance-benaderingen en conflicten met betrekking tot biodiversiteitsbehoud. In

Hoofdstuk 5 beschrijven we een recent opkomend natuurbehoudsconflict tussen reuzenschildpadden (*Chelonoidis spp*.) en landbouwers op het eiland Santa Cruz. We gaan in de hoofdstuk na hoe de sociale en ecologische variabelen met elkaar interageren en hoe die kennis kan gebruikt worden om biodiversiteitsbehoud- duurzaamheidsstrategieën te ontwikkelen en/of te verbeteren.

In de algemene bespreking in **hoofdstuk 6** analyseer ik de verschillende bevindingen van dit werk door het nut uit te leggen van transdisciplinaire en participatieve processen om samen kennis te creëren, om de specifieke systemische problemen af te bakenen en verder om nieuwe oplossingen te vinden om beleidsmakers te helpen in de overgang naar duurzaamheid en het behoud van biodiversiteit. Verder maak ik ook een diepgaande analyse en vergelijking van de resultaten van de gehanteerde methodologieën, evenals hoe overdracht van kennis bereikt werd door transdisciplinariteit en participatie. Ten slotte geef ik een analyse van de inzichten uit dit werk en hoe die gebruikt kunnen worden in andere contexten evenals om andere internationale beleidslijnen ter bescherming van biodiversiteit en duurzaamheid toe te passen. In **hoofdstuk 7** geef ik een reeks conclusies die refereren aan: i) de relevantie van werken naar consensus om kennis te integreren in complexe situaties m.b.t. biodiversiteitsbehoud en waar conflicten in bewijsvoering vaak voorkomen, ii) het belang van discoursanalyse om vroegere en huidige mens-natuurrelaties te begrijpen om toekomstige uitdagingen in behoud en duurzaamheid aan te pakken. Ook de relevantie van discoursanalyse in socio-ecologische systemen om verschillende machtsrelaties vast te leggen en bloot te leggen opdat specifieke behouds- en duurzaamheidsregels als fair en legitiem worden ervaren door alle actoren betrokken bij het proces. iii) Het significante gebruik van een transdisciplinaire en participatieve aanpak op de uiteenlopende belanghebbenden te betrekken in behoudskwesties, om kennis te integreren en om het interpersoonlijk en interinstitutioneel vertrouwen tussen de belanghebbenden te verhogen waar conflicten over behoud optreden.

Nieuwe wetenschappelijke benaderingen, die lokale kennis, wetenschap en beleid combineren om tot resultaten te komen die de transitie naar duurzaamheid en biodiversiteitsbehoud ondersteunen, zijn noodzakelijk. Dit werk wenst bij te dragen tot het dichten van de kloof tussen natuur- en sociale wetenschappen en methodes, beleid en maatschappij.

RÉSUMÉ (FR)

Les concepts de durabilité (ou développement durable) et de la conservation de la biodiversité visent à la protection des écosystèmes naturels. Bien que les deux concepts soient intrinsèquement liés, les différences pratiques concernant leur conceptualisation et leur mise en ouvre amènent le risque de divergence entre les objectifs de conservation et de la durabilité. Ceci est lié à la compréhension multidimensionnelle du concept de développement durable et aux approches bio-centriques de la conservation, qui ont eu tendance à déconnecter les systèmes humains des systèmes naturels, au lieu de considérer ces premiers comme une partie intégrante des systèmes naturels. Pour surmonter ces défis, il faut comprendre les liens entre les systèmes sociaux et les systèmes écologiques. Cependant, ces liens sont complexes et interagissent à différents niveaux. Simultanément, des processus de gouvernance interagissent à plusieurs à plusieurs échelles (du niveau local au niveau global). La compréhension de ces liens nécessite l'échange et la production de connaissances cohérentes et actionnables; connaissances qui sont idéalement pertinentes dans toutes les disciplines scientifiques, ainsi que pour la société. De cette façon des solutions pratiques, contribuant à la réalisation de la transition vers la durabilité et de la conservation de la biodiversité, peuvent être développées. Par conséquent, des approches inter- et transdisciplinaires sont nécessaires pour produire et combiner les différents types de connaissances, notamment pour combler l'écart entre les connaissances souvent déconnectées générées par les sciences naturelles et sociales. Dans cette thèse, nous adoptons donc une approche inter- et transdisciplinaire afin d'étudier la conservation de la biodiversité et la durabilité des systèmes socio- écologiques. Cette thèse s'appuie sur trois études de cas empiriques effectuées pour étudier les problèmes de conservation et de développement durable dans les îles Galapagos. Ce faisant, nous avons utilisé trois différentes méthodologies participatives (Delphi-Q-PRA) qui synthétisent ou génèrent des connaissances à partir d'une grande variété d'acteurs de la société des Galápagos.

Ainsi, dans le **Chapitre 3**, nous avons d'abord caractérisé les interrelations dynamiques générales et les relations causales du système socio-écologique des Galapagos, qui génère des impacts environnementaux, ainsi que les réponses sous la forme d'action politique et de gestion qui sont nécessaires pour atténuer ces impacts. Dans le **Chapitre 4**, nous avons par la suite exploré des discours de conservation pour expliquer une série de questions de conservation en identifiant les conflits, les valeurs et les relations de pouvoir et la façon dont ces discours sont liés à différentes approches de gouvernance de la conservation et

des conflits de conservation (impliquant d'autres espèces). Dans le **Chapitre 5**, nous caractérisons un conflit pratique et émergent centré sur les tortues géantes (*Chelonoidis* spp.) et les agriculteurs dans la zone rurale de l'île de Santa Cruz. Dans ce chapitre, nous évaluons la relation entre plusieurs variables sociales et écologiques étroitement liées, et nous étudions comment ces variables peuvent être utilisées pour améliorer les stratégies de conservation et de durabilité. Dans la discussion générale du **Chapitre 6**, nous offrons une analyse des différentes perspectives de ce travail en expliquant l'utilité du processus transdisciplinaire et participatif pour co-créer des connaissances, définir les problèmes spécifiques du système et pour trouver de nouvelles solutions afin de pouvoir aider les décideurs politiques dans les transitions vers la durabilité et de la conservation de la biodiversité. Par ailleurs, nous incluons également une analyse approfondie et une comparaison croisée des résultats entre les méthodes utilisées, et comment le transfert de connaissances a été réalisé par la transdisciplinarité et la participation. Enfin, nous offrons une analyse des perspectives de ce travail et comment elles peuvent être utilisées dans d'autres contextes et servir à opérationnaliser d'autres cadres de conservation et de la politique de développement durable internationaux.

Enfin dans le **Chapitre 7**, nous tirons quelques conclusions qui se réfèrent à: i) La pertinence de la recherche pour la formation de consensus pour intégrer les connaissances dans des situations complexes dans les milieux de conservation complexes et où les conflits d'éléments de preuve sont communs. ii) L'importance de l'analyse de discours pour comprendre la relation homme-environnement (présente et passée) afin d'aborder les futurs défis de la conservation et de la durabilité. De même, la pertinence de l'analyse de discours dans les systèmes socio-écologiques pour capturer et exposer les différentes relations de pouvoir. Dans le but que les règles spécifiques pour la conservation et de la durabilité sont perçues comme étant justes et légitimes par tous les acteurs qui sont impliqués dans le processus. iii) L'utilisation significative d'une approche transdisciplinaire et participative pour impliquer divers acteurs dans la caractérisation et la solution des enjeux de la conservation afin de permettre d'intégrer les connaissances et d'augmenter la confiance interpersonnelle et interinstitutionnelle entre les partis. De nouvelles approches scientifiques qui combinent les connaissances locales, la science et les politiques pour produire des résultats appropriées, persistants et durables sont urgents pour atteindre une transition adéquate vers la durabilité et à la conservation de la biodiversité qui en fait partie. Ce travail est une contribution pour combler l'écart entre les différentes sciences naturelles et sociales, les méthodes, la science et les processus politiques, et les scientifiques et la société en général.

RESUMEN (ES)

La sostenibilidad y la conservación de la biodiversidad tienen como objetivo la protección y el mantenimiento de los ecosistemas naturales. Aunque los dos conceptos están intrínsecamente relacionados, diferencias prácticas en su conceptualización e implementación conllevan el riesgo de crear conflictos entre los objetivos de la conservación y la sostenibilidad. Esto está relacionado a la comprensión multidimensional del concepto de la sostenibilidad y a los enfoques bio-céntricos de la conservación que han tendido a desconectar los sistemas humanos de los sistemas naturales, en lugar de considerarlos como una parte integral de ellos. Superar estos desafíos requiere de la comprensión de los vínculos entre los sistemas sociales y ecológicos. Sin embargo, estas relaciones son complejas e interactúan a diferentes niveles interconectados: de social a ecológico y a los procesos de gobernanza, que a la vez, interactúan en varias escalas de local a global. La comprensión de estos vínculos requiere del intercambio y generación de conocimiento coherente y procesable que sea relevante tanto para las variadas disciplinas científicas y la sociedad, para que soluciones prácticas contribuyan a la transición hacia la sostenibilidad y la conservación de la biodiversidad. En consecuencia, se requieren enfoques y transdisciplinarios capaces de producir y agregar conocimiento, y en particular para disminuir la brecha entre los, a menudo desconectados, puntos de vista generados por las ciencias naturales y sociales.

Por lo tanto, considero que es propicio tener un enfoque transdisciplinario para estudiar la conservación de la biodiversidad y la sostenibilidad de los sistemas socio-ecológicos. Esta tesis doctoral se fundamenta en tres estudios de casos empíricos para estudiar los retos de conservación y sostenibilidad en las Islas Galápagos. Para ello, he utilizado tres diferentes metodologías participativas (Delphi-Q-PRA) que sintetizan y/o generaran conocimiento a partir de una amplia variedad actores sociales de Galápagos. Por lo tanto, en el **Capítulo 3**, caracterizamos las dinámicas generales de las interrelaciones y las relaciones causales del sistema socio-ecológico de Galápagos que generan impactos ambientales y las respuestas en forma de acciones políticas y de gestión que se requieren para mitigar estos impactos. A continuación, en el **Capítulo 4** nos concentramos en explorar los discursos de conservación para explicar e identificar una serie de asuntos relacionados a la conservación como conflictos, valores y relaciones de poder; y cómo además, estos discursos están asociados a diferentes enfoques de gobernanza de la conservación y conflictos con otras especies. En el

Capítulo 5, caracterizamos un caso práctico del conflicto de conservación emergente entre las tortugas gigantes (*Chelonoidis* spp.) y los agricultores de la zona rural de la isla de Santa Cruz. En este capítulo, evaluamos la relación entre diversas variables sociales y ecológicas, estrechamente relacionados entre sí, y cómo pueden ser utilizadas para mejorar las estrategias de conservación y sostenibilidad.

En la discusión general en el **Capítulo 6**, proporciono un análisis de los diferentes resultados de este trabajo, explicando la utilidad del proceso transdiciplinario y participativo para co-crear conocimientos, delinear problemas específicos del sistema y para encontrar soluciones novedosas para ayudar a las políticas y tomadores de decisiones para la transición hacia la sostenibilidad y conservación de la biodiversidad. Además, también proporciono un análisis comparativo exhaustivo entre los resultados de las metodologías, y como se puede conseguir la transferencia del conocimiento a través de un acercamiento transdisciplinario y participativo. Por último, proporciono un análisis de los resultados de éste trabajo para su aplicación en otros contextos y su utilidad en otros esquemas políticos internacionales de sostenibilidad y conservación. Por último en el **Capítulo 7**, proporciono una serie de conclusiones que se refieren a: i) la relevancia de la formación de consensos para integrar el conocimiento en entornos complejos de conservación y donde los conflictos de evidencia son comunes, ii) la importancia del análisis de discurso para comprender las relaciones pasadas y actuales entre los humanos y la naturaleza para hacer frente a los futuros retos de la conservación y sostenibilidad. Asimismo, la relevancia del análisis de discurso en los sistemas socio-ecológicos para capturar y exponer las diferentes relaciones de poder para que las reglas específicas de la conservación y la sostenibilidad se perciban como justas y legítimas por todos los actores que intervienen en el proceso. iii) El uso significativo de las metodologías participativas para incluir a varios actores locales en temas de conservación, para integrar conocimiento y para aumentar la confianza interpersonal e interinstitucional entre las partes interesadas, donde se producen conflictos de conservación.

Nuevos enfoques científicos que combinen el conocimiento local, la ciencia y las políticas para producir resultados adecuados, persistentes y sostenibles son urgentes para lograr una transición adecuada hacia sostenibilidad y la conservación de la biodiversidad. Este trabajo es una contribución a reducir la brecha entre las diferentes ciencias naturales y sociales, los métodos, la ciencia y las políticas, y los científicos y la sociedad en general.

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LIST OF ABBREVIATIONS

AIC	Akaike Information Criterion
BC	Biodiversity Conservation
BL	Biodiversity Loss
CBC	Community Based Conservation
CBD	Convention on Biological Diversity
CDF	Charles Darwin Foundation
CI	Conservation International
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
DFED	Driving Forces of Environmental Degradation
DPSIR	Drivers Pressures State Impact Responses
DWQ	Decreased Water Quality
EU	European Union
EI	Environmental Impacts
ES	Ecosystem Services
ESA	Endangered Species Act
EU	European Union
GBA	Galapagos Biosecurity Agency
GGC	Galapagos Governing Council
GGT	Galapagos Giant Tortoises
GIS	Geographic Information System
GMP	Galapagos Management Plan
GMR	Galapagos Marine Reserve
GNP	Galapagos National Park
GPS	Geographic Positioning System
GSL	Galapagos Special Law
HF	Habitat Fragmentation
HRE	Hampreys' Rule of Extraction
IAD	Institutional and Analysis Development framework
ILK	Indigenous Local Knowledge
ICZM	Integrated Coastal Zone Management
INEC	Ecuadorian National Institute of Statistic and Census (Abb. Spanish)
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
ILK	Indigenous Local Knowledge
IS	Introduction of Species
LA	Landscape Alterations
LBR	Loss of Biological Resources
LUC	Land Use Change
MAGAP	Ministry of Agriculture, Farming and Fisheries (Abb. Spanish)
MCDA	Multi-Criteria Decision Analysis
MEA	Millennium Ecosystem Assessment
MIDUVI	Ministry of Urban Development and Livelihood (Abb. Spanish)

MIES	Ministry of Economic and Social Inclusion (Abb. Spanish)
MPA	Marine Protected Areas
NBS	Nature Based Solutions
NGO	Non-Governmental Organisation
PA	Protected Area
PCA	Principal Component Analysis
PE	Pressures on the Environment
PRA	Participatory Rural Appraisal
REFIT	Regulatory Fitness and Performance Programme
R_Ec	Responses to Economic Alternatives
R_EI	Responses to Environmental Impacts
R_PE	Responses to Pressures on the Environment
R_PS	Responses to Population Growth Strategies
R_So	Responses to Social Alternatives
R_TS	Responses to Tourism Growth Strategies
SA	Sustainability Assessment
SARC	Structured Approach to Reduce the Concourse
SD	Sustainable Development
SDG	Sustainable Development Goals
SDST	Social Decision Scheme Theory
SES	Social-ecological System
SI	Sustainability Indicator
SSI	Semi-Structured Interviews
TNC	The Nature Conservancy
UNEP	United Nations Environmental Programme
UNESCO	The United Nations Educational, Scientific and Cultural Organisation
USA	United States of America
WBO	Water Basin Overexploitation
WCS	Wildlife Conservation Society
WWF	World Wide Fund for Nature

GLOSSARY

The following definitions are the concepts as understood and used in this doctoral thesis, unless expressly stated otherwise, as for instance in a review of various views or when referring to a particular context or statement.

Conservation conflicts: situations that occur when two or more parties with strongly held opinions clash over conservation objectives and when one party is perceived to assert its interests at the expense of another

Delphi approach: a method for structuring a group communication process that can facilitate a group's decision-making to deal with complex problems. It consists of an iterative and anonymous survey of experts.

Discourse: is the different ways in which humans integrate different ideas, concepts, and representations that are reproduced and transformed and that evoke particular understandings and may subsequently enable particular types of practices and actions that give meaning to the physical and social realities (Hugé, 2012).

Driving Forces-Pressures-State-Impacts-Responses framework (DPSIR): a framework that improves the understanding of the causal social ecological relationship chain (drivers-pressures-state-impacts-responses) with indicators and appropriate responses to the human activities on the environment (EEA, 2006).

Expert: a person or participant who, by a verifiable mean (particular job position, expertise/knowledge, publications), is known to have information or that has access to information.

Governance: all the processes undertaken by individuals or groups of individuals of formal or informal organisations to manage their affairs over a defined territory.

Iconic species: charismatic species that serve as a symbol or focus point to raise environmental consciousness

Institutional and Analysis Development framework (IAD): a systematic framework to collect policy analysis functions where institutions are viewed as human-made systems within which individual choices take place and which configure the consequences of the respective choices.

Knowledge: any individual or collective form of facts, information and descriptions that are acquired through learning processes.

Participation: any form of interaction between societal actors that allows for expressing opinions about societal decisions in any realm of human and social activities and its interconnections to the ecological system.

Participatory: any process whereby information flows back and forth between different stakeholders or actors.

Participatory rural appraisal (PRA): a methodological approach to emphasise the empowerment of local people to take decisions and act for themselves.

Q methodology: a systematic research method to study peoples' opinions, views and discourses.

Social ecological dynamics: the feedbacks within and between social and ecological systems and their changes.

Social-Ecological Systems (SES): nested, multilevel systems consisting of interacting biophysical and social factors.

Social-Ecological System framework (SESF): a decomposable multitier hierarchy framework that allows the comparison and organisation of many social and ecological variables and their interconnection.

Sustainability assessment: an influential approach for environmental management that has emerged as a process to turn sustainable development into a decision-guiding strategy.

Chapter 1

GENERAL INTRODUCTION

OBJECTIVES AND THESIS OUTLINE

GENERAL INTRODUCTION

Analogical reasoning is any kind of argument, a thought that relies upon analogies. It is an explicit representation of a form of reasoning that cites accepted similarities between two systems to support the conclusion that some further similarity exists (Bartha, 2013). In simple words, the information from one domain can be used to help solve the problem of another domain and vice versa. In my case, although this analogical reasoning can be understood as just a means to an end, I follow Kuhn's approach on the role of paradigmatic analogies over time for shaping the development of scientific research (Kuhn, 2012). This doctorate started with the analogical reasoning about biodiversity conservation (BC) and sustainability. In doing so, I have investigated sustainability and biodiversity conservation and how, although the concepts are inherently related and have similarities and can be considered nested, practical differences in their conceptualisation, interpretation and implementation can affect one another. Sustainability is not understood as a synonym of biodiversity conservation or as mostly coinciding with it. Each of their specificities will be detailed and explained in the following chapters and subchapters. Wherever necessary I will clarify and conceptualise the conservation and sustainability concepts. The premise of this thesis is therefore based on the idea that biodiversity conservation needs to be sustainable and that to achieve sustainability, biodiversity conservation needs to be integrated with any development priorities or intentions so that the best practices to conserve biodiversity can benefit both nature and humans.

1.1. The sustainability concept

Sustainability is a term that is mostly frequently associated with balance, durability and equality and equity among the human and natural systems. It appeared as a derived consequence of the term: "sustainable development". A political term that intends to frame development with ecological boundaries, so that the present and future generations can meet their needs or in other words an *intergenerational equity.* Although the term sustainable development may be traced back to several centuries ago (Waas *et al.*, 2011), the modern political consolidation as a model of development was strengthened and coined in 1987 at the World Commission on Environment and Development (WCED) after the release of '*Our Common Future*[1]' most commonly called the '*Brundtland report'.* This report introduces the problems of development, clearly pointing out the world's problems between developing and developed countries industrialisation processes. '*Our common future*' is the first text that impacts the international policy legislation by voicing the international concern about the world's environmental degradation and this is where its merit is undisputable. *'Our common future'*, had and still has such an impact because of a particular context and political momentum. Sustainable development was in fact a logical extension of arguments within the environmental literature of the 1960s, 1970s and early 1980s.

The concept of sustainable development as articulated in *"Our common future*" is driven by two major influential environmental concerns: First, by the environmental concerns resulting from the 19th century views on how to preserve or conserve natural areas. So, on the one hand the 'preservationists' favouring the preservation of (perceived) pristine natural areas; and on the other hand, the 'conservationists' also favouring the protection of natural areas but for a later human use. Robinson (2004) argues that the importance of this difference is that the spectrum between a utilitarian (conservationist) and a more spiritual approach (preservationist) to environmental concern remains as contested terrain in the sustainability literature and environmental movement. Thus, one's interpretation of the meaning and significance of the concept of sustainable development is coined by one's position on this spectrum (Robinson, 2004). The second influential but different environmental concerns that allowed to articulate the concept of sustainable development in "*Our common future*", emerged in the second half of 20th century. These concerns were centred on pollution, non-renewable resource depletion, and population growth (Carson, 1962; Boulding, 1966; Ehrlich Paul, 1968; Hardin, 1968; Meadows Donella *et al.*, 1972). This set of issues also generated a debate about the relative importance of 'technology' and 'individual human responsibility' as a response to the most important causes of

[1] WCED. 1987. Our common future. Oxford University Press.

environmental degradation. Both issues have been a predominant theme in the population/resources/pollution literature since the early 1970s, and were mostly illustrated by the arguments between Paul Ehrlich (human responsibility) and Barry Commoner (technology).

In this regard, Robinson (2004) argues that although the human responsibility/technology debate is different from the utilitarian (conservationist) and spiritual (preservationist) divides, there are intriguing similarities between the two disagreements. In each case one side focuses more on questions related to values and fundamental changes in individual attitudes towards nature (the sustainability argument) while the other side takes what they believe to be a more pragmatic and collective approach, oriented towards efficiency gains and improvements in technology (sustainable development). Table 1.1. illustrates these connections in two columns (‘technical fix’ and ‘value change’) to oversee how the concept of sustainable development was articulated by drastic changes in behaviour and priorities.

Table 1.1. Forms of environmentalist response

	Technical fix	Value change
Natural area management	Conservation (*utilitarian*)	Preservation (*spiritual*)
Pollution and resources	Technology (*collective policies*)	Lifestyles (*individual values*)
Preferred language	Sustainable development	Sustainability

Adapted from Robinson (2004)

However, the UN Commission on Environment and Development (the Brundtland Commission) focused more on socio-political and distributional issues; in particular on the social and economic conditions in developing countries, and their connection to environmental degradation. Thus, as Robinson (2004) explains, the Brundtland report combined two important radical and reformist elements. The radical element had to do with resolving simultaneously and in a mutually reinforcing way the complex issues of environmental deterioration with the complex issues of human development and poverty. The reformist element had to do with a human-centred nature, to promote more (not less) human development but that was sensitive to environmental concerns. The Brundtland report's interlinked logic was then that:

- If under-development threatens the global environment and human welfare, then more development is required.
- If, however, over-development is equally a threat, then a new form of 'sustainable development' is required. Accordingly the definition of SD as we know it: ' *a development that meets the needs of current generations without compromising the ability of future generation to meet their own needs'* (WCED, 1987)

Certainly from the beginning of the emergence of the SD term, concerns and criticisms have been expressed by many environmentalists and the scientific community in general (Gibson, 1991; Ekins, 1993; Daly *et al.*, 1995; Campbell, 1996; Mebratu, 1998; Lafferty and Meadowcroft, 2000; Redclift, 2005). Most of these concerns and critics about the SD concept relate to three interconnected aspects:

i) *A conceptual vagueness* which is related to the plethora of meanings that the SD concept has for many people and organisations and who have rather emphasised political and philosophical positions to propose definitions (Mebratu, 1998; Morelli, 2013; e.g. Imran *et al.*, 2014). However, the open construction of the SD terminology may profit from what is called a constructive ambiguity. This means that rather than having a definitional rigour imposed, while frustrating from a scientific point of view, this might be appropriate for the messy world of politics and policies, where the lack of definitional precision can represent an important political opportunity (Robinson, 2004).

ii) *The misuse and overuse of the terminology* to promote unsustainable activities by governments and business in what is called 'cosmetic environmentalism' and 'cynical green-washing' (Winfield *et al.*, 2010; Waas *et al.*, 2011)

iii) *The delusions of the terminology*, which can distract us from real problems and potential solutions by focusing on wrong issues. This is related to the primordial biophysical or social concerns that each individual has. Thus, as previously mentioned, the underlying debates on the differences of values between primarily utilitarian focus on human-well-being (anthropocentric) and a more spiritually-oriented focus on the human relation with the natural world (bio-centric) (Robinson, 2004). This latter point is of particular relevance for conservation because the same overlapping views (anthropocentric, bio-centric) also co-exist and shape the position, values, and practice of conservation, as I will detail and explain in section 1.3.

So, the concept of SD and/or sustainability deals with several contradictory ontological and philosophical conceptions, which required to be assessed in order to analyse, if its over-ambitious social and environmental goals are to be met. In particular when we consider the continuous and increasing global trends of biodiversity losses over the past four decades (Butchart *et al.*, 2010); but also the remarkable economic growth of many developing countries in Asia, Latin and South America where however little increase in protected naturals areas is noted (Frank and Schlenker, 2016).

1.2. Reflections on sustainability and biodiversity conservation

Understanding the contribution of the sustainability concept in science is of particular relevance because, as I explained earlier, the intrinsic nature of the SD concept(s) revolve(s) around the interdependence of human systems and natural systems. This means that biodiversity conservation is a derived terminology of SD concept(s). In order to understand and to reflect upon sustainability when dealing with conservation I used the keywords 'sustainable development', 'sustainability', 'biodiversity conservation' and 'conservation biology' in a search query within the ISI Web of Knowledge data base (http://apps.webofknowledge.com) from 1987 to 2015 (last fully available year record) refining the search only to research articles. The results show a steady increase in the count of terms from 1987 to 2015, with a major use of the sustainable development and sustainability terms compared to biodiversity and biological conservation (Figure 1.1). This is most likely related to over-use of the sustainable development and sustainability terms as umbrellas and multidimensional concepts (Nykvist and Nilsson, 2009) that have varied meanings and interpretations. They involve both natural ecosystems and social systems (incl. socio-economic issues) (Hopwood *et al.*, 2005). In addition regional differences in the interpretations of sustainability may be discerned (e.g. between north and south) (Hugé, 2012). Hence, the use of the SD terminology is much broader if compared to biodiversity conservation. These wide meaning and interpretation forces SD to be assessed and evaluated, in particular when management and decision-making processes are involved and are linked to biodiversity conservation.

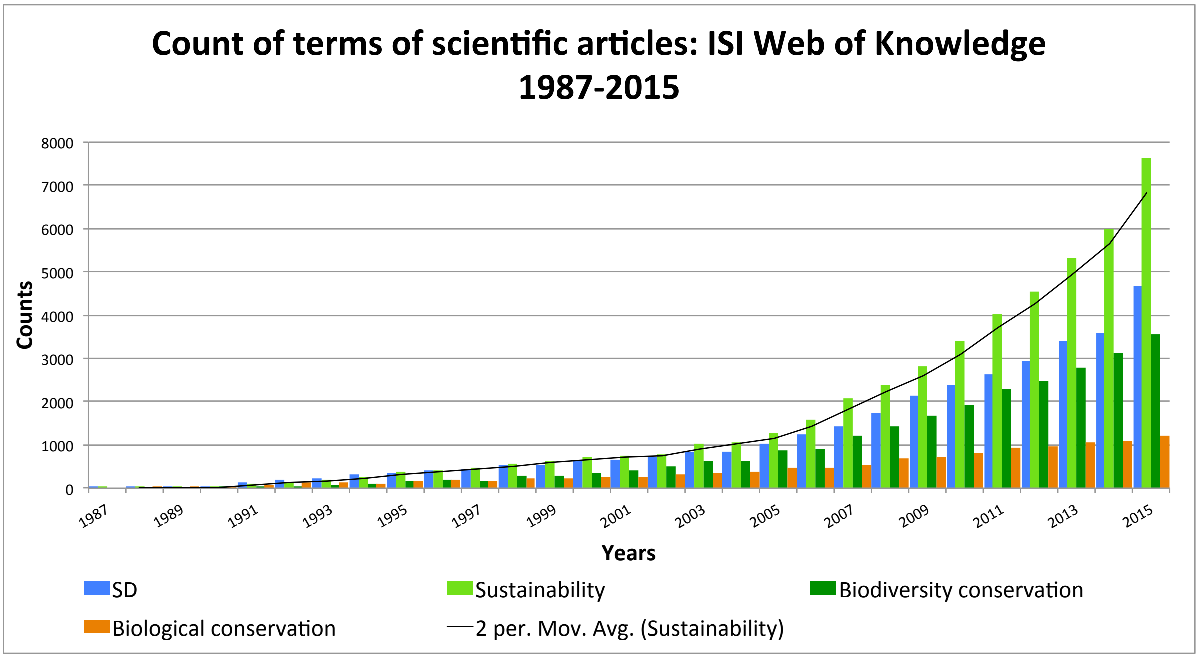

Figure 1.1. Comparison of the usage of terms (1987-2015)
The comparison reflects the use of the terms sustainable development (SD), sustainability, biodiversity and biological conservation in accordance the scientific literature as reflected in the ISI Web of Knowledge.

Sustainability assessment (SA) is an influential approach for environmental management that has emerged as a process to turn sustainable development (SD) into a decision-guiding strategy (Hugé *et al.*, 2011), with emphasis on finding the proper balance between ecosystem preservation and enhancement of human well-being (Singh *et al.*, 2009). A wide variety of SA approaches exist because of the inherent multidimensionality that SD carries with it (Nykvist and Nilsson, 2009). Certainly SA is criticised as it can be too narrow and overly selective, and even be used as a 'cynical green-washing' approach (Winfield *et al.*, 2010). As mentioned in section 1.1, this can be partially related to the interpretational abuse of sustainable development which carries the risk of promoting 'sustainable smokescreens' (Hugé *et al.*, 2011) or 'cosmetic environmentalism' (Robinson and Meaton, 2005).

The constructive ambiguity of SD/sustainability terminology can also represent a political opportunity. In fact, sustainability has become an increasing relevant point for politics, economy and science at national and international scales (Heinrichs and Biermann, 2016).

Even though policy contents and arenas vary between different policy levels, there is a tendency towards working on interconnected policy issues. A perspective that is accompanied by new instrumental developments such as sustainability strategies, sustainability assessment, and communicative and cooperative approaches (Heinrichs and Biermann, 2016).

Hence, the increase use of the SD and sustainability terms might also be related in the 'power' of the term(s) to channel political dialogs, to frame problems as questions of political choice given the uncertainties and constrains of the social, economic and environmental dimensions. Sustainability can arguably be said to have also become a reflection of the way conservationist and policy makers currently perceive global challenges. This means that, at least at policy level, compromises between environmental, social and economic dimensions are being exposed and articulated. In this regard, the conservation community and in particular the scientific community has an important role to play as honest science policy advocates. As Pielke (2007) argued, if scientists are open about their views, it is advantageous to get involved in the policy-making process as honest brokers of knowledge.

In order to avoid falling over the recurring debates on the difficulty of defining sustainability, I here emphasise that sustainability needs to be recognize as a political issue. I follow the stance of Lafferty and Meadowcroft (2000), that we should not start from an *'autonomously derived (either logical or philosophical) interpretation of what sustainable development 'really means'*. Instead Lafferty and Meadowcroft (2000) take sustainable development to be an expression, the sense of which is given by relevant usage: in this case '*the international discussions and accords through which it has become an accepted goal of international and national policy'.* So this means that sustainable development is not a given, but at least partly a social construct[2]. Therefore, the effectiveness or usefulness of the sustainable development concept needs to be assessed for its implicit and explicit goals, indicators, values and practices are questionable (Robert *et al.*, 2005). This is where the

'Social constructs are defined as meanings, notions, or connotations that are assigned to objects and events in the environment and to people's notions of their relationships to and interactions with these objects'. Darity. 2008. International encyclopedia of the social sciences. Macmillan Reference USA. Detroit combination of natural and social sciences is key to assess sustainability, which also reconnects to the idea of assessing biodiversity conservation in the same manner.

1.3. Biodiversity conservation

The Convention on Biological Diversity (CBD) defines biological diversity as "*the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; including diversity within species, between species and of ecosystems*". Although, it would be easy to assume that biodiversity conservation will then be the protection and maintenance of the biological diversity, conservation scholars have different views about the interpretation of conservation. These divergent views mainly concern the intrinsic value of nature (bio-centric conservation) vs. the use of nature by humans (anthropocentric conservation). In other words, this is acknowledging (or not) the role of the human systems and dimensions as an integral part of conservation definition(s), research and actions (Soule, 1985; Kareiva *et al.*, 2011; Kareiva and Marvier, 2012; Soulé, 2013; Hunter *et al.*, 2014; Marris, 2014). In this thesis while trying to integrate the different definitions of conservation notably from Michael Soulé, Peter Kareiva and Giorgina Mace: I conceptualise conservation[3] as a "*spatially and temporally dynamic discipline and practice that addresses the protection of species, communities, ecosystems, biodiversity and human wellbeing while also recognising the diversity of views and values about nature that constitute it*". In this conceptualisation of conservation I take into account the importance of acknowledging the diversity of views and values about nature reflecting on the article by Mace (2014): "*Whose conservation*?". Mace's article provides an interesting retrospective analysis of the four major conservation framings that have shifted -and continue to co-exist- over the past 50 years ranging from the initial protectionist approaches to conservation in the 1970s, to more community-based conservation approaches around 2010 to present (Figure 1.2). These shifts are related to the way the relationship between humans and nature is viewed, affecting the integration of science into conservation (Mace, 2014).

[3] Note that though conservation is a conceptualised as process, the term is often used for a sector in society, for a complex of thoughts and governance, not always directly intending the process or its outcome.

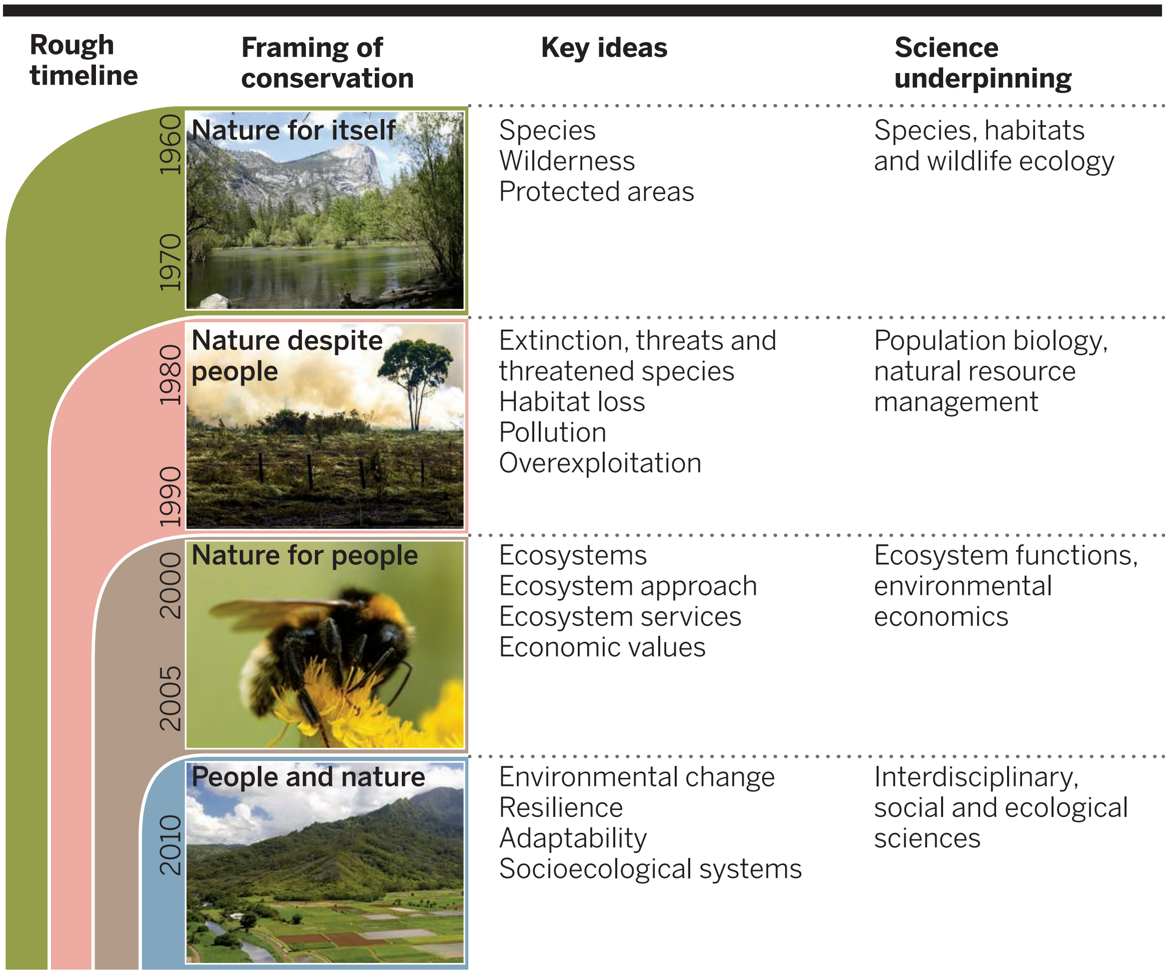

Figure 1. 2. Changing views of nature and conservation
Over the past 50 years, the prevailing view of conservation has changed several times, resulting, for example, in a shift in emphasis from species to ecosystems. None of the framings has been eclipsed, as new ones have emerged, resulting in multiple framings in use today. Figure source and legend: Mace (2014)

However, it is important to note that -in time- the role of nature in relation to humankind stretches beyond the idea of conservation. Max Oelschlaeger in the "*The Idea of Wilderness: from Prehistory to the Age of Ecology*" (in ref.) provides an excellent philosophical treatise that follows the evolution of the western perceptions of the wilderness and the place it occupies in the human psyche. Oelschlaeger (1991) argued that the current views on nature and wilderness are a reflection of the historical production in the human character and a significant component of the evolution of human culture that can be described in four major periods. I here summarise Oelschlaeger's analysis:

- **Palaeolithic view on nature:** The first attempt to transform the natural world begins with the primitive manifestations of culture in the 'Magna Mater'. Nature is home, living and sacred. Humans are part of this functioning reality, and occupied a place within it. The idea of humans existing outside nature is not apparent because of the nomadic lifestyle and the dependence upon nature for sustenance and life. Nature is intrinsically feminine and alive and is associated with the divine that takes many natural forms. The natural world is considered a direct manifestation of God. Time is synchronous because the transient lifestyle followed the growth patterns of the seasons and the paths of the animals that were at the same time responding to seasonal patterns. Rituals are essential to sustain the cycles of life and death, thus sustaining the harmony and order of creation. This Palaeolithic view on nature is estimated to have remained unchanged for 200 000 years. In spite of the suggestion of the term label, it still exists today.

- ***Neolithic view on nature:*** It is only in the Neolithic revolution (10 000 ybp) that humans began to view themselves as outside the natural world. This change of view came along with the process of learning to control and transform the forces of the natural world in agriculture, developing in the wake of climatological changes (last Ice Age). With limited resources available, human experimentation with agriculture led to a sedentary culture. The natural birth control, inherent in the nomadic lifestyle, ceased and population expansion started. This was favourable for an agricultural life transforming human labour into a commodity. While the hunter-gatherers were at home in nature, the agriculturalists created a human outside nature to protect themselves from the threats of the wilderness. This sedentary lifestyle can be considered as the initiation of the consumer life style of the modern times. The accumulation of wealth created a hierarchy and inherent inequality in society between those who have and those who have-not. The accumulation of wealth, claiming of resources and increased populations, institutionalised warfare as a mean of acquiring goods and labour. Moreover, with the development and mastering of tools, came the self-awareness and recognition that humans are in many ways different from nature. The former idea that nature was a divine manifestation of God vanished because humans were able to dominate nature in many ways. However, to account for the realisation that some natural forces were still beyond human control and domination, explanatory Gods appeared.

- ***The Mediterranean and Early-Christian view on nature:*** The emergence of animal idolatry, polytheism and the rise of fertility cults in the Mediterranean still reflected a connection with the natural world. However, within the midst of polytheism, and following the cult of fertility, a monotheistic supernaturalism cult of Early-Christians (Yahweh) emerged. Early-Christians marked the end of the recognition of humans outside the world. The primary view is of domination and differences rather than in sacredness with the natural world. The visible world is profane and God is transcendent and above the outside world. Man is created a part from nature to the image and likeness of God. This dissociation with nature allows its indifferent exploitation and is used as a rationale and corollary of the expansion of agriculture. The emergence of Christianity marks a point in the historical awareness and the subsequent linear sense of time. However, it is the Greek rationalism that completed the evolution of the Early-Christians' ideas of wilderness around 100 years a.c.e. The Greek culture's idea of separation of the body and the soul creates a dichotomisation of thought that conceptualises the difference between human and nature. The persistent concepts of body and soul, Man and God, allowed for the final idea of the separation and domination over the wilderness. However, it is the deep Christian concern for the afterlife that culminated in the idea that nature is fallen and Heaven is the only true home. The incongruences in nature and the natural world are explained by the Divine plan created by God, even if unknowable. This separation between God and the natural world persists until the Middle Ages where the view was to subdue nature through work, pain and suffering. This desire to subdue nature will later influence the rise of science, as technology becomes the new salvation.

- ***Resourcist view on nature:*** The Medieval times (5^{th} to 15^{th} century) were characterised by a view of evil governing life. Thus, the only purpose of life is the salvation of the soul. Wild nature was an evil that had to be tamed, civilised and brought into harmony with the Divine order. Forests that were worshipped by pagans had to be cleared and destroyed. Deforestation in the Medieval times is then used simultaneously to justify God's plan, punish the pagans, and satisfy the resource need of a rapidly expanding population. Therefore, deforestation in the Medieval times is the driver of destruction that would later need to turn to coal and steam power during the Industrial Revolution some 700 years later. However, it is in the Renaissance (14^{th} to 17^{th} century) that the conception of Wilderness changes dramatically. With the rise of secular states and the undermining of the power of the Church, an entrepreneurial class emerged. The increasing urban and commercial life needed several resources to meet the demands and to support the growing industries. Thus, the exploitation of the environment increased dramatically. During the Reformation (16th century), the Church was weakened by the rise of Protestant individualism. The measure of success was based on the accumulation of wealth, which was proof of God's favour. The focus then was of economics and growth. The exploitation of nature reached a climax, as the purpose of society was to capitalise and accumulate the resources provided by nature as quickly as possible. This resourcist view on nature has continued through time until the present. However, this view was also nourished by two important historical events:

- *The Scientific Revolution*, embodied among others by Galileo Galilei and his important contribution to the new logic of science. Galilei broke the established Greek Christian-adopted paradigm of Geocentrism, and further when under home-arrest, in 1638, he wrote *'Two new Sciences'* (in ref.). An early contribution to mechanics, physics and motion (the forbearers of modern material engineering and kinematics). With the same scientific logic and justification Francis Bacon stressed the idea that science could fashion nature for human purpose. René Descartes introduces the idea of the natural world as a machine. Nature is then reduced to mechanical principles (the ecomachine). Animals, like machines, do not feel pain and are only valuable if they are put to human use. Finally, it is in Newton's idea with his work '*A treatise of the System of the World'* (in ref.), first published in 1687 that provided the response to the human desire for a logical and absolute understanding of the physical world. Change is understood as a mechanical, repetitive and patterned process that is predictable and determinable through specific set of phenomena. Physics is then viewed as the instrument of human happiness.

- *The Enlightenment and the Industrial Revolution* (18th century) complete the historical production of the human western culture that comprises the modern idea of Wilderness. Modernism continues to motivate the thinking of our world today but there were several thinkers in the Industrial Revolution, such as Adam

Smith with '*The wealth of Nations'* first published in 1776 (in ref.), whose ideas have been actualised into the market economy. Smith postulated that continual progress was a law of nature where individualist acts could lead to harmonious outcomes at a societal level. Consumption, in this construct, is equated to happiness, thus a wealthy person is a happy person. Consumption is thought as a way to overcome the evils of society, and forms the ethical basis of Capitalism. In this view, nature has value in the utility of its consumption, which is defined by the market.

The relevance of Oelschlaeger's treatise is the description of a stepwise process describing the gradual but fundamental shift of priorities regarding nature (conservation) over time, with often obliteration of former relations. These four major historical periods form the basis of the modern societal conception of Wilderness. However, Oelschlaeger (l.c.) also provides a detailed analysis of the scientific, literary and philosophical communities that almost immediately opposed during the Modernism times (late 19th and mid 20th century). Some of these thinkers include Henry David Thoreau, John Muir, Aldo Leopold and the American wilderness poets: Robison Jeffers and Gary Snyder. John Muir translated his views to effective action with tangible and persistent conservation results. Oelschlaeger concludes with an outlook of the postmodern efforts (until the 1990s) to reconceptualise humans with nature. These include conservation inter-related views such as preservationist, eco-centrism, deep-ecology and ecofeminism (for more details and definitions see Gafta and Akeroyd, 2006; Hay, 2010; Gaard, 2013; Chakraborty, 2015; Kopnina, 2016). These different views and more recent ones such as 'Nature and People' (Mace, 2014), are constantly shifting and co-existing together and are a reflection of the current humans-nature relationship within conservation. Therefore, understanding the diverse views and values that underlie conservation is necessary to situate the extent of conservation efforts and of its success (Sandbrook *et al.*, 2011). In fact, new reflections on the effectiveness of conservation decisions is pointing towards transparency, diversity of views and transdisciplinary research (Adams, 2016).

However, this contrasts with the conventional focus on conservation that mostly relies on the effectiveness of protected areas (PAs) to meet conservation objectives (Timko and

Satterfield, 2008; Leverington *et al.*, 2010; Butchart *et al.*, 2012; Geldmann *et al.*, 2013; Kolahi *et al.*, 2013; Le Saout *et al.*, 2013). The creation of marine and terrestrial PAs has rapidly expanded around the world due to the increasing and alarming global current rates of extinction that are 1000 times higher than in other recent times of history (Pimm *et al.*, 2014). Although there is evidence that well managed PAs have allowed to maintain species population levels and to reduce the rates of habitat loss in terrestrial and marine environments, the rapid growth of PAs in the latter half of the twentieth century has also generated conflicts with the needs of local communities and with the efforts to address poverty and increase economic development (Watson *et al.*, 2014). PAs are in fact the stage of conservation conflicts, as I will explain in the following sub-section (1.3.1).

Furthermore, hitherto there has been little analysis at global scales of the factors that can drive conservation actions towards success, which ought to be defined and contextually interpreted regardless of being in national parks, PAs or less physical/site-related actions. For example Chapman *et al.* (2014), using a global survey directed to the conservation community, found that conservation projects or initiatives are perceived as 'successful' when they are long-term (>10 years), small-scale (0-100 km^2), with relatively small budget (<100 000 USD/year) and when a protectionist approach to conservation is used, either alone or in combination with another approach (Chapman *et al.*, 2014). In contrast, Luther *et al.* (2016) found a positive association between the funding allocated for a species and their population trend; as well as with habitat protection and educational awareness. This conclusion was based on more available data but only from avian species under the Endangered Species Act (ESA) of USA. The results also indicated major differences between conservation action implementation and resource allocation between ESA listed species on the mainland and on islands of the USA (Luther *et al.*, 2016).

At the international conservation policy level the EU has developed some encouraging initiatives such as the creation of the Birds and Habitat Directives and the Natura 2000 network (EU, 2016a), starting in the 1970s and as a direct implementation of the Bern Convention (1975) as well as under great public pressure in that decade (Merken, 2015). In 2007, Donald *et al.* showed the quantitative positive impact of supranational conservation policies to protect birds in Europe. The study compared EU member states (15 countries) that since 1979 with the creation of the Birds Directive adhered to certain conservation measures to protect birds, e.g. special protection areas (SPAs), and non-EU member states that did not adhere to any conservation measures. The results clearly proved the benefits to bird populations in the EU and the effectiveness of international policy interventions to address conservation issues over large geographical areas (Donald *et al.*, 2007). Currently, the EU commission, through the general Regulatory Fitness and Performance Programme (REFIT), also evaluates the 'fitness' of the EU Birds and Habitat Directives (EU, 2016b). With these examples I can illustrate some of the complexities, opportunities and challenges in conservation. As we can see, the challenges do not only come from the side of the natural systems (e.g. species extinction rates), but also from the inter-dependent human systems and structures (e.g. funding allocations, educational awareness, political momentum, governance, unified international conservation policies). Understanding and situating conservation is therefore important, and requires an integrative approach that is able to capture and explain the dynamics and inter-linkages of both social and ecological systems (Liu *et al.*, 2007; McClanahan *et al.*, 2008).

1.3.1. Conservation conflicts

Conservation conflicts are centred in studying the interactions between humans and other species (mostly wildlife) and/or ecosystems. However, these interactions encompass many forms and interrelated aspects between the human activities and natural systems. Often, conflicts between humans and wildlife have been widely framed as human-wildlife conflict, but the term is misleading as it suggests that species are conscious human antagonists (Peterson *et al.*, 2010). So, here I build on a neutral definition of conservation conflicts which is defined as "situations that occur when two or more parties with strongly held opinions clash over conservation objectives and when one party is perceived to assert its interests at the expense of another" (Redpath *et al.*, 2015). This definition recognises that conservation conflicts are basically conflicts between humans. Thus, although disagreements are an inevitable part of human society, the real challenge is to find solutions that minimise their destructive nature. Persistent and unsolved conflicts can amplify the consequences for both wildlife and people, more so when the wildlife in question is a large charismatic species (Peterson *et al.*, 2010; Redpath *et al.*, 2014). These conflicts besides being destructive and costly undermine conservation, human social-economic development and any envisioned sustainability perspective. For example, when protected wildlife (i.e. African elephants) raids farmers' crops or when fencing and illegal hunting affects the wildlife survival (Naughton-Treves and Treves, 2005; Anthony *et al.*, 2010). Managing such a situation requires not only ecological data but also a deeper understanding of the underlying causes of the conflict that go beyond the material differences between stakeholders, which are associated with cognitive levels, power relations and different social and cultural-historical contexts that shape our values behaviour and attitudes (Adams *et al.*, 2003; Niemela *et al.*, 2005; Raik *et al.*, 2008). In the following subsections, I will review the main origins of conservation conflicts which relate to the different co-existing conservation views and objectives that can or have lead to more tensions and conflicts (Young *et al.*, 2010). While exposing these problems I will then also centre to useful management approaches that have been proposed to solve or mitigate conservation conflicts.

1.3.1.1. The origin and management of conservation conflicts

Although several categories have been proposed to understand the underlying causes of the emergence of conflicts, these categories have often failed to capture the complex and context-specific characteristics of conflict (Young *et al.*, 2010). However, Redpath *et al.* (2013) argue that there would be four main causes underlying conservation conflicts:

i) *The different understanding of human-nature relational values*, which give origin to conflicts when the intrinsic and instrumental values of nature are confronted and disputed as two separate solutions, instead of considering that many important concerns about nature could be a shared element to both (Chan *et al.*, 2016).

ii) *The exclusion of stakeholders in conservation planning,* which is often related to the presence, imposition or extension of Protected Areas (PAs), where local communities are removed from their land with no consultation or adequate compensation. Thus, generating increasing conflicts between the different stakeholders involved (e.g. park managers and farmers) (Benjaminsen and Svarstad, 2010; Andrade and Rhodes, 2012).

iii) *Power asymmetries between stakeholders,* which is related to particular actors usually within organisations or institutions (e.g. governments, NGOs) who exert more control over certain resources and use that 'power' to control and take advantage over the control of other resources from other actors (Raik *et al.*, 2008; Armitage *et al.*, 2009; García-Frapolli *et al.*, 2009).

iv) *Historical factors* which are on the one hand related to historical perspectives, believes and human-nature related practices that make conservation appear threatening (Niemela *et al.*, 2005), or on the other hand, when new conservation perspectives assume that historical perspectives and human nature-related practices are threatening (Campbell, 2007).

These four main points are at the core of conservation conflicts, and allow us to understand that in order to manage such conflicts, transdisciplinary approaches that integrate natural, social and humanity sciences are necessary (Redpath *et al.*, 2013). There are different ways to manage conservation conflicts and these include several policy decision analysis tools (Davies *et al.*, 2013), game theory (Colyvan *et al.*, 2011; Ramsbotham *et al.*, 2011) and last but not least, participative and deliberative approaches (Jones-Walters and Çil, 2011; Redpath *et al.*, 2013). This last is of particular relevance in the framework of this thesis, and although I will detail more on participatory approaches to conservation in **Chapter 2,** in the follow subsection I will review some important aspects of the participation process in the management of conservation conflicts.

1.3.1.2. Participatory processes to manage conservation conflicts

The idea of participation to manage conservation conflicts is to find shared solutions between the opposed parties involved in the conflict to encourage coexistence (Redpath *et al.*, 2013). This is of course a difficult task because the different values and interests of the opposing parties need to find a channel to engage in discussions with the final goal of finding acceptable solutions that satisfy both parties. For this to happen, the involvement of stakeholders is essential, and the use of a participatory approach can help in the process to engage parties and manage conflict (Chase *et al.*, 2004). It follows that a participatory approach is the first essential element to generate a participatory and deliberative process.

This participatory and deliberative process involves several steps from the identification of stakeholders to the implantation of solutions (Figure 1.3).

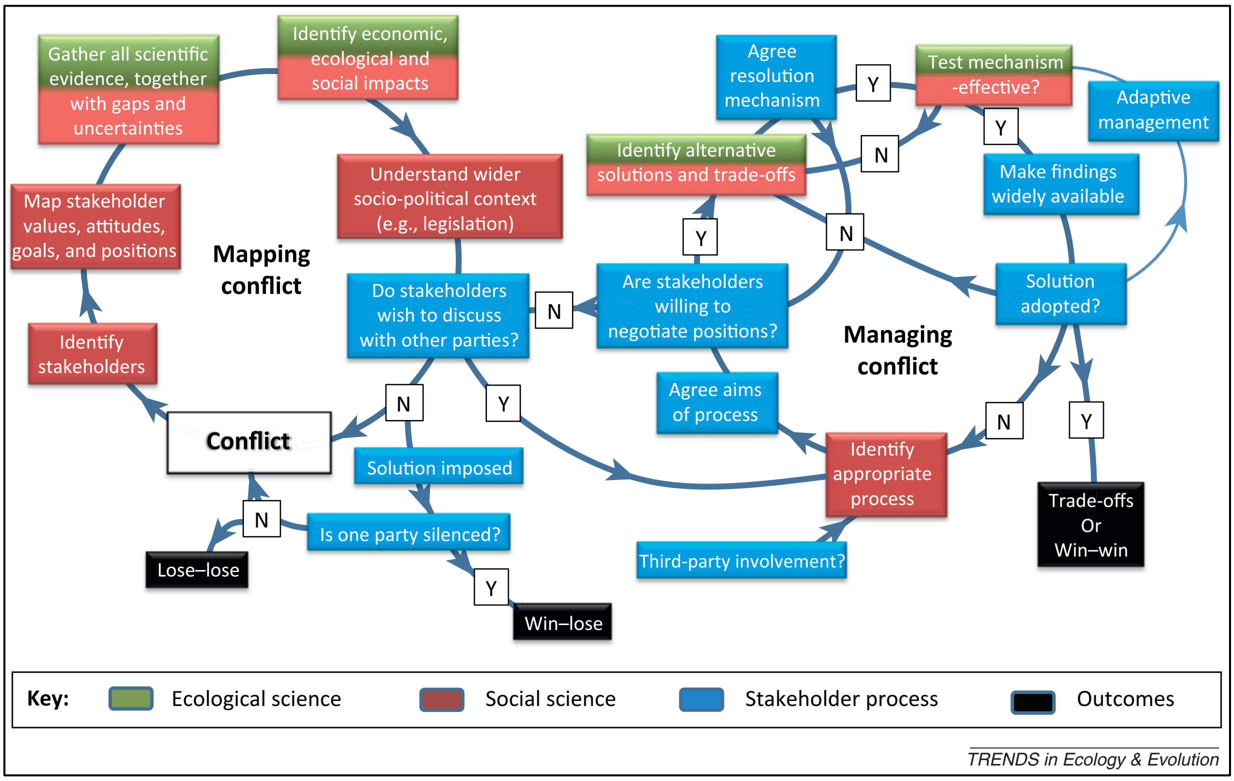

Figure 1.3. A roadmap to guide effective management of conservation conflicts.
The two main elements of the roadmap are: (i) passive mapping of the conflict, garnering evidence, and considering the context; and (ii) more active attempts at conflict management involving engagement, often with a third party, exploring alternative solutions, and developing strategies within an adaptive management framework. The entire participatory process involves social and ecological scientists together with stakeholders, policy makers, and usually mediators. Figure source and adapted legend: Redpath *et al.* (2013)

Within the steps of this participatory process, six key elements need to be highlighted as they may influence in the management outcomes towards more or less desirable solutions:

i) Stakeholders' knowledge and values. These are reflected in the participatory research process play an important role in accepting public decision-making and the perceived legitimation (Gross, 2014; Daniell *et al.*, 2016). Thus, after the identification of stakeholders and the gathering of social and ecological information about the conflict, it is necessary to start a discussion among the involved stakeholders and encourage further engagement. If distrust and lack of engagement are a problem, a third powerful or morally authoritative party (e.g. government, agency) can be engaged to facilitate negotiations (Redpath *et al.*, 2013).

ii) Explicit and transparent articulation of goals, arguments and trade-offs to avoid unrealistic win-win solutions (Hirsch *et al.*, 2011; McShane *et al.*, 2011).

iii) Consideration of spatial and temporal scales in the discussion dialogue. Large geographical areas can reduce the representation of relevant stakeholders and reduce social learning (Borowski *et al.*, 2008). Investing sufficient time in the process will also enable parties to develop trust, to gather scientific evidence, and adequately examine mitigation strategies (Young *et al.*, 2010).

iv) Evaluation of the possibility for economic incentives or compensation schemes only if they satisfy all the involved parties (Redpath *et al.*, 2013).

v) Avoidance of strict enforcement of legislations which can accentuate the conflict in particular when laws and institutions are perceived as illegitimate and unfair by any of the parties (Heydon *et al.*, 2011).

vi) Maintenance of a transparent research process. In particular, scientists conducting the research need to keep their assumptions, values and inferences as neutral and explicit as possible, so that the parties involved in the process can trust them (White *et al.*, 2009). The role of the scientist as the honest broker *sensu* Pielke (2007) is in line with this step.

So as I have detailed in this section, conservation conflicts involve a complex layering of diverse issues related to different values, trust, and power asymmetries. Following these six key elements can guarantee a more effective participatory process to manage conflicts. I highlight however the last point (vi) as perhaps the most important element. During a participatory research process, the researcher shares power with other stakeholders such as local communities or government parties. Although the degree of a stakeholder's involvement and power sharing may vary, only an honest, transparent position and attitude from the researcher can guarantee the correct provision and devolution of the decision making authority to participants (Pielke, 2007; Benham and Daniell, 2016). In **Chapter 5,** I will present a case on conservation conflicts and the use of a mixed approach of social and ecological methods to understand and provide management of social-ecological information to address the conflict.

1.3.2. Conservation policy and governance

Policy is the making and implementation of collective decisions, essentially by governments, about what is good or bad for society and the economy Hague and Harrop (2010). Environmental issues often have many aspects, and governments need several policy instruments (i.e. regulatory, economic incentives, technology transfer) to address each issue adequately to ensure that they do not undermine each other nor overlap, or result in unnecessary costs (Hambler and Canney, 2013). National policies and laws are essential for conservation and international agreements and platforms (i.e. CBD, CITES, Ramsar convention, Paris Climate Agreement, IPCC) have played a major role in shaping norms in which states and actors can participate in and approve certain activities (Brockington *et al.*, 2008). In the following subsections, I will review two important and new international agreements and platforms (2030 Agenda and the IPBES), which are related to the context of this PhD thesis and discussions on sustainability and biodiversity conservation.

However, besides the international agreements and platforms, the representatives of the 'transnational elite' of conservation arising from large influential organisations (e.g. WWF, CI, TNC, WCS), scientists, corporate directors, government officials, celebrities and individuals working in media, are the ones that dominate and promote how conservation is discussed/presented/talked about, thought and practiced at a global scale (Holmes, 2010). This conservation lobbying to national and international legislations has been mostly be geared towards the exclusionary type (i.e. national parks and protected areas) at least initially, which has received much critique due to the ties with corporations (Rothkopf, 2008) and the increasing economic and political expansion of some conservation NGOs (Chapin, 2004; Birchard, 2005; MacDonald, 2008; Holmes, 2010). Therefore, the international scholarly and policy debate concerning the appropriate approach to conservation has become very dynamic in recent years. This has led to the need for analysis of the variety of conservation approaches such as protectionist or exclusionary approaches, participatory community-based conservation (CBC), regulatory and, non-state market-driven approaches. In **Chapter 4**, building on our own research findings, I will discuss each of these approaches in more detail.

1.3.2.1. The 2030 Agenda for Sustainable Development

Commonly known as the Sustainable Development Goals (SDGs), the 2030 Sustainability Agenda builds on the Post 2015 Agenda and the Millennium Development Goals (MDGs). Headed by the United Nations, the 2030 Agenda came into effect on the 1st of January 2016, with the intention to complete what was not achieved by the MDGs, particularly reaching the most vulnerable and with the commitment to ending poverty in all its forms and dimensions by 2030 (Assembly, 2015b). The Agenda consists of 17 sustainable development goals (SDG) with 169 associated targets. Although it is as ambitious as the MDGs, the MDGs were only targeting developing countries; whereas the 2030 SDG adresses focuses on local to global challenges. Thus, the SDGs encompass almost every issue that can be relevant for sustainable development, which can be both the strength and weakness of the Agenda (Colglazier, 2015). In this sense it is worth noting the effort that it sets to achieve social, economic and environmental compromises, which is ideal for channelling policy dialogues and choices about global challenges. Particularly, concerning conservation, three of the 17 SDGs have immediate action potential:

- SDG 13: Take urgent action to combat climate change and its impacts
- SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development
- SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

This fact has also made possible the alignment of important international nature conservation organisations. For example, the IUCN is fully aligned with 2030 SDGs because it considers that now the Agenda fully embraces all dimensions of sustainable development, including the environment (IUCN, 2016). Hence, the 2030 Agenda is perhaps the most important international guiding framework for future development and conservation actions. Correspondingly, another interesting aspect about the 2030 Agenda, is that although science, technology and innovation (STI) is emphasised along the 17 SDGs and targets, it also includes several targets that are directed to enhance human responsibilities/values towards nature (e.g. SDG13-13.3, SDG14-14c, SDG15-15c). Hence, the 2030 Agenda has been designed to deal with sustainability and its related environmental challenges with more integrative and constructive criteria than happened in previous years, commissions (i.e. Brundtland commission) or agendas (i.e. MDG). Another important aspect is that the last goal (SDG17: means of implementation) cuts across all SDGs and is intended to revitalise global partnerships among governments, civil society, the private sectors and other actors. It is also remarkable to see that insights from social sciences have been taken, particularly for SDG 4 (education), SDG 5 (gender equality), and SDG 16 (peaceful and inclusive societies). As Colglazier (2015) argued it is very likely that many indicators will be chosen from measures that have already been developed by natural and social sciences. I would add that transdisciplinary research could also play an important role in the development and selection of relevant indicators for the SDG.

1.3.2.2. The Intergovernmental Policy-Science Platform on Biodiversity and Ecosystems Services (IPBES)

Established in 2012 and administered by the UNEP, the IPBES is an intergovernmental body consisting of 125 country members, and with the auspice of the UNEP, UNESCO and FAO. The IPBES was established to strengthen the science–policy interface for the conservation of biodiversity, ecosystem services, long-term human well-being, and sustainable development (IPBES, 2016). Although similar to the Intergovernmental Panel on Climate Change (IPCC) in that it carries out assessments of existing knowledge in response to governments and stakeholders, IPBES deals with more complex challenges. These challenges are related to finding scalable and fine-scale solutions to the heterogeneous biodiversity distributions and conservation status for the improvement of global biodiversity (Díaz *et al.*, 2015). At the core of these challenges, the IPBES embraces three key features:

i) The engagement of a diversity of stakeholders (e.g. policy makers, practitioners, civil society organisations, private sector) to jointly define questions, assessing trends and identify solutions.

ii) The incorporation of knowledge from social, natural, engineering sciences and indigenous and local knowledge (ILK).

iii) The inclusion of capacity building, the development policy tools and catalysis of the generation of critical new knowledge.

In order to unite the different elements of these features, which involve complex interactions between the natural systems and the social systems, the IPBES constructed a conceptual framework (CF). The CF was constructed in two years of consultative work with a group of multidisciplinary specialists, and opened to comments by more than 100 governments and NGOs (Díaz *et al.*, 2015). The CF includes six interlinked elements constituting a social-ecological system that operates at various scales in time and space (Figure 1.4).

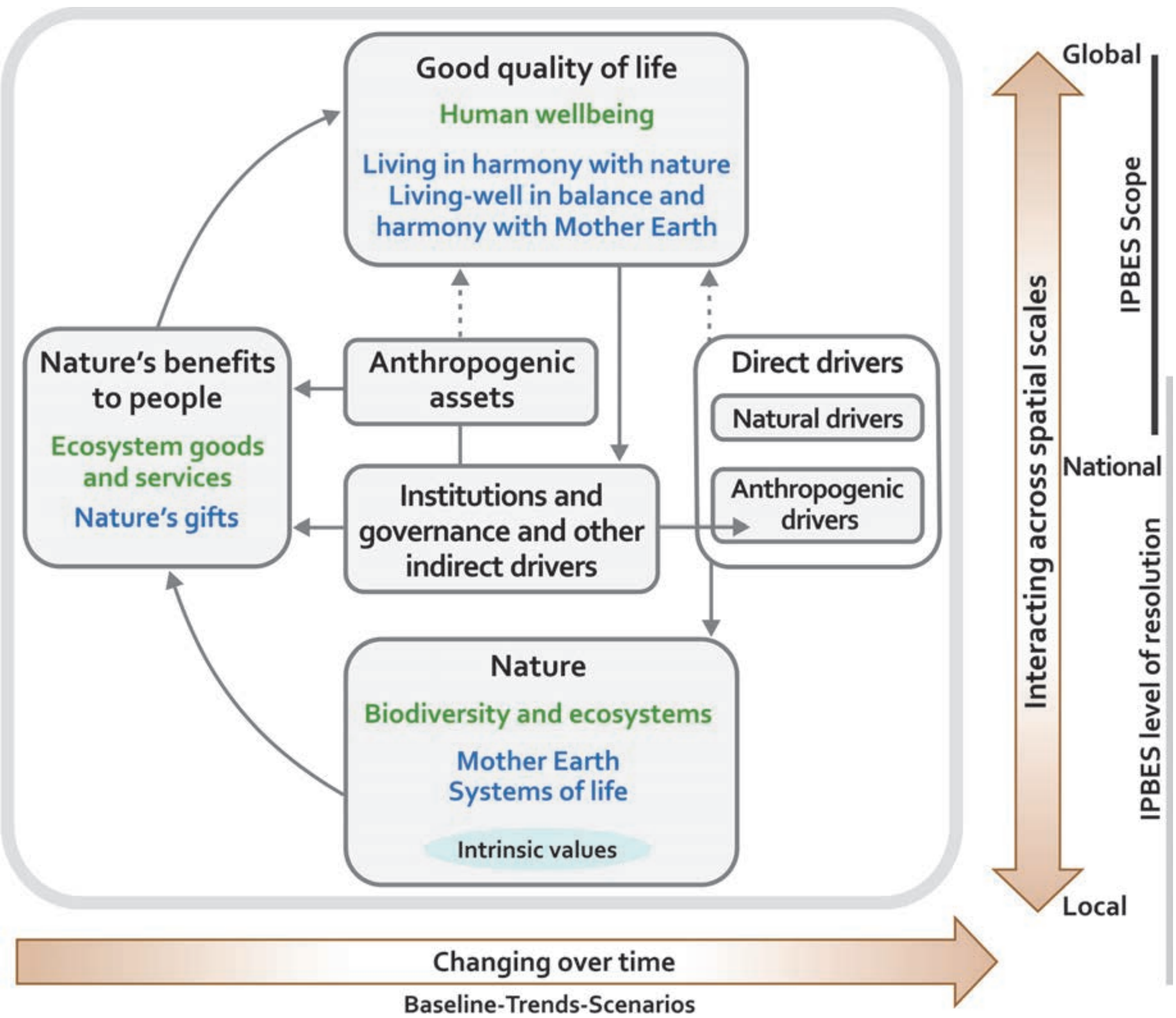

Figure 1.4. The IPBES Conceptual Framework (CF).
In each of the boxes, the headlines in black are the six interlinked elements. In green are illustrative categories of western science (in green) and equivalent or similar categories according to other knowledge systems (in blue). Figure source and adapted legend: Díaz *et al.* (2015)

In the IPBES Conceptual Framework we find a combination of views, which we outlined in section 1.3 (Oelschlaeger, 1991; Mace, 2014). The innovative aspects of the IPBES Conceptual Framework are however its coherent, transparent and participatory construction process and its explicit consideration of diverse scientific disciplines, stakeholders, and knowledge systems, including indigenous and local knowledge. Hence, the IPBES Conceptual Framework is all about co-construction of integrative knowledge and diverse conceptualization of the multiple values about nature and its benefits. All these are very relevant in the context of this doctoral thesis and highlight the importance of new integrative and participatory approaches as transdisciplinary tools to generate and co-create knowledge and solutions to real world challenges. Moreover, the different categories and elements of each box also underline the effort to of the IPBES integrate the different the range of values (e.g. utilitarian, scientific, and spiritual) that shape human views of nature. This reconnects in the usefulness of CF to bridge the varied meanings of sustainability, which as explained earlier (section 1.1) is related to one's position on the divide between utilitarian and spiritual approaches to nature. As mentioned by Díaz *et al.* (2015) '*the CF is now a kind of 'Rosetta Stone*[4]*' for biodiversity concepts that highlights the commonalities between very diverse value sets and seeks to facilitate crossdisciplinary and crosscultural understanding*'.

1.4. Social-Ecological Systems (SES)

In this thesis the theory-oriented frameworks and elements of social-ecological systems (SES) will be used as an analytical lens to situate conservation and sustainability. SES is rooted in systems ecology and complexity theory but differs in the sense that it includes some central societal concerns (e.g. equity and human well being) which are not central for complex adaptive system theory, and there are areas of complexity theory (e.g. quantum physics) that have little relevance for understanding SES (Cumming, 2011). SES research emerged in the 1970s along with many sub-disciplines such as: political ecology, ecological economics and environmental ethics (Bateson, 1979). In fact, the 1970s marked a decade characterised by global international institutional awareness, increasing public pressure,

[4]The Rosetta Stone is a inscribed rock tablet discovered in Egypt in 1799, which held the key to understanding Egyptian hieroglyphs because a same text was written in several languages and scripts (Diaz *et al.,* 2015).

institutionalisation of civil society movements, actions and initial international legislations for conservation. Important NGOs, global institutions and international legislation were created during the decade of 1970s. Below follows a non-exhaustive overview of important examples. In 1971: Greenpeace, the Man and Biosphere Reserve-UNESCO, RAMSAR convention. In 1972: World Heritage Convention-UNESCO, the publications of the Club of Rome's `The Limits to Growth', United Nations Conference on the Human Environment (UNCHE). In 1973: the USA Endangered Species Act, the Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES, also the Convention of Washington). During 1976-1978: the drafting of the Bern Convention by the Council of Europe. In 1979: the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), the Bern Convention, and the European Birds Directive by the then European Communities (Merken, 2015). It was also the decade during which environmental movements generated political parties (e.g. in Germany, Belgium) and directly entered the political scene.

For SES research it is only from the mid-1990s that considerable efforts were invested to approach SES from a practical perspective, often integrating concepts such as resilience, vulnerability, sustainability and complexity (Berkes *et al.*, 2003; Anderies *et al.*, 2004; Folke, 2006; Ostrom *et al.*, 2007; Ostrom, 2009; Cumming, 2011). Many environmental frameworks were developed as adaptive management tools to address the existing and emergent problems of SES: the Drivers-Pressures-State-Impacts-Responses (DPSIR) framework developed by the European Environmental Agency (Stanners and Bourdeau, 1995), the integrated coastal zone management (ICZM) framework (Olsen, 2003); and the drivers, ecosystem-services, human well-being framework developed by the Millennium Ecosystem Assessment (MEA, 2005). Generically an SES framework can be defined as: '*a set of assumptions, concepts, values and practices that constitute the way of viewing the specific reality of SES, which in turn are a nested, multilevel system that provides essential services to the society such as food, fiber, energy and drinking water*' (Berkes *et al.*, 2000; Binder *et al.*, 2013). However, it was the Social-Ecological System Framework (SESF) (Figure 1.5a) developed by the Economic Nobel Prize Laureate Elinor Ostrom that allowed for a more defined research-oriented guideline on how SES research should be conducted by the social and natural scientists (Ostrom, 2007, 2009).

1.4.1. Social-Ecological Systems Framework (SESF)

The SESF intends to help scholars and policymakers to accumulate knowledge from empirical studies and assessments of past efforts and reforms and to organise their analytical, diagnostic and perspective capabilities (McGinnis and Ostrom, 2014). The framework serves to diagnose the key interacting components and interactions that drive sustainability challenges in SES (Partelow, 2016). McGinnis and Ostrom (2014) have argued that the template of SESF is intended to remain 'theory neutral' so that competing hypotheses from alternative theoretical perspectives can be evaluated on a common basis, although they acknowledge that no framework is neutral. One of the great features of the SESF is that it is open and decomposable and amenable for the integration with other frameworks and concepts. In the past years the SESF has been constantly updated and modified (Ostrom, 2007, 2009, 2011; McGinnis and Ostrom, 2014; Vogt *et al.*, 2015). For example, recent analyses on SES research points out that most of the published research tends to include more social than ecological variables, which is reflected in the fact that 51% of SES research uses only qualitative methods, and only 17% uses quantitative and qualitative methods (Rissman and Gillon, 2016). Hence, Epstein *et al.* (2013) and Vogt *et al.* (2015) have suggested to include ecological rules in the framework (see Figure 1.5a). The SESF is organised in a decomposable first tier variables (Figure 1.5a) into a second multiple tier of sub-variables (Table 1.2) that is intended to allow scholars to describe SES potentially with high clarity and precision, and to evidence their diversity and complexity. Thus, the first tier of nested subsystems and variables expands to the four core subsystems (RU, RS, GS, A), with the Related Social, Economic, and Political settings (S), the Related Ecosystems (ECO), and the recently added exogenous context of Ecological Rules (ER) as suggested by Vogt *et al.* (2015). Furthermore, the SESF also allows fine-tuning of governance systems of the SES with the Focal Action Situations in which the Interactions occur (I) and Outcomes are produced (O). Ostrom (2011) suggested using the analytical structure of the Institutional Analysis and Developmental framework (IAD) to assess these Focal Action Situations (Figure 1.6). The second-tier of variables (Table 1.2) are useful to guide primary and secondary data collection within a contextual SES case. However, it is important to note that not all the second-tier components may be relevant within an SES case, but these can provide a checklist for understanding system complexity and diversity of the human-environment interactions and the potential driving components to consider when designing inductive SES research (Partelow, 2016). This however does not mean that SESF is only used for inductive SES research. On the contrary, SESF is being used for deductive research to test theories on the role of certain system components, their interactions and system outcomes (see Epstein *et al.*, 2014; Cox *et al.*, 2016). Thus the SESF has offered a unique tool for conducting large sample comparative studies that has contributed to identifying the right institutional fit for a wide variety of SES (Clement, 2013).

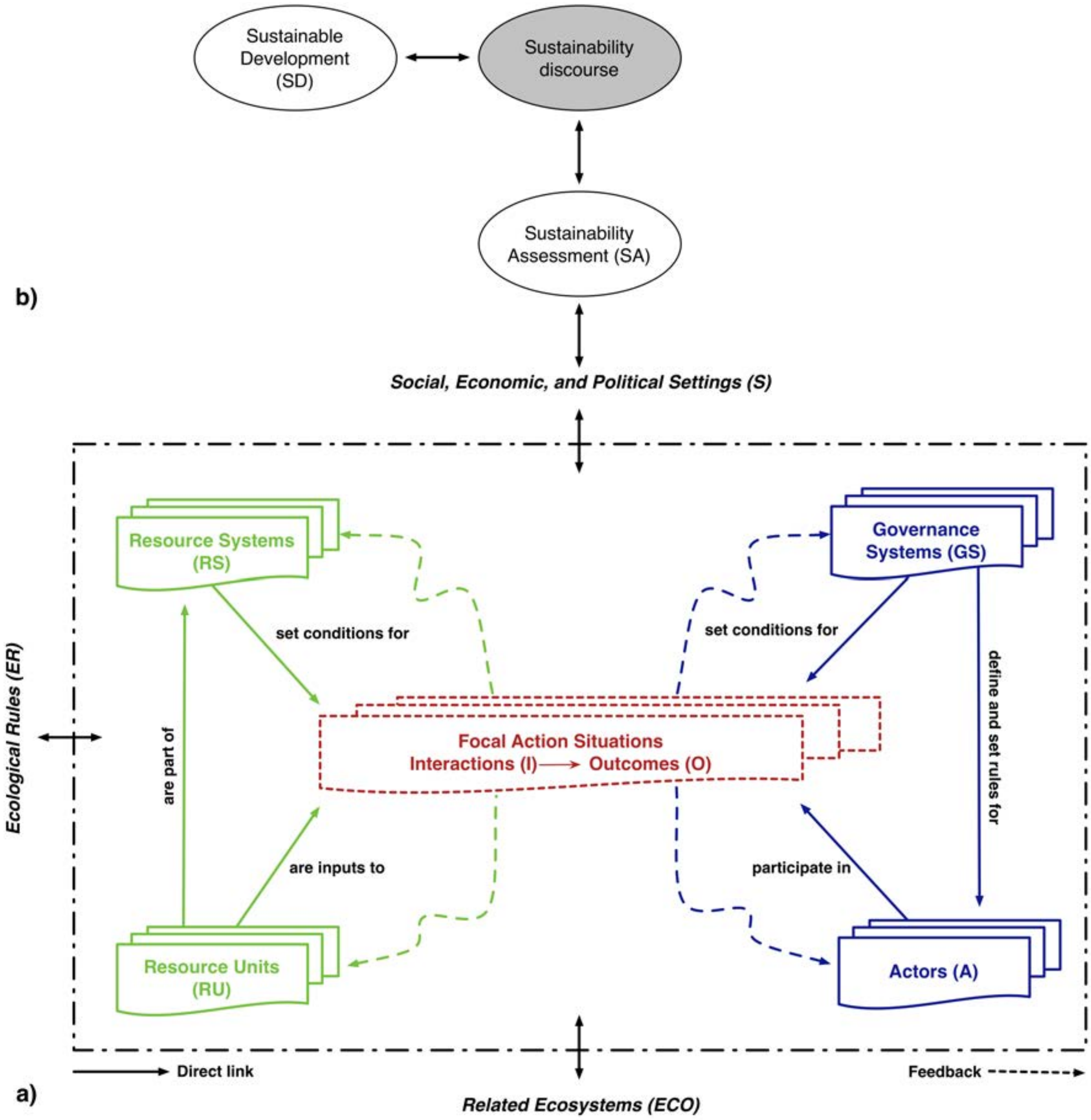

Figure 1.2. Modified framework for analysing SES.
a) The diagnostic SESF with the four decomposable first-tier variables, which are presented in each of the four corners. In the centre (red coloured), the template for assessing their interactions and outcomes is visualised. **b)** Added variables for the analysis of the SESF. Sustainability discourses (grey circle) connects SD and SA (white circles) to illustrate the influence of SD and sustainability concepts in the core subsystem (S). Adopted and modified from (McGinnis and Ostrom, 2014; Vogt *et al.*, 2015).

Table 1.2. Second multilevel tier of variables of the SES framework.

<table>
<tr><td colspan="3">Social, economic, and political settings (S)
S1 Economic development. S2 Demographic trends. S3 Political stability.
S4 Government resource policies. S5 Market incentives. S6 Media organisation.
S7 Technology.</td></tr>
<tr><td></td><td>Resource systems (RS)
RS1 Sector (e.g., water, forests, pasture)
RS2 Clarity of system boundaries
RS3 Size of resource system*
RS4 Human-constructed facilities
RS5 Productivity of system*
RS6 Equilibrium properties
RS7 Predictability of system dynamics*
RS8 Storage characteristics
RS9 Location</td><td>Governance systems (GS)
GS1 Government organisations
GS2 Nongovernment organisations
GS3 Network structure
GS4 Property-rights systems
GS5 Operational rules
GS6 Collective-choice rules*
GS7 Constitutional rules
GS8 Monitoring and sanctioning processes</td></tr>
<tr><td>Ecological Rules (ER)
ER1- Physical rules.
ER2- Chemical rules.
ER3- Biological rules.</td><td>Resource units (RU)
RU1 Resource unit mobility*
RU2 Growth or replacement rate
RU3 Interaction among resource units
RU4 Economic value
RU5 Number of units
RU6 Distinctive markings
RU7 Spatial and temporal distribution</td><td>Actors (A)
A1 Number of relevant actors
A2 Socioeconomic attributes
A3 History or past experiences
A4 Location
A5 Leadership/entrepreneurship
A6 Norms (trust-reciprocity)/social capital
A7 Knowledge of SES/mental models
A8 Importance of resource (dependence)
A9 Technology available</td></tr>
<tr><td></td><td colspan="2">Action Situations: Interactions (I) → outcomes (O)</td></tr>
<tr><td></td><td>I1 Harvesting
I2 Information sharing
I3 Deliberation processes
I4 Conflicts
I5 Investment activities
I6 Lobbying activities
I7 Self-organising activities
I8 Networking activities
I9 Monitoring activities
I10 Evaluative activities</td><td>O1 Social performance measures (e.g., efficiency, equity, accountability, sustainability)
O2 Ecological performance measures (e.g., overharvested, resilience, biodiversity, sustainability)
O3 Externalities to other SESs</td></tr>
<tr><td colspan="3">Related Ecosystems (ECO)
ECO1- Climate patterns. ECO2- Pollution patterns. ECO3- Flows into and out of focal SES.</td></tr>
</table>

Table source from: Epstein *et al.* (2013); Vogt *et al.* (2015)

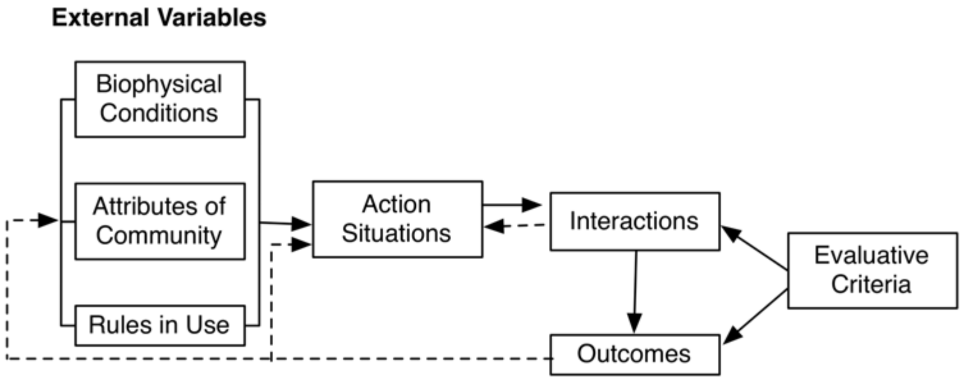

Figure 1.6. Institutional and Analysis Development framework.
Source (Ostrom, 2011)

1.4.2. Social-Ecological Systems research

SES research intends to clarify the social and ecological inter-linkages by recognising and proposing interdisciplinary and transdisciplinary research that can generate knowledge that is able to support the effective implementation of practical and sustainable solutions for real world challenges. However, there are still challenges, in particular the lack of tools to integrate transdisciplinary knowledge into one mutually aggregate package. Therefore, SES research needs to develop conceptual pathways and tools that can guide and support the aggregation of knowledge contributions within different academic communities as well as to clarify the multi-dimensional concept of sustainability (Fischer *et al.*, 2015; Partelow, 2016). In this regard, Ostrom (2009) already argued that the sustainability of the SESF will depend on establishing rules (by the users or a government) that are congruent with the local conditions. Ostrom (l.c.) also stated that these rules have to match the attributes of the resource systems, resource units and actors. However, Clement (2013) argued that the need of SES studies should go beyond identifying the right institutional fit, and to place power and discourses at the core of their analysis. In the following subsection, I will provide an overview and conceptualisations of power and discourses, as these are very important in the framework of this doctoral thesis.

1.4.2.1. Power and discourse

Power and discourses are often very contested concepts in social sciences. However, one of the best known power-discourse conceptualisations is that of Michel Foucault who conceptualised discourses as an instrument and an effect of power at a strategic level (Foucault, 1975). This dual conceptualisation of cause and effect is important to realise the close links that exist between discourses and power. However, in order to understand the links between power and discourse, I will first analyse them as separate elements:

1.4.2.1.1. Power, power relations and knowledge

Power can be defined as the capacity to mobilise resources. Resources broadly defined as persons, assets, material or capital, including human, mental, monetary, artefactual and natural resources (Avelino and Rotmans, 2009). Therefore, power relations in a system can generically be defined as the ability to mobilise people, thereby exerting power 'over' them. Avelino and Rotmans (2009) propose three typologies of power relations, which can produce a state of balance or imbalance of a system (Table 1.3.). I consider these as central to understand power relations.

Table 1.3. Typology of power relations

Type of power relation	*Balance*	*Imbalance*
Having power 'over'	A depends on B but B also depends on A, so A and B have power over each other = **mutual dependency**	A depends on B but B does not depend on A, so B has power over A = **one-sided dependency**
Having 'more' or 'less' power	A mobilizes more resources than B, but A and B have goals that are collective or co-exist = **co-existence/ cooperatio**n	A mobilizes more resources than B, while A and B have mutually exclusive goals = **competition**
Having a 'different' power	A exercise power in such a way that it enables and enforces the power exercised by B = **synergy**	A exercises power in such a way that it disrupts or prevents power exercised by B = **antagonism**

Source: Avelino and Rotmans (2009)

Explicitly recognising these three typologies of power relations and their role in conservation management of SES, can allow us to be strategic in the actions to democratise and equalise asymmetrical power relations such as when conservation conflicts occur (Raik *et al.*, 2008). However, the relation between power and knowledge might also play an important constituent in the equalisation of power relations in a system. Avelino and Rotmans (2009) define knowledge as '*the mobilization of mental resources (information,* *concepts, ideas and beliefs) to reach a specific goal*', which is by definition an exercise of power. So, by constructing and communicating knowledge, we are exercising power. As Avelino and Rotmans (2009) explain, this is not only in terms of '*mobilizing mental resources*', but also in terms of influencing how other actors mobilise all the other type of resources (human, artefactual, natural and monetary). In order to know which resources to mobilize to reach a specific goal, and in order to know how to mobilize these resources, it is necessary to have knowledge about these resources (Avelino and Rotmans, 2009). This last aspect is extremely relevant in the context of a participatory research process, and again highlights the responsibility and honest attitude that scientist have to embrace while conducting research with social and political implications (Pielke, 2007).

1.4.2.1.2. Discourse

Like power, discourse is used in a variety of ways in different bodies of literature. A simple definition of discourse is: 'the *shared, structured ways of speaking, thinking, interpreting, and representing things in the world* ' (Dryzek, 2013). However, as I have presented along this chapter, many issues in sustainability, conservation and SES encompass a variety of social related practices from actors, systems and policies. Hence, a Foucaultian approach to discourse[5] brings new perspectives for understanding several social-political processes. In essence, Foucault defined discourse as a system of representation of the interaction of the binomial knowledge-power, which embraces actions and practices; and where the struggles and negotiations between actors are specified by their discursive formation linked with various strategies of power (Pochet, 2014). In this doctoral thesis I will also follow Maarten Hajer's reading of Foucault, who uses discourse analysis to bring out the "secondary discursive realities" of environmental politics. This means the close links between policy outcomes and discourses (Hajer and Versteeg, 2005). In **Chapter 2**, I will detail more on discourses analysis and several related approaches and methods.

[5] A Foucaultian approach to discourse, rather than exploring the rules that govern meaning-making, focuses on the power inherent in the language and seeks to understand how historically and socially instituted sources of power construct the wider social world through language. Given. 2008. The Sage Encyclopedia of Qualitative Research Methods: A-L ; Vol. 2, M-Z Index. SAGE.

Therefore, taking Hajer's perspective on discourses we can argument that indeed power and discourse could be central in the SESF as suggested Clement (2013). For example, if we reconnect discourse and power to a sustainability assessment (SA) we could firstly analyse the varied meanings and interpretations of sustainability concepts; and secondly the theory and practice of SA which influences the linked social, economic and political settings (S) of the SESF (See Figure 1.5b for suggested application). As Hugé (2012) argues, a sustainability discourse can trace how SD emerges as a key policy principle in a particular context, and how its meaning evolves and shapes institutional settings, patterns of social life, guides discussions and becomes institutionalised in practices such as sustainability assessment (Hugé, 2012). Hugé explains that there would be a two-way relationship between discourse and sustainability assessment:

- First, discourses influence SA, as particular sustainability discourses enable and constrain the consideration of available policy options to solve sustainability challenges. Consequently, the range of available policy options, assessed through SA, will be influenced by the dominant sustainability discourse(s) in a particular context.
- Second, SA may also impact upon dominant discourses, as the results of a SA and the actors involved in the assessment process that may gradually change the dominant sustainability discourse through the assessment practice and its outcome. Discourse analysis can therefore enhance the understanding of SA practice and contribute to enhancing the actual impact of SA on policy decisions (Hugé, 2012).

Similarly, in conservation, SES research intends to include cultural, societal structures and institutions to develop sustainable and resilient interactions between humans and nature (Mace, 2014). However, to date much of the SES research has not been able to couple social and ecological aspects of the systems, and in most cases it does not include any biodiversity measures (Rissman and Gillon, 2016). Accordingly this refers back to the suggestion by Epstein *et al.* (2013) and Vogt *et al.* (2015) to include more ecological theory into the framework (Ecological Rules, Table 1.2.). For conservation this is critical because the resulting and complex inter-linkages of SES have many feedback mechanisms that if not addressed correctly can lead to or increase conflict (Vogt *et al.*, 2015; Rissman and Gillon, 2016). SES research is expanding and its relevance to real-world problems is more apparent, which if widely accepted, can provide guidelines and rules of thumb to form the basis of the theory and practice of the management of natural resources (Cumming, 2011).

1.5. Adaptive co-management of SES

Adaptive management is an approach to resource management based on the science of learning by doing, that emerged as a novel attempt to reconcile conservation biology with sustainable development (Holling and Programme, 1978; Walters, 1986; Lee, 2001). However, the complex paradox of adaptive management that appeared as a policy innovation, failed to deliver certain conceptual soundness aspects as well as technical, ethical and pragmatic policy considerations (Lee, 2001). Therefore, adaptive co-management emerged as better suited terminology and practice that bases its premises in the sharing of power and responsibility among local actors and resource management agencies (Pinkerton *et al.*, 2003); as well as, with the processes of learning and collaboration to respond to complex SES and to link science with policy (Armitage *et al.*, 2009; Kofinas, 2009; Armitage *et al.*, 2010).

An adaptive co-management requires that knowledge of a desired future state (the goals and objectives) of the inter-linked social and ecological systems have to be understood (Van Putten *et al.*, 2016). However to achieve this target, an adaptive co-management requires an explicit acknowledgement of the high uncertainty and the lack of understanding of many key-underlying processes within the SES (Cinner *et al.*, 2009). This means that to deal with the uncertainty and lack of understanding of SES processes, the policy and science communities need to work together to create and implement policies for SES, and to predict and evaluate the outcomes of the management actions (Carpenter *et al.*, 2009). In other words, governance depends on the input from science; and in SES, this input needs to come from the information and conceptual contributions from the natural and societal systems. Although the role of science is critical for governance, one of the major problems in the science-policy interface is the knowledge gaps between science, actions and policy. Therefore to reduce this gaps, scientists have to be able to provide evidence with technical rigour but also equally understand the policy making process to correctly frame practical solutions and inform policy makers (Rose, 2014). These practical solutions should be generated by the co-production of knowledge from a variety of non-state actors: NGOs, private corporations as well as the scientific community and other actors of civil society (Luks and Siebenhüner, 2007). Therefore, novel participatory methodologies and tools that can retrieve adequate information about the key-underlying processes of SES and which can engage a variety of stakeholders, are necessary. In conservation, these methodologies must provide understandable outcomes that can guide and be applied by policy and decision makers so that potential conservation problems are mitigated and not increased. In Chapter 2, I will introduce participatory methods and provide an overview of three methodologies that I have selected and used for my research. Their application, based on three cases, will be detailed in the empirical section of this thesis (**Chapters 3-5**).

1.6. The Galapagos Islands

For this doctorate thesis I base my research on the Galapagos Islands. The Galapagos archipelago straddles the equator approximately 960 km west of mainland Ecuador and 1100 km south of Costa Rica. The archipelago comprises seven major islands (> 100 km^2), 11 smaller islands (1–100 km^2), and 120 islets and rocks. The total land area of the archipelago is approximately 7980 km^2, 97% of which is protected by the Ecuadorian government as a National Park (GNP). Additionally, the Galapagos Marine Reserve (GMR), which is the third largest in the world (~133,000 km^2), protects the waters within 40 nautical miles of the island group (Figure 1.7). This unique archipelago has a global significance for conservation and in particular for natural and evolutionary scientists. However, beyond its renowned association as a living evolutionary laboratory, the Galapagos archipelago is also a place where much less known, but very interesting social-ecological dynamics are taking place. This was -in part- one of the major motivations to structure this doctorate thesis centred in the Galapagos Islands as a SES. However, as I have introduced in the previous subsections, the study of SES encompasses many interlinked social and ecological dynamics. Yet, in Galapagos from the creation of the Galapagos National Park in 1959, most of the research as well as its governance has tilted towards protectionist conservation approaches. Using narratives such as “nature at risk” to accentuate how human activities degrade the environment and in particular certain societal groups (e.g. fishermen and farmers), which have constrained possible conflict resolutions and rather reinforced relations of power, privileges and class (Lu *et al.*, 2013). This may have been strengthened by the fact that the Galapagos archipelago has no native human population, giving human presence to many the character of 'intruding'. However, as I will show in **Chapter 4**, the evolution of conservation discourses in Galapagos has shifted and now also includes more human and nature approaches to conservation. Moreover, although I will introduce the Galapagos Islands in the empirical sections of the thesis (**Chapters 3-5**), in **Chapter 3** and based on the research we have produced, a clear overview of the current status of Galapagos as an SES will be fully illustrated. Therefore, in this section I will briefly describe the recent history and relationship between humans and nature in the Galapagos Islands.

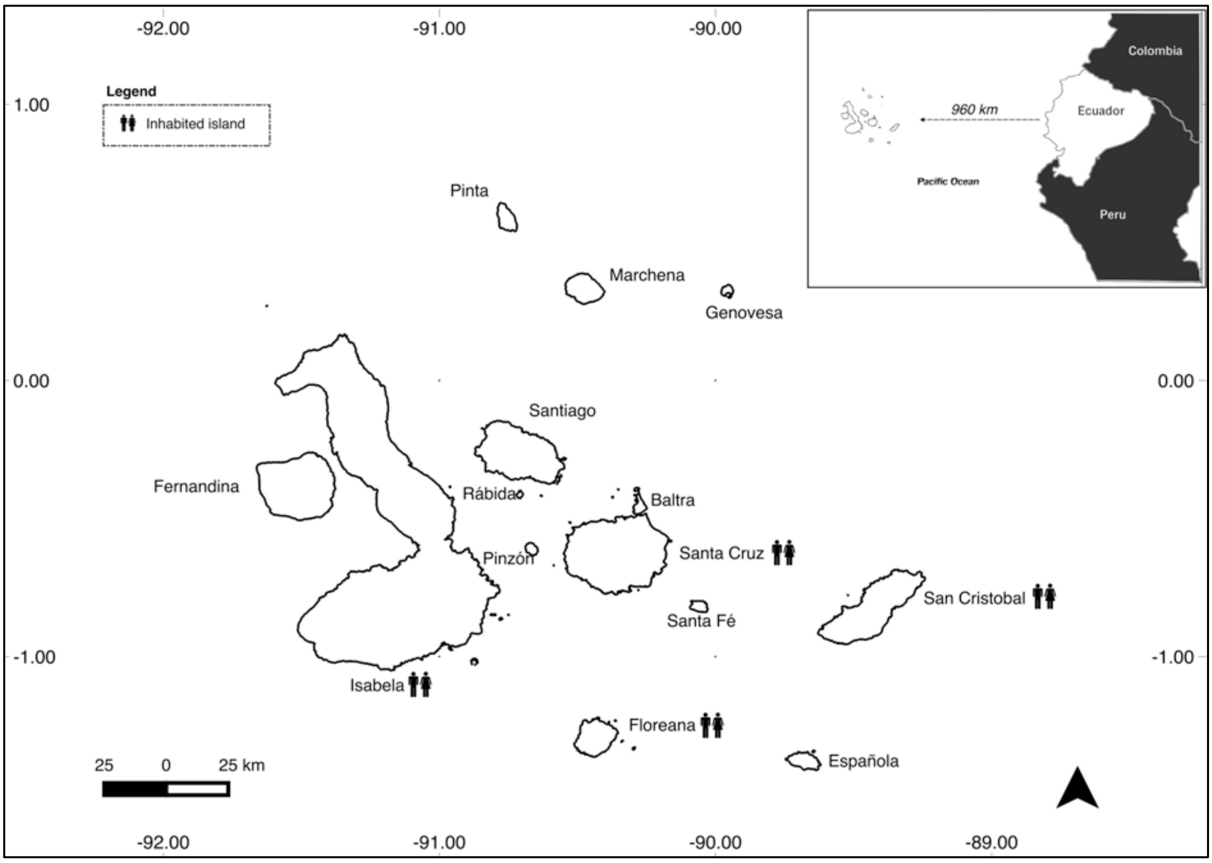

Figure 1.7. Map of the Galapagos Islands.

1.6.1. The history of the human-nature relationship in the Galapagos Islands

If compared to other oceanic archipelagos the history of the human-nature relationship is relatively short and can be grouped into four major periods: (i) discovery and extractive exploitation, (ii) colonisation and global geopolitics, (iii) protectionist conservation; and (iv) new conservation views and policies. The resulting human-nature values associated with these four major periods are largely influenced by the prevailing global resourcist view on nature (Oelschlaeger, 1991); and are all concurring today in Galapagos (see Figure 1.8).

1.6.1.1. Discovery and extractive exploitation

The Holy Roman Emperor Charles V and king of Spain, instructed Fray Tomás de Berlanga, the bishop of Panama, to journey to Peru and unravel the feuding of the conquistadores (Spanish and Portuguese) over their new empire. This is how Fray Tomás de Berlanga, after losing the trajectory for several days from the equatorial coast, came to discover the Galapagos archipelago on the 10^{th} of March 1535. In the letter to Charles V deposited in Sevilla in the Archivio de los Indias (in ref.), Fray Tomás describes the journey and the discovery of the remote islands. However, what he found and wrote was of little value for the empire: no gold, no freshwater, deserted volcanic lands unsuited for agriculture and strange creatures such as snake-like iguanas and many giant tortoises whose carapaces resembled horse saddles (Galapagos in Spanish); for which the islands were known as *Las Islas Galapagos* (Torres de Mendoza, 1869).

It is clear that in this point of history, Galapagos wilderness was of no value since its resources could not be gathered or exploited for human use. After this period Galapagos remained little explored only by a few pirates around the year 1570. However, in 1684 during the 'golden age of piracy and buccaneering' (1650s- 1730s) and ‘mapping’, James Edward Cook with the explorer William Dampier and the buccaneer William Ambrose Cowley, landed on Galapagos. They are the first to provide detailed maps and accounts of the islands’ natural history, as well the archipelago’s ability to provide food from fish, birds and sea and giant tortoises (Stewart, 2006). Years later in the 1790s when the world whaling returns were declining in the Atlantic, Dampier’s book ‘*A new voyage round the world*’ (in Ref.) provided the British-based whaling company Enderby and Sons with sufficient elements to send Captain James Colnett for an explorative Royal mission to the Pacific Ocean. Colnett’s report allowed for 70 years of commercial whaling in Galapagos waters, as well as realising the value of giant tortoises for their long-standing ability to live during months without water and food (Townsend, 1925). From then onwards, the natural history of Galapagos changed. It was not only the excessive exploitation of sperm whales *Physeter macrocephalus* for their oil, of seals *Arctocephalus galapagoensis* for their furs, of giant tortoises *Chelonoidis* spp. for their meat and oil that is estimated in the extraction of 200 000 adult individuals (Stewart, 2006); but also the introduced rats, goats, plants and probably insects (Tye *et al.*, 2002) that all contributed to alter the pristine and unique environment of the Galapagos archipelago.

1.6.1.2. Colonisation and global geopolitics

In 1832, two years after the creation of the Republic of Ecuador, General José Villamil was determined to take possession of the archipelago by setting the first colony in Floreana Island named after the first President of Ecuador Juan José Flores. Villamil established the first colony in the archipelago together with a few artisans, political dissenters, banned soldiers, convicts and deported prostitutes from Guayaquil city. Villamil had invested most of his personal fortune to exploit and to manufacture dyes from the lichen *Roccella babingtonii* (Idrovo, 2005). This is also the time when Charles Darwin, in 1835, arrived to Galapagos and was in fact received by one of Villamil's English delegates, the co-governor Nicholas Lawson (Darwin, 1845). Although many crops (fruits, vegetables) and animals (pigs, cows, dogs and cats) were brought to allow the human population to thrive in Floreana, the harsh conditions of the island for farming, the scarcity of water, the increasing number of convicts sent from the mainland and the fact that the lichen project did not make any profit, ended by the collapse of Villamil's project in 1838. This forced people to move to other inhabited islands such as Chatham, today San Cristobal Island (Idrovo, 2005; Stewart, 2006). From 1839 to 1869, the economical debts and the political instability for the consolidation of the Ecuadorian State, favoured three attempts to sell the Galapagos Islands to the United Kingdom in 1839, France in 1862 and USA in 1868. All nations rejected the offers. During the Ecuadorian military presidency of Gabriel Garcia Moreno in 1869, a second colonisation attempted was set under the direction of the Spanish merchant José Valdizán to restart the lichen enterprise in Floreana. The enterprise failed and ended in 1878 when one employee, a former convict, murdered Valdizán. It is important to note the contribution during this period of the German naturalist Theodor Wolf, who from 1875 to 1878 retrieved bio-physical data from Galapagos (ocean temperatures, humidity and elevation measurements), and provided the first geographic maps of Ecuador and Galapagos (Wolf, 1892).

The lack of government interest in Galapagos and the generalised latifundium[6] reaction to the liberal reforms in Ecuador attracted Manuel J. Cobos, a lone entrepreneur who settled in Chatham (San Cristobal Island) in 1879. The available resources of the island were water, salt, 10 000 heads of wild cattle, fish and giant tortoises. These would be sufficient to maintain the population of 100 people inhabiting the island. Hence, Manuel J. Cobos first focused on the livelihood subsistence trough traditional agriculture (crop cultivation) and cattle rearing. Later he expanded with his most lucrative enterprise 'the oil extraction from giant tortoises'. By 1888 Cobos already counted with 800 heads of domesticated cattle and approximately 107 hectares of crops (Latorre, 1999). Manuel J. Cobos built one of the most important sugar cane farms (*El Progreso*) of the region. By 1889, the farm was so prosperous that it even depleted the scarce giant tortoises from the Island, just to sell their oil for the obsolete street lighting in Guayaquil city. Although *El Progreso* produced sufficient sugar for the whole mainland during 25 years (1879-1904), it also produced several crops that were sufficient to feed the 400 workers of the farm. These crops included: coffee, manioc, plantain, potatoes, corn, beans and other legumes. Cobos managed to have a magnificent railway infrastructure, a seaport with fleet vessels permanently traveling to the port of Guayaquil with cattle and products such as sugar and coffee, irrigation canals and drinking water infrastructure (Chiriboga and Maignan, 2006). However, the success of the farm was not a mere coincidence. Manuel J. Cobos was known to be a tyrant and slaver and in 1904 an assassination complot was carried out by his workers, which ended his life. (Idrovo, 2005). After this, Cobos' son managed the farm, although with less success, until 1946 when it finally collapsed. Today Cobos' heirs claim to have more than 1800 ha of land in San Cristobal (Chiriboga and Maignan, 2006).

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[6] A latifundium is a large piece of contiguous land that belongs to a single individual or family. It is a form of property as well as a mode of production that for centuries has determined the socioeconomic structures in many parts of the world, even through to the present day Darity. , ibid.
i

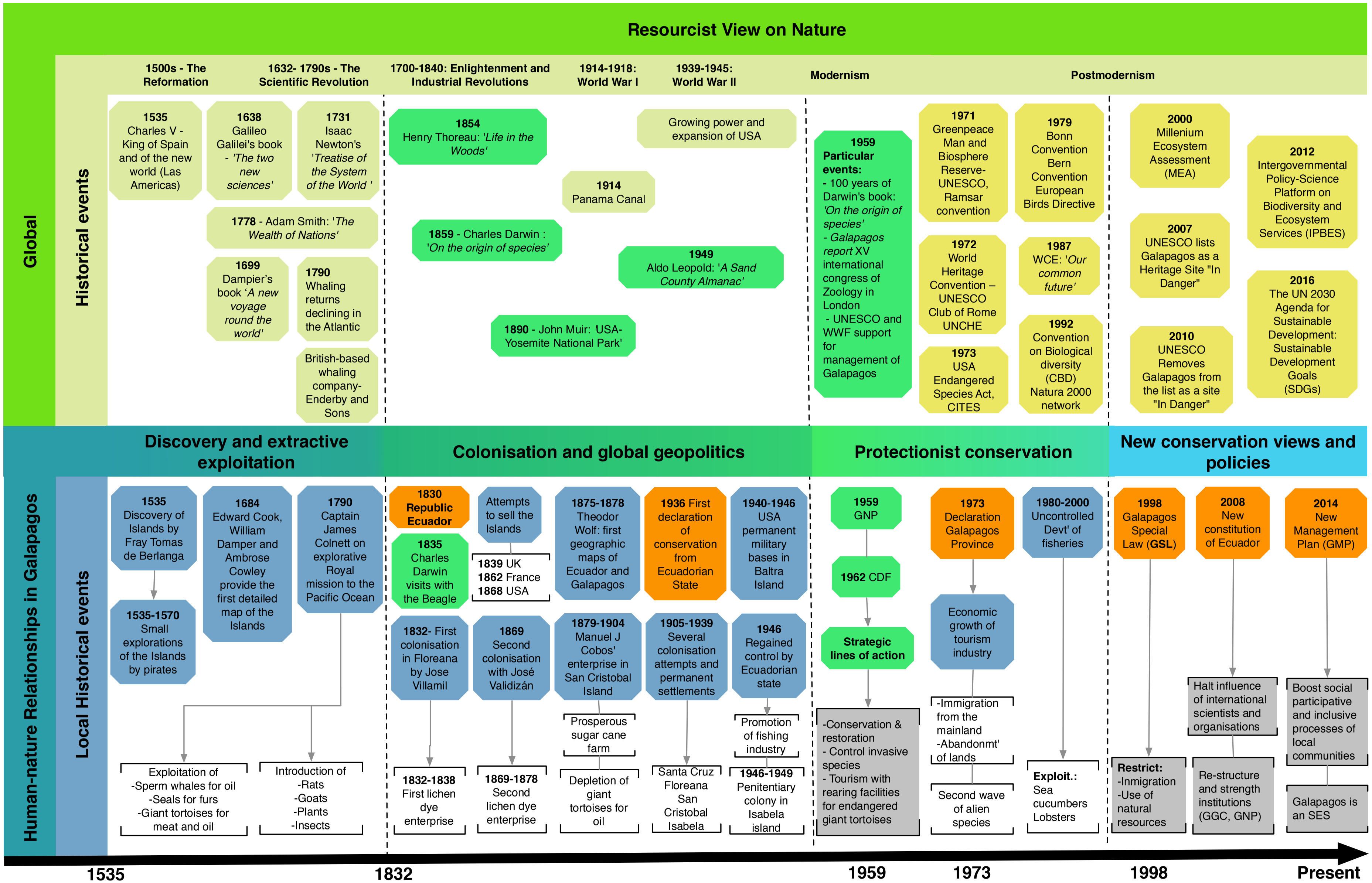

Figure 1.8. Timeline of a selection of crucial events and processes of the four major periods of human-nature relationships in Galapagos
Events at global scale (green), include also the resourcist view on nature sensu Oelschlaeger (1991). Important conservation events (bright green), local legislation(s) and policies (orange), and creation of important international treaties, legislations, organisation, steps of scientific conservation related progress (yellow) are also indicated. Moreover, some of the resulting strategic actions and management plans (grey) that are at the bottom of the timeline.

It is important to note that besides sugar, also coffee was produced in large quantities and exported. By 1905, it was estimated that there were 100 000 coffee plants in San Cristobal, many of which were still present by 1990, although unproductive (Latorre, 1999). Manuel J. Cobos represents the entrepreneurial class that emerged during the Industrial Revolution to supply the growing urban and commercial centres in Ecuador with the necessary resources. From 1905 to 1939, several colonisations attempts and further permanent settlements were established in the current four inhabited islands: Isabela, Santa Cruz, San Cristobal and Floreana. During this period the archipelago remained little inhabited with an estimated population of 500 and 700 people in 1920 and 1940, respectively (Table 1.2). However, the decade of the 1920s was characterised by increasing demands for plots of land to colonise these islands, which was mostly a consequence of the economic crisis that Ecuador underwent and that would reach its peak in 1923 (Latorre, 1999). Yet, the colonisation attempts that received more attention were not from the mainland Ecuador but from groups of European countries, mainly Norway, Germany and Austria. The motivations behind these groups of Europeans were varied, but one that prevailed and attracted many of them was the romantic idea of pristine and natural environment, largely influenced by William Beebbes' book '*Galapagos: World's Eden*' (Beebe, 1924).

This is how in 1925 the Norwegian August Christensen signed an official 10 years agreement with the Ecuadorian Government to settle in Floreana, San Cristobal and Santa Cruz. Christensen and his Norwegian enterprise were granted 22 plots of 20 hectares each, and the permission to hunt and fish in the archipelago. In 1926 the first wooden house for the whaling and fishing centre was built in Floreana. In 1927, 30 Norwegian families (80 people) settled in Santa Cruz 42 Norwegians settled in San Cristobal. However, by 1928 all the Norwegian enterprises collapsed. The alleged causes for the collapse were once again, the harsh conditions of the islands, including the lack of water for growing crops, the unfamiliarity with the tropical conditions for preserving fish, and the relative isolation of the Archipelago with only one or two boats coming from the mainland every year (Latorre, 1999). From 1929 to 1934 a few Germans and Austrians came to settle in Floreana. However, unlike the Norwegians who had come with the idea of setting a prosperous enterprise in Galapagos, the Germans and Austrians came to Floreana to run away from the moral crisis in Europe. A crisis that was attributed to the modernisation and mechanisation and that had caused a wave of suicides, corruption and violence. The history of these settlers in Floreana is rather dramatic and full of mysterious deaths (4 out of 6) and has remained as part of the human history of the Archipelago[7].

For this period it is important to note that Galapagos received the first declaration of conservation from the Ecuadorian State to become a national reserve, in 1936. The law enacted three main premises: *i*) delimited areas for agricultural development and exploitation, *ii*) the value of the flora and fauna for tourism; and *iii*) all the islands were declared protected areas with the exception of the north part of Isabela and the south part of San Cristobal which were legally owned by a few families. This transition from an exploitative/resourcist view to the first protectionist views in Galapagos is the result of a process in which the value of nature is recognised and politically legitimised. However, although this declaration was an important first step, it was only truly enforced some 25 years later as described in the following sub-section.

Table 1.4. Number of people inhabiting the island from 1883 to 2010

Year	Number of people	Inhabited Island (s)
1833	120	Floreana
1835	300	Floreana
1890	400	San Cristobal
1920	500	Isabela and San Cristobal
1940	700	Isabela, San Cristobal, Santa Cruz
*1950	1346	Isabela, San Cristobal, Santa Cruz, Floreana
1979	4865	Isabela, San Cristobal, Santa Cruz, Floreana
1982	6241	Isabela, San Cristobal, Santa Cruz, Floreana
1990	9800	Isabela, San Cristobal, Santa Cruz, Floreana
2006	20000	Isabela, San Cristobal, Santa Cruz, Floreana
2010	25000	Isabela, San Cristobal, Santa Cruz, Floreana

** First official census in Galapagos, before 1950 the number are estimates. Source: Ospina (2006)*

This period of colonisation is also remarkable by the global geopolitical events that would directly or indirectly involve the archipelago. In particular the construction of the Panama Canal (1914), World War I (1914-1918) and World War II (1939-1945) and the growing

[7] This part of the human history in Galapagos has been portrayed in an interesting documentary entitled: "*The Galapagos Affair: Satan Came to Eden*" (2013). Directed by Daniel Geller, Dayna Goldfine

power and expansion of the USA. Because of its location, the Galapagos Islands were considered as a strategic war point to defend the Panama Canal and also as an intermediate scale from Panama for the US planes and large Clipper hydroplanes towards Samoa, the Philippines and Hong Kong. In 1940 after World War II had begun, the influence of the USA in the whole Latin American region was set. Galapagos was considered a vital strategic site in the south Pacific not only for the protection of the Panama Canal but also to fight the Axis which were US enemies in the Pacific such as Japan. After several military treaties with Ecuador, the US Navy and military set up a permanent base in the archipelago in the island of Baltra and would take full control of the archipelago until 1946 when the Ecuadorian state reclaimed its sovereignty over the archipelago. World War II was a decisive point in the history of the region and would allow to ultimately promote the booming of neoliberalism in Ecuador for more than 50 years with the installation of US military bases in the mainland until 2008 (Idrovo, 2013). After WW II and with more regained control by the Ecuadorian State, Galapagos served two main purposes: to promote the fishing industry and to use Isabela Island as a large penitentiary colony. This ended tragically in 1959 due to the many deaths caused by the awful humanitarian conditions the prisoners underwent (Idrovo, 2013). Today, the ‘wall of tears’, a touristic site in Isabela is the only reminder of these obscure times in the Island (Rodas-Ziadé and Vivancao-Cardenas, 2012).

1.6.1.3. Protectionist conservation

By 1959, Galapagos’ unique native ecosystems, especially in the humid highlands of the inhabited islands, were transformed. In particular due to the expanded agricultural activities (livestock rearing and crops), but also by the increasing number of exotic plants and animals which accelerated the rate of change (Gonzalez *et al.*, 2008). Thus, in the same year three concatenated events pressured the Ecuadorian State to protect the Islands: i) the detailed report about Galapagos presented at the XV International Congress of Zoology in London by the Austrian biologist Ireneus Eibl-Eibesfeldt, ii) the UNESCO and WWF support for the management and protection of the archipelago, iii) the celebration of 100 years of Darwin’s book *“On the origin of species”* (in ref.). Thus, the 20th of July 1959, the Galapagos National Park (GNP) reserve was created with the goal of protecting 97% of its flora and fauna (7995 km^2), with the exception of the formerly colonised areas. Almost simultaneously, the Belgian scientist Victor van Straelen received the economic support from the Belgian Kingdom to create the Charles Darwin Foundation (CDF) in Brussels, and set up the first independent international scientific research station in Santa Cruz Island in 1962. The Charles Darwin research station immediately worked on unravelling the status of species at risk by censing the birds and marine mammals in the whole archipelago.

This protectionist conservation period is characterised by Galapagos' conservation policies being guided by international scientists and being influenced by foreign institutions (Gonzalez *et al.*, 2008). During the following three decades, the CDF jointly with the GNP defined the strategic lines of action that included: conservation and restoration, research and management, involvement of visiting scientists, education and training, international workshops, control of invasive species and tourism with rearing facilities and corrals of adult endangered giant tortoises (Cayot, 2008). Although there was a relative success with the breeding of giant tortoises and control of invasive species, the declaration of Galapagos as a new province of Ecuador in 1973, boosted social conflicts (Box 1.1). Conservation and development objectives clashed, mostly due to the effects of the economic growth from the tourism industry that attracted immigration from the mainland and motivated the rural agricultural population to abandon their lands and move to the coastal villages; thus favouring the arrival of a second wave of alien invasive species (Gonzalez *et al.*, 2008). Moreover, from the beginning of the 1980s to the early 2000s, the growing and uncontrolled development of fisheries with the over-exploitation of sea cucumbers and lobsters ('gold-rush' on exploited species), generated a new era of conflicts in the archipelago (Bremner and Perez, 2002) .

Box 1.1. Social movements and land distribution in Galapagos

In 1904 after the assassination of Manuel J. Cobos in El Progreso in San Cristobal, the agricultural sector in Galapagos, although predominant, remained considerably small and under-developed. In part, this was related to the small number of inhabitants (700 in 1940), but also because of the isolation and the difficult conditions for farming in the archipelago. Late in the decade of the 1940s, the overruling latifundia scheme was gradually changed to a minifundia scheme, which as only institutionalised under the first agrarian reform of Ecuador in 1964 (Chiriboga and Maignan, 2006). However, by 1950 agriculture became less predominant as new sectors became leaders. The most important of these sectors was fishing, which started to grow in the 1950s (Quiroga, 2013). During the 1950s and 1960s the precarious conditions of farmers in the mainland and several catastrophic events (e.g. earthquakes, droughts) favoured a large immigration of people to the archipelago. The new immigrants would either dedicate to farming (required appropriation of lands), fishing or commerce.(Chiriboga and Maignan, 2006). However, more and more, people living in the highlands and dedicated to agriculture descended to the coastal areas to participate in the fishing activities, mainly fishing bacalao (*Myctorperca olfax*). Green and red spiny lobsters fisheries (*Panulirus penicillatus* and *P. gracilis*) which started in the 1960s became major exports in the 1980s (Hearn, 2008).

In 1974, after Galapagos was declared a Province, a process of legalisation of lands was initiated. This process involved the government's incentive to people or institutions to take as many lands as they wanted. The process was also aimed at concreting the delimitation between the rural areas and the national park. Thus, former workers, farmers and anyone with interests in farming took possession of plots of lands, which varied from 10, 20 or even 200 ha. By 1980, all plots lands were registered and any new immigrants coming to the archipelago would have to buy the lands. Chiriboga and Maignan (2006) explain that the legalisation of lands triggered the development of agriculture with commercial purposes. Many farmers captured wild cattle to regroup it in their lands, as a way of marking possession or to exploit the large areas that they had received. The production of vegetables increased while the main ports were being developed. Many landowners hired day labourers to cope with the increasing demand of agricultural products. However, the growing competition with the fishing and public sectors; and the agricultural products coming from the mainland with more frequency (twice a month), made agriculture little attractive for local people. In 1980 the first shortage of local labour was reported, although it was compensated with an increasing influx of labourers from the mainland. The 1980s is characterised by the establishment of several families in the agricultural sector, but only if they did not have any other work opportunities in the other sectors. This group of families constitute most of the productive farmers in Galapagos today (Chiriboga and Maignan, 2006). In 2010, the latest population and housing census reported 762 individuals working in the agriculture sector in Galapagos, which represents one farm worker for every 31 ha of agricultural land. At the national level, the average is of one worker for every 10 ha (Guzman and Poma, 2015).

1.6.1.4. New conservation views and policies

The increasing social conflicts (increased by tourism and immigration) and ecological degradation (invasive species and depletion of marine resources) that emerged during the 1990s (Box 1.2), was counter-acted by creating and passing the Galapagos Special Law (GSL) in 1998. The GSL gave the archipelago a special political autonomous status that was intended to achieve conservation and sustainable development in the province and its National Park (GNP) and Marine Reserve (GMR). The GSL was used to enforce the restrictions of the immigration from the mainland and the use of natural resources by the local communities; in particular of fishermen. However, the GSL was criticised because it had excluded local communities, polarised power to weak governmental entities, and favoured certain societal groups who took control of tourism, fisheries and the administration of urban areas (Grenier 2007). As Hoyman and McCall (2013) explain the problem with the GSL, as with many public policies, is that innate cultural, political and social forces influence the successful implementation and enforcement of such legislations. In Galapagos, these forces are mostly related to: i) a social capital formed by a knit community that inhibits government duties and, ii) persistent policy conflicts by groups of powerful economic interests (e.g. fishermen vs. conservationists) which often results in competing policy goals (Hoyman and McCall, 2013). These forces clearly illustrated the power relations in Galapagos and that produce an imbalance of the system (competition). Solving these issues will require several mechanisms such as institutional level reforms or the creation of a societal conservation culture. However, I here argue that it will also be very important to account and include all the different views and values that form the current Galapagos society. More inclusive and honest relationships need to be built and these will only be created by the exchange and co-generation of knowledge among the various societal actors. Only then the implementation of any intended policies and legislation for conservation and sustainability will succeed (Jerneck *et al.*, 2011; Brandt *et al.*, 2013).

In 2007, the continuous and unsolved conflicts in the archipelago from the weak governance to increasing ecological degradation of the protected terrestrial and marine areas, forced the UNESCO to place the archipelago on the list of World Heritage Sites “In Danger”. However, with the new constitution of Ecuador established in 2008, new policies and governance changes for Galapagos were established (Constitution of the Republic of Ecuador, Article 258). One of the most notorious changes was to halt the influence and control of international scientists and organisations (e.g. CDF, WWF, CI) in the governance, and re-structure and strengthen the local weakened institutions and governance. Thus, the Galapagos Governing Council (GGC) was created as the entity in charge of planning the coordination and management of the natural resources in the archipelago, which includes the protected and non-protected areas. The second institution that was strengthened was the Galapagos National Park (GNP), which was designated as the only responsible entity for the conservation, ecological integrity and biodiversity of the islands and marine ecosystems of the protected areas (GMR) as well as the rational use of goods and services, generated by or for the local community. The role of other influential international organisations such as the CDF was reduced and limited to the provision of technical and advisory support based on scientific research to the local and national institutions to guide decisions on Galapagos conservation issues. From 2008 to the present, new management plans and conservation views have emerged. Thus, in 2010 the UNESCO removed Galapagos from the ‘In Danger’ list, as they considered that enough efforts were being taken to control and prevent biodiversity loss. The latest goals and visions for conservation in the newly released Galapagos management plan for its Protected areas in Galapagos (GMP) intends to boost social participative and inclusive processes by linking the distant local communities to conservation (objective No. 4) and by acknowledging the management of Galapagos as a social-ecological system[8] (objective No. 5) (DGNP, 2014). These legislative and governance dynamics are the backdrop against which this doctoral research has been conducted. I expect it strongly shaped the discourse landscape today though retrospective observation of social attitudes and former discourses are no longer possible. This is why we intended to gauge the actual discourse landscape and its societal actors, which will define the policy options of the (near) future.

[8] Social-ecological systems are defined in the GMP as: *“an ecological system that in a complex way is associated and interacts with one or more social systems. The ecological systems encompass the biophysical base (natural capital) in which the socio-economic and cultural systems, comprising all the components related to human welfare, are being developed* (DGNP, 2014).

Box 1.2. The beginning of social conflicts and social research in Galapagos

With the growing southeast Asian economies and consumer purchasing potential, came an increased demand for sea cucumbers (*Isostichopus fuscus*) for which an emergent unregulated fishing industry developed in the early 1990s (Hearn, 2008). The GNP tried to regulate the fishing industry but this resulted in tensions and conflicts which would extend from 1994 to 2005 (Hearn, 2008; Quiroga, 2009). The conflicts with the fishing sector were the underlying cause of the appearance of social studies in in the archipelago's science landscape, which was by then heavily dominated by natural sciences. It is only from the early 1990s that social related studies (anthropology, sociology, human geography) emerge. Social-economical and territorial aspects, including the first suggestions to halt immigration, reduce tourism and the common pool management of natural resources, were among the most notorious contributions of the social studies for the planning and management of the archipelago (Grenier, 2007). However, most of these studies were also almost exclusively centred on the fishing sector and its actors often involving attitudinal, gender, socio-economic and management aspects of the fisheries (e.g. Arboleda, 2002; Viteri and Chávez, 2007). As Ospina (2006) notes: "although the links between social research, planning for development and ecosystem conservation have been strengthened since 1991, other political and important economic sectors such as construction, agriculture or even tourism still remain completely understudied" (Ospina, 2006). Today, this reality remains little changed with counted contributions related to tourism and economy (Powell and Ham, 2008; Taylor *et al.*, 2009; Hennessy and McCleary, 2011; Pizzitutti *et al.*, 2014; Mejia and Brandt, 2015) and a few more contributions in the fields of political ecology, social ecological studies, management and governance (Gonzalez *et al.*, 2008; Cairns, 2012; Celata and Sanna, 2012; Cairns *et al.*, 2013; Ciccozzi, 2013a; Benitez-Capistros *et al.*, 2014; Benitez-Capistros *et al.*, 2016).

OBJECTIVES AND THESIS OUTLINE

1.7. Objectives and thesis outline

The practice and implementation of biodiversity conservation and sustainable development, although conceptually interconnected, depend upon the correct understanding of the SES dynamics in place. Understanding these SES dynamics requires integrating the knowledge of the various societal actors that create and shape the way in which conservation and sustainability are practiced, talked about and will ultimately be implemented. In the Galapagos Islands the interconnected and dynamic social, ecological and governance processes interact in a complex SES at different levels (Figure 1.9). These linkages need to be explored and understood so that the best practices of biodiversity conservation and sustainable development do not overlap and can benefit both nature and humans.

1.7.1. General objective

The **general objective** of this thesis is to elucidate the understanding of key-underlying processes of social-ecological systems with novel participatory methodologies, in order to support and guide conservation science and management in the context of a dynamic, changing governance of the Galapagos archipelago.

1.7.2. Specific objectives

1. To generate a set of consensus expert-based indicators that can explain the general environmental impacts and the relationship with human activities and ecosystem services on the Galapagos Islands, as well as to provide solutions to facilitate the conservation and management of the archipelago.

2. To determine and map conservation discourses in the Galapagos Islands to assess the degree to which these are influenced by the successful conservation of the iconic Galapagos giant tortoises; as well as to compare these discourses to global

conservation governance and conflicts with other iconic or well-known species elsewhere.

3. To characterise the emergent conservation conflict between humans and giant tortoises in the rural agricultural area of Santa Cruz island, in order to assess several specific socio-economic and ecological inter-linkages and to provide a range of possible scenarios and actions to effectively inform policy makers and managers to improve the social-ecological fit of conservation strategies.

4. To provide decision and policy makers with understandable recommendations about the use and application of the different participatory methodologies to address the gaps of knowledge in the complex social-ecological dynamics for conservation science and management.

5. At the same time, as a scientist, I intend to understand the Galapagos Islands case in order to provide a system, which can then be used to understand the relevance and applicability of the research to other non-Galapagos social-ecological systems.

6. Assessment of suitability and applicability of the various participatory and survey methods for a complex social-ecological system (SES).

1.8. Thesis outline

This thesis is divided into eight chapters. **Chapter 1** serves as an introduction to the crosscutting issues related to sustainability, biodiversity conservation and social-ecological systems (SES). It provides an overview of the concepts, processes and problems in conservation from governance to conservation conflicts and how they could be addressed within SES research. Moreover, this section introduces the selected study site: the Galapagos Islands, and provides a brief overview of the history of its human-nature relationships. Chapter 1 concludes with presenting the general and specific objectives of the thesis. **Chapter 2** introduces participatory approaches in conservation and the description and use of the three selected methodologies in conservation. The chapter includes a presentation of the research framework (Figure 2.1). **Chapter 3** introduces the first case study with the use of the Delphi methodology to study the social-ecological dynamics of the Galapagos Islands. The perceptions of environmental impacts and its relation to ecosystem services and to develop impact mitigation strategies in the Galapagos Islands are presented.

Chapter 4 is the second case study and explores conservation discourses, around the iconic Galapagos giant tortoises, through the use of the Q-methodology. In this chapter we compare and relate our findings with global conservation discourses and conservation conflicts with other iconic species elsewhere. **Chapter 5** is the last case study and is centred on studying the social-ecological dynamics of conservation conflicts between the Galapagos giant tortoises and farmers in the rural area of Santa Cruz Island. This chapter presents the use of social and ecological methods: The participatory rural appraisal (PRA) used to retrieve and analyse socio-economic information (social factors); and the transect field observation method used to estimate giant tortoises population densities in the rural area (ecological factors). **Chapter 6** is the general discussion of the thesis in which also a comparison of the methodologies and related results is provided and their relevance and use for conservation and SES in other contexts beyond Galapagos. **Chapter 7** is the concluding section of the thesis where I detail the relevance of the work and reflect on dynamic inter-linkages in SES, discourse analysis for conservation and sustainability of SES; and conservation conflicts. This chapter concludes with the implications and perspectives for conservation science and management of SES. **Chapter 8** comprises the appendices.

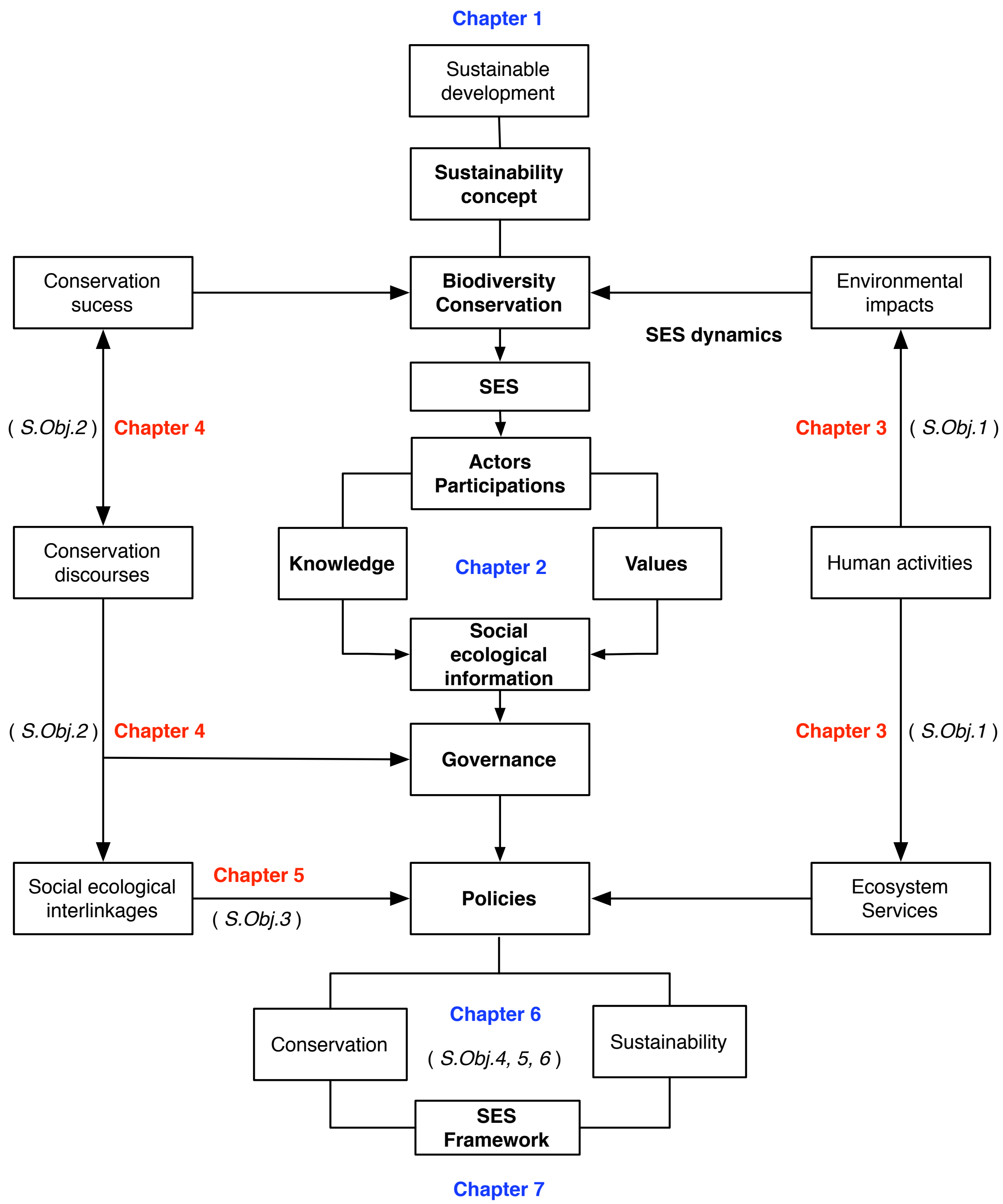

Figure 1.9. Conceptual scheme of the structure of this doctoral thesis.

The scheme represents the connection between concept(s) and component(s) –Sustainability, Biodiversity Conservation, SES, Actors Participation, Social-ecological Information, Governance and Policies– and the corresponding position of the different **Chapters** and **Specific Objectives** (*S.Obj*) that structure this thesis. The empirical **Chapters (3, 4, 5)** are red coloured and are indicated at the extremes of the scheme. In the centre of scheme are the main concept(s); and coloured in blue are the corresponding introductory (**Chapter 1**), methodological (**Chapter 2**), analytical (**Chapter 6**) and concluding chapters (**Chapter 7**) of the thesis.

Chapter 2

METHODOLOGICAL APPROACH

2.1. Transdisciplinary and participatory research in conservation

The shifts in conservation framings over the past decades have also changed conservation research from a strong natural science focus to an interdisciplinary discipline which increasingly integrates social sciences such as sociology, anthropology and psychology (Mascia *et al.*, 2003; Campbell, 2005). The recognition of social factors (e.g. economical, political, institutional) as important drivers of biodiversity decline (Balmford and Cowling, 2006), has engaged conservation scientists with social research and its applications. Hence, participatory approaches to conservation are a consequence of such understanding and change of vision, which recognises that conservation problems are social problems (Moon and Blackman, 2014). The underlying premise of participatory approaches in conservation is that local communities and conservationists have common interests for which conservation scientists can contribute to solutions by providing information to feed decisions by local communities (Newing, 2010). Moreover, integrating local knowledge to science is of particular relevance to reconcile conservation goals and local and indigenous people with governance (Mistry and Berardi, 2016). New collaborative effort between scientists, policy makers, and local communities are increasingly regarded as essential to meet conservation objectives (Brondizio and Tourneau, 2016). Thus, transdisciplinarity and participatory methods have become increasingly widespread within conservation research (Lang *et al.*, 2012; Redpath *et al.*, 2013; Cundill *et al.*, 2015; Adams, 2016) and natural resource management and research, as the benefits of these approaches are realised (Barreteau *et al.*, 2010; Benham and Daniell, 2016).

This however, does not imply that all participatory research and methods are transdisciplinary. What distinguishes and integrates transdisciplinary research and participatory methods is the possibility of engaging stakeholders in the research process. This characteristic is what differentiates transdisciplinary approaches with other approaches, which involve collaboration between researchers working within different disciplines (multidisciplinarity), or on areas that overlap between disciplines (interdisciplinarity) (Benham and Daniell, 2016). Thus, in the context of transdisciplinarity and participation the co-production of knowledge is considered a collaborative process of knowledge production that involves multiple disciplines and stakeholders from several sectors of the society (Pohl, 2008). The co-production of knowledge can foster knowledge transfers between science and decision makers and science and the community (Cvitanovic *et al.*, 2015; van der Molen *et al.*, 2015). Additionally, besides transcending boundaries between academic disciplines, allowing the co-production of knowledge and knowledge transfer among stakeholders, transdisciplinary and participatory approaches to research can encourage environmental policy integration by prompting environmental managers and policy makers to adopt a system approach to decision-making (e.g. SES) that considers socio-economic and ecological aspects as one (Pohl, 2008).

Several key elements have been highlighted as the most relevant ones to consider when conducting transdisciplinary research. According to Russell *et al.* (2008) these should include: i) *Addressing a 'real world problem'*, ii) *iteration and reflection*, and iii) *collaboration and integration of stakeholder concerns*. Lang *et al.* (2012) addresses other complementary issues concerning three phases of transdisciplinary research, which are embedded within broader societal and scientific discourse and practice: Phase A) *Problem framing and team building,* Phase B) *co-creation of solution-oriented transferable knowledge,* and Phase C) *reintegration and application of created knowledge.* Taken together these 6 main elements can improve the development and practice of transdisciplinary and participatory research. In this doctoral thesis I will use these elements to select particular research methods to further discuss the implications of the co-creation of knowledge to provide co-shared solutions to 'real world problems' and its uptake by the different involved stakeholders (**Chapter 6).**

2.2. Participation and stakeholder engagement in research

The rapidly expanding literature on participatory approaches in various domains (e.g. science and technology, health, urban planning, natural resources, industry, risk management), shows a tremendous diversity in purpose, process design and implementation (von Korff *et al.*, 2010). This diversity spreads to the practice of participation, always with the same of 'participatory' label, and with the risk of increasing confusion. Therefore, in this thesis I will focus in particular on participation in scientific research, which addresses the creation of more policy-relevant research outcomes, easier access to information or better diffusion of results (Barreteau *et al.*, 2010). Since in this doctoral thesis I use a social ecological system (SES) perspective, participation could simply be outlined as a process in which the interactions between human and ecological systems are increasingly influenced by public or stakeholder participation von Korff *et al.* (2010). Here however, I will elaborate some more and define participation as *a "process in which the interaction between actors allows for expressing opinions about decisions in any realm of human and societal activities and its interconnections to the ecological system".*

Although defining participation can be somehow scientifically rewarding, this should not be the main focus of participatory research. Instead the strength of participatory research is the diversity in design and implementation, which makes it functional and allows for adaptation and flexibility (Stringer *et al.*, 2006). Details in participatory research are very important, in the sense that outcomes depend on process (Barreteau *et al.*, 2010). The process in turn will be influenced by the degree of involvement of the different stakeholders and powersharing in the process and outcomes. Stakeholders' involvement can have multiple dimensions from designing the research and/or controlling the analysis of data to the dissemination of research findings. Conversely, powersharing will vary from limited information sharing to more extensive engagement and dialogue and deliberative approaches which emphasise informed discussion, reflectivity and the devolution of decision-making authority to participants (Benham and Daniell, 2016).

2.2.1. Key elements and typologies of participatory research processes

As highlighted above, a participatory research process can be complex. However, to illustrate and capture this complexity Barreteau *et al.* (2010) provide an interesting analogy. They reason that participatory research should be considered as a type of public good: *'Any researcher who invites people to take part in a participatory research process will contribute positively to this public good if these participants are happy with the actual process and the outcomes, or will contribute negatively to it if they are not'* (Barreteau *et al.*, 2010). While this analogy is illustrative and understandable it also pinpoints towards certain elements that should be considered in participatory research process. Here, I highlight four key elements based on Barreteau *et al.* (2010):

i) *Procedural transparency.* Already in 1995, Cornwall and Jewkes stated that '*the key element of participatory research lies not in the methods but in the attitude of the researcher… so who defines research problems, and who analyses, generates, represents owns and act on, the information that is sought'* (Cornwall and Jewkes, 1995). Hence, special attention has to be given to the person who has control over the research process and how its outcomes are disseminated. Barreteau *et al.* (2010) argues that although there are no established rules or authorities to enforce adherence to a specific definition, a 'procedural transparency' during the participatory process is required. Primordially, transparency refers to better inform the decision of potential participants to accept or refuse to participate in proposed research processes. Achieving this procedural transparency will also improve researchers' learning about the practice of participatory research (Barreteau *et al.*, 2010).

ii) *Clarifying participants control over information flow.* A participatory research process involves a sequence of information flows in a network of four categories of nodes, where each node represents a category of actors: Stakeholder (S), Policy maker (P), Researcher (R), and Model (M), which is any kind of representation of a system. To clarify the participants control over information Barreteau *et al.* (2010) suggest to use six examples of flow patterns, as observed in different case studies (Figure 2.1).

iii) *Clarify how actors will be involved in the process*. Based on Bots and van Daalen (2008), Barreteau *et al.* (2010) recognises three ways in which actors can be involved in the participatory research process (Figure 2.2). Any of these can be subject to selection by the researcher and his/her methodological reasons:

(a) Stakeholders are involved individually.

(b) Stakeholders are involved as a group that is considered as a whole by the researcher, independent of stakeholders' diversity.

(c) Stakeholders are involved as a heterogeneous group, meaning that the participants have divergent, and possibly conflicting, interests and problem perceptions, and that the participatory process is organized with subgroups to deal with this heterogeneity.

iv) *Clarifying the timing and the setting where information is exchanged.* Timing refers to how the capacity for framing (e.g. influencing issues, questions, and methods) is distributed among the actors in the different stages of a participatory research process. The setting is the arena where the actors exchange information. This arena should be announced and clarified so that any potential discomfort by the actors is anticipated and disappointment is reduced.

These four key elements provide the basis for setting a standard for practice of participatory research. Barreteau *et al.* (2010) considered that these elements are important from an ethical perspective in terms of demonstrating respect towards participants. I consider these as important elements to take into consideration in the practice of transdisciplinary and participatory research. However, as I have mentioned along this section, there is a great variability of approaches to participatory research; there are many modes of participation that may come into play at different phases within the research process, or with different stakeholder groups, and a single research project may contain elements of a variety of participatory approaches such as both co-design and collaboration (Benham and Daniell, 2016). Recognising this complexity, several authors have developed a number of frameworks to categorise participatory approaches to research. Here, I chose to use the typology of participatory research from Benham and Daniell (2016) who already drew on the different categories of participatory research from Probst *et al.* (2003) and Barreteau *et al.* (2010). This typology of participatory research approaches is based on the level of stakeholder control over the research process and outcomes (see Table 2.1).

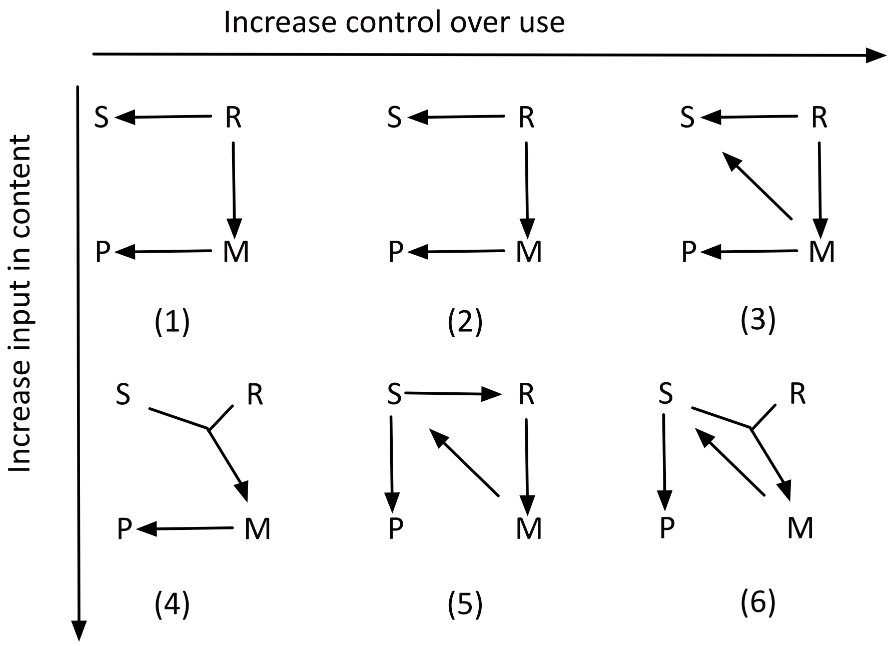

Figure 2.1. Categories of participatory research process according to flows of information
(1) Information on research outcomes and no control over model use, (2) consultation and no control over model use, (3) dialogue with researchers and no control over model use, (4) co-building of a model and no control over model use, (5) Dialogue with researchers and control over model use; and, (6) Co-building of a model and control over model use. Modified figure and adapted legend source: Barreteau *et al.* (2010).

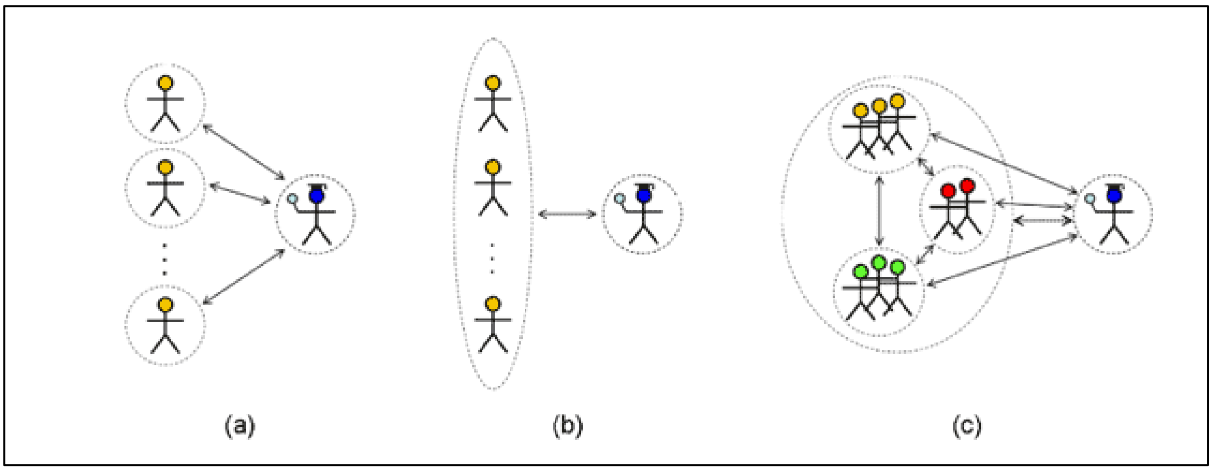

Figure 2.2. Different ways of involving heterogeneous actors in participatory research
The dotted lines demarcate interaction boundaries between actors, and the arrows denote interaction organized and facilitated by the researcher. Modified figure and adapted legend source: Barreteau *et al.* (2010).

Table 2.1. A typology of participatory research approaches

Form of participation	Direction of information flow	Characteristics
Information	One way	One or more actors (researchers, managers or policymakers) can be considered the 'owner' of the research process. Research participants are informed by owners about how their information will be used in research outputs.
Consultation	Limited two-way	Most of the key decisions are made by the researcher(s), but emphasis is put on consultation and gathering information from other actors, especially for identifying constraints and opportunities, priority setting, and/or evaluation. In consultative research, "researchers may filter the information provided by stakeholders, translating this information into pieces of knowledge for the model according to their own pre-existing sets of knowledge and beliefs". The 'owner' of the research process has control over the research design and most of the decisions taken in the research process. Other actors participate in activities defined by this 'owner' by providing services and support.
Delegation	Limited two-way	The 'owner' of the research process has control over the research design and most of the decisions taken in the research process. Other actors participate in activities defined by this 'owner' by providing services and support.
Dialogue	Two-way	Iterative and interactive processes between stakeholders and researchers. Researchers still translate stakeholder inputs and make final decisions but there is genuine feedback between groups that informs the research process and outputs.
Collaboration/ Partnership		Different actors collaborate and work together as colleagues or partners, emphasising links through an exchange of knowledge, different contributions, and a sharing of decision-making power during the process. "Ownership" and responsibility are equally distributed among the partners, and decisions are made by agreement or consensus among all actors. This may occur through deliberative processes
Citizen control	Limited two-way	Research participants are the "owners" of the process and they hold primary decision-making power. Deliberative decision making rules and processes may be used.

Table source: Benham and Daniell (2016)

2.3. Selection of participatory methodological approaches

While there might be no specific rules selecting a participatory methodology, in the frame of this transdisciplinary work two important elements will be considered as crucial in the selection and use of a participatory methodology. First, to involve, as much as possible, a wide variety of stakeholders in the research participatory process; and second, to conduct the research process with 'transparent attitude' in order to define the problems, act on the information and knowledge that will be gathered and co-created and subsequently disseminated. With this we expect to bridge local knowledge to science and policy. The initial problem definition and selection of a methodological approach will need to respond to the specific objectives 1, 2 and 3, which correspond to the empirical **Chapters 3, 4,** and **5**. Therefore, in the following subsections I will align each of these specific objectives with an overview of a related methodological approaches and the methodology of choice to respond to conservation challenges and policies (Figure 2.3). The selected methodologies will be detailed in their corresponding empirical **Chapters** (**3, 4 and 5**), while in **Chapter 6** I will provide a comparison of the three methodological approaches as found in the different stages of the research (Table 6.1).

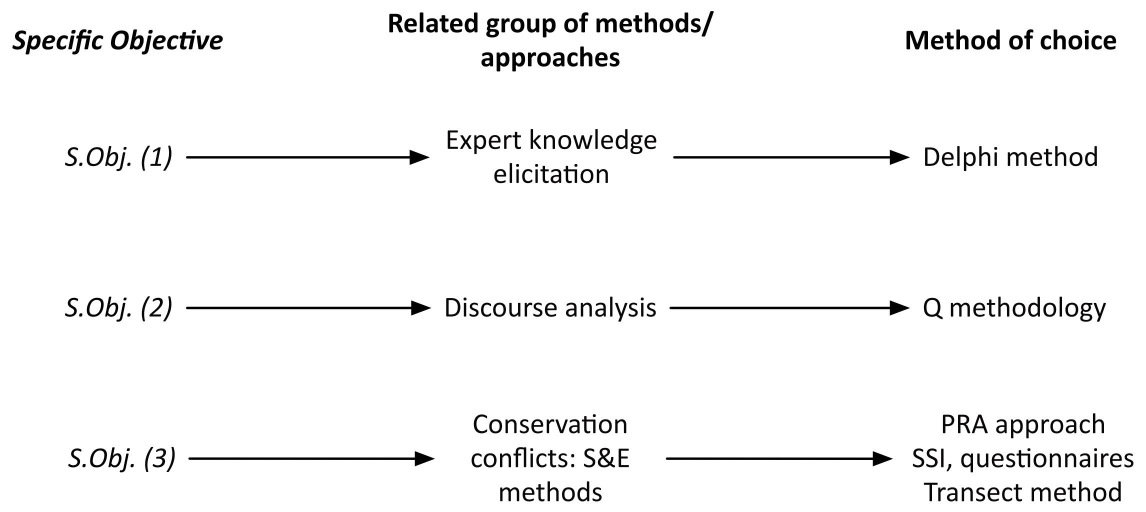

Figure 2.3. Alignment of specific objectives and final method of choice in this doctoral thesis
Abbreviations are: Social and ecological (S&E), participatory rural appraisal (PRA), semi-structured interviews (SSI).

2.3.1. Expert knowledge elicitation

The use of expert knowledge in conservation has been driven by the need to characterise dynamic, complex systems, limited resources and time to collect new data, and the urgency of conservation decisions (Kuhnert *et al.*, 2010; Krueger *et al.*, 2012). An expert elicitation approach can make a valuable contribution to informed decision-making. Although it is gaining popularity in environmental related public sectors, it is still less common in other public sectors (Morgan, 2014). Some concerns regarding the use of expert knowledge relate to the biases that expert judgment can generate and lead to poor inference and decision-making, but substantial research has been concentrated on methods to overcome these problems (Kynn, 2008; Martin *et al.*, 2012). Other issues are related to difficulty of determining who and what is an expert and what is knowledge (Burgman *et al.*, 2011). For example, experts might have very different understandings of the natural and social systems or in the knowledge they use (scientific, traditional, practical) and in the knowledge that is drawn (Stier *et al.*, 2016). However, focusing on diversity of knowledge, transdisciplinarity and transparency could potentially solve these issues (Adams, 2016).

The process of expert knowledge elicitation involves either single or multiple experts. In the case of single experts, information can be elicited directly in terms of quantities (e.g. probabilities) or indirectly where experts are required to answer questions related to their experiences. In the case of multiple experts, information can be elicited independently and then combined, or by group opinion (Martin *et al.*, 2012). Here, I will provide an overview of the three most common group opinion methods: Expert panels, Cooke's method and the Delphi method (the method of choice in this work).

2.3.1.1. Expert panels

An expert panel usually syntheses a variety of inputs (e.g. testimony, research reports, outputs of forecasting methods) to produce a report that provides a vision and/or recommendations for future possibilities and needs for the topics under analysis (Steyaert and Lisoir, 2005). Although expert panels foster pooling of knowledge among experts and agreement on the problem and questions at hand, the full diversity of opinions are lost and responses are subject to biases, including dominance of one or more members of the group, polarisation among subsets of members, and group-thinking (Martin *et al.*, 2012). Other constrain include the associated costs that involve bringing experts into a setting and facilitating all the necessary logistics arrangements, which include paying staff and materials and accommodation of the participants (Steyaert and Lisoir, 2005).

2.3.1.2. Cooke's method

This method weighs the opinion of each expert on the basis of his or her knowledge and to judge relevant uncertainties (Cooke, 1991; Cooke and Goossens, 2004). The process consists of bringing experts together to discuss a particular topic under the guidance of a facilitator. After the group discussion, experts are asked individually to give their judgment. To weight each expert on the basis of accuracy, each expert is also asked a set of test questions for which the answers are known. Accuracy of answers to the test questions is used to weight their judgment, and the weighted judgment of all experts are pooled to provide a consensus judgment (Martin *et al.*, 2012). Cooke's method is used for rapid risk assessments, which is required in urgent decision-making situations. For example, to produce a 'rational consensus' for many hard-to-assess risks, from earthquake hazards to the probable lethal dose of a poison or the acceptable limits of an air pollutant (Aspinall, 2010). According to Aspinall (2010) the advantages of the methods are:

- The speed with which the elicitations is conducted (e.g. in two days), and;
- The fact that the method encourages experts wary of getting involved in policy advice, which due to the structured, neutral procedure, and the collective nature of the result, reassures experts and relieves them of the burden of sole responsibility.

Another important issue is the impartiality of the facilitator to be able to deal with differences of opinion with tact, to prevent individual experts from hijacking the debate, and to avoid other pitfalls, such as asking misconstrued or leading questions, or prompting the experts. At the same time, he or she needs to keep all the participants fully engaged and focused (Aspinall, 2010).

2.3.1.3. Delphi method

Delphi is defined as 'a method of structuring a group communication process so that the process is effective in allowing a group of individuals as a whole to deal with a complex problem' (Hugé et al. 2009). The method involves an iterative survey of experts where systematic solicitation and collection for judgments on a particular topic are gathered through a set of carefully designed sequential questionnaires interspersed with summarised information and feedback of opinions derived from earlier responses (Chu & Hwang 2008). The idea is that the entire group of experts can weight dissenting views and the consensus increases from round to round. Although, initially designed for experts, the Delphi methodology is increasingly more inclusive as a greater diversity of participants (e.g. conservationist, local communities, policy makers) provides the approach with a wider range of perspectives and minimise bias arising due to self-interest (or information bias) by any particular group in the topic under consideration (Mukherjee *et al.*, 2015). The Delphi has been used in many disciplines ranging from medicine to environmental, scientific and policy evaluations (Swor & Canter 2011; Sharon & Wright 2006; Linstone & Turoff 1976). However, it has been used much less in conservation science despite its potential to solve complex conflicting information that requires dialogue between experts, decision makers and the public (Mukherjee *et al.*, 2015). Delphi's major constraints involve: a timeframe that might not be compatible with shorter policy time frame requirements; as well as the increasing participants' dropouts by round due to its time consuming nature for participants.

Compared to the other methods of expert elicitation, the characteristics of the Delphi method (e.g. inclusion of varied group of expert stakeholders, reduction of platform to dominant personalities) are more appropriate to respond to specific objective 1:

S.Obj 1. To generate a set of consensus expert-based indicators that can explain the general environmental impacts and the relationship with human activities and ecosystem services on the Galapagos Islands, as well as to provide solutions to facilitate the conservation and management of the archipelago.

2.3.2. Discourse analysis

Current research on discourses analysis includes different and numerous social sciences such as linguistic, anthropology and philosophy. As Hugé (2012) reasons forming part of an interpretative tradition in the social sciences, discourse analysis assumes the existence of multiple constructed realities. The basic assumption underlying discourse analysis is that humans are not so much driven by objective interests, rational calculations, social norms or overt power struggles, but by knowledge production and (collective) interpretations of the world (Arts and Buizer, 2009). However, despite the variety of discourse and discourse analysis interpretations, what all share in common is specific focus on the instances of language. The term "discourse" then, not only becomes a count noun, but further also refers to a broad conglomeration of linguistic and non-linguistic social practices and ideological assumptions that together construct and profoundly shape our views about certain issues (Hajer, 1995; Schiffrin *et al.*, 2008). This means that the way that people give meaning to certain aspects of life in societies creates -a series of- discourses, which reflect coherent -yet normative- world views (Hugé, 2012). In fact, as pointed out by Barry and Proops (1999) between individuals with shared experiences and personal attributes, there may be some degree of commonality or sharing of discourses. Indeed, discourse analysis is not mainly concerned with individuals' discourses, but rather with the nature of shared perceptions; i.e. with social discourses (Barry and Proops, 1999). This reconnects to the interpretation conservation, which as explained Chapter 1, involves a series of highly political and social issues, entailing shared perceptions, power struggles between the actors who participate in the definition and implementation of policies (Pochet, 2014). Several approaches to discourses analysis exist (see Arts and Buizer, 2009), but overall Hugé (2012) highlights two main interrelated approaches:

i. *Textually oriented discourse analysis*, refers to the study of discourses to what is said and written, focusing in the way in which language changes our perceptions and makes things happen.
ii. *Socially constructed or argumentative*, refers to the structured ways of representation that evoke particular understandings and many subsequently enable new types of actions to be thought about.

Both approaches are interrelated, in particular when we consider the mutually constitutive relationship between discourse and actions, as studied by Phillips *et al.* (2004).

In this work, as already mentioned I will follow Hajer and Versteeg (2005) approach to discourse analysis to studied the links between policy outcomes and discourses. Methodologically speaking discourse analysis is mostly qualitative and done by the researcher(s) interpretation of texts (e.g. secondary data, reports) and/or speech (e.g. through interviews, recordings) who will then analyse, summarise and provide a synthesis of the results (Gee, 2014). Nevertheless, six relevant approaches and techniques for discourses analysis are highlighted by Glynos *et al.* (2009):

(i) Political Discourse Theory (PDT)
(ii) Rhetorical Political Analysis (RPA)
(iii) Discourse Historical Analysis (DHA) in Critical Discourse Analysis
(iv) Interpretative Policy Analysis (IPA)
(v) Discursive Psychology (DP)
(vi) Q Methodology

Glynos *et al.* (2009) argues that although the purpose of each approach might be different (e.g. explanatory, critical, descriptive), all share an overriding concern with questions of meaning and the centrality attributed to subjects in the construction and apprehension of meaning. It is this concern with meaning and subjectivity that drives the selection of different methods or techniques in the study of discourse, whether these are qualitative, quantitative, or some combination of the two Glynos *et al.* (2009). Thus in line with our specific objective 2, we decide to select the Q methodology as the method of choice for discourse analysis:

S.Obj 2. To determine and map conservation discourses in the Galapagos Islands to assess the degree to which these are influenced by the successful conservation of the iconic Galapagos giant tortoises; as well as to compare these discourses to global conservation governance and conflicts with other iconic or well-known species elsewhere.

The reasons for selecting this method were varied; including its structured and flexible design, its use in environmental policy (Addams and Proops, 2000; Frantzi *et al.*, 2009), conservation (Sandbrook *et al.*, 2011; Cairns, 2012; Cairns *et al.*, 2013; Rastogi *et al.*, 2013), and stakeholder involvement and participation (Barry and Proops, 2000; Visser *et al.*, 2011).

2.3.2.1. Q methodology

Q methodology provides a systematic and rigorous way to understand people's opinions about a particular issue. It is systematic and rigorous because the process of data collection and generation involves several steps, which we describe in detail in **Chapter 4** (see figure 4.2 and Appendix B1). In conservation it has been used to understand attitudes in much better detail where other methodologies such as attitude surveys fail to capture the complexities inherent in the way people think, the viewpoints of the individual and because these surveys require a large number of participants (Winter *et al.*, 2005; Sandbrook *et al.*, 2011). In Q methodology subjectivity is defined as a person's point of view on any matter of social or personal importance. These subjective viewpoints are considered communicable, which makes them amenable to objective analysis through the use of statistical data reduction techniques (factor analysis or PCA) that combine a group of correlated variables into fewer variables. This process typically identifies shared viewpoints (discourses) about a range of statements that address a person's thinking on a particular issue (Sandbrook *et al.*, 2011). The method is widely used in social science research and is increasingly used in conservation biology and policy-related research where the exploration of conservation discourses, governance and relations of power is associated to each Q-discourse (Addams and Proops, 2000; Barry and Proops, 2000; Kalof, 2000; Davies and Hodge, 2007; Frantzi *et al.*, 2009; Cuppen *et al.*, 2010; Sandbrook *et al.*, 2011; Rastogi *et al.*, 2013). The major constraints in Q methodology also involve the timeframe to gather and analyse data which might not be compatible with the shorter policy time frame requirements. Similarly, the selection of participants although it does not require to be large in number, it requires a thorough and deliberate selection of participants that reflect varied and relevant viewpoints about the research topic (Watts and Stenner, 2012). Unlike R methodologies, the interest of Q methodology is to capture the existence of a particular viewpoint and thereafter to clarify and compare them within the emerging factors, rather than making generalisation about people (For an intersting response to Q methodology critics see Brown *et al.*, 2015). Nevertheless, depending on the question we want to answer, locating and selecting participants can be a difficult process. Thus, to avoid possible biases a Stakeholder Analysis (SAN) can be used in conjunction with Q, to be able to capture and cover a wider spectrum of participants that may have interesting viewpoints regarding the research question (Cuppen *et al.*, 2010).

2.3.3. Conservation conflicts: Social and ecological methods

As detailed in section 1.3.1, the study of conservation conflicts involves different forms of interactions of interrelated aspects between humans and natural systems. Thus, both social and ecological methods are required to address conservation conflict (Redpath *et al.*, 2013). While the selection of ecological methods is often more straightforward, the selection of social methods remain eclectic because social methods involve not only quantitative, but also qualitative and/or mixed-methods. Quantitative methods provide numerical data that is easy to analyse using statistics, which means that inferences can be made from a sample to a larger population, and hypotheses about cause-effect relationships or correlations between different variables can be tested rigorously (Newing, 2010). On the other hand, qualitative methods are less precise but more flexible. They are better at exploring issues that cannot be clearly defined at the start (e.g. social and cultural contexts), and at providing in-depth description and understanding (Newing, 2010). Therefore, these differences are important to take into account when planning a project in conservation. However, as explained earlier, an important element to find solutions in conservation conflicts is assuring the involvement of stakeholders. While the use of a participatory approach can help in the process to engage stakeholders to manage the conflict (Chase *et al.*, 2004), the transparent attitude of the researcher will be essential to guarantee the correct provision and devolution of the decision making authority to participants (Benham and Daniell, 2016). While we could decide to select any qualitative/quantitative method to directly respond to specific objective 3, this would not have provided us with the important element of participation at basis. Therefore, here we here opted to frame the research under a Participatory rural appraisal (PRA) approach. We made this choice because PRA is an overarching methodological approach that emphasises empowerment of local people, in particular in farming systems (Friis-Hansen and Sthapit, 2000); and also because it has been used in conservation conflicts research where the combination of social and ecological methods is essential (Zhang and Wang, 2003; He *et al.*, 2011; He *et al.*, 2014).

2.3.3.1. Participatory rural appraisal (PRA)

Participatory rural appraisal (PRA) was developed in the 1980s as a philosophical approach to emphasise the empowerment of local people to take decisions and act for themselves (Chambers, 1994). However, because of the varied techniques that are used to collect and generate empirical data, PRA is often used to refer to the use of a set of interactive methods involving people or groups of people (Newing, 2010). Its outstanding characteristics are flexibility, minimal resource requirements, and the central role given to intensive dialogue, varied types of communication, and researcher-community cooperation in order to access community knowledge. Most of the PRA techniques such as semi-structured interviews and questionnaires are inexpensive and easy for anyone to use and participate in. They generate a great deal of information in a short time and provide insight into social behaviours and management practices (Friis-Hansen and Sthapit, 2000). PRA is mostly used in conservation as an overarching approach to study conflicts in PA and their surrounding rural and urban environments, in particular when conflicts involve wildlife species and farming systems. PRA is often used in combination with other ecological methods (e.g. density transects, vascular plant surveys) to supplement the observations with quantitative data (Zhang and Wang, 2003; Wilfred *et al.*, 2007; He *et al.*, 2011; He *et al.*, 2014; Tiwari, 2015). The main constraints of PRA concern the critiques in the level of control that is exerted by researchers, especially in a community workshop setting, and the lack of true empowerment of local people (Newing, 2010). Framed under a PRA approach we selected semi structure interviews and questionnaires to gather socio-economic information and the line transect method (ecological method) to estimate giant tortoise population densities. With this combined approach we intend to respond to our specific objective 3:

S.Obj 3. To characterise the emergent conservation conflict between humans and giant tortoises in the rural agricultural area of Santa Cruz island, in order to assess several specific socio-economic and ecological inter-linkages and to provide a range of possible scenarios and actions to effectively inform policy makers and managers to improve the social-ecological fit of conservation strategies.

2.3.3.1.1. Semi-structured interviews (SSI)

Newing (2010) defines the following key features of semi-structured interviews:

- Compared to other qualitative interviews, SSI are based on an interview guide that is prepared in advance. The points on the interview guide may be open-ended questions or they may simply be general topics. The wording and order of the points is not necessarily fixed in advance, and the initial response to each question can be followed up with comments, prompts and further questions so that a conversation develops.
- SSI are most appropriate when the researcher knows the topic of research but does not know enough about the likely responses to design a set of precise questions that would be needed for a questionnaire.
- Semi-structured interviews are more targeted than unstructured interviews but more flexible than questionnaires.

2.3.3.1.2. Questionnaires

Questionnaires are lists of questions designed to elicit specific information from individuals or from the primary research samples being studied within a community (e.g. households, groups working on the same agricultural plot) (Friis-Hansen and Sthapit, 2000). Questionnaires are the most widely used social science method in conservation and ecology (White *et al.*, 2005). In ecology, they are used to test research hypotheses when information is required from a specific human target population. A subset of the target population is contacted by the researchers and asked to participate in the questionnaire by providing information. Data are collected from respondents and analysed to test the hypotheses. (White *et al.*, 2005).

2.3.3.1.3. Ecological method: Line transects (applied to faunal density)

Line transects are the most widely used method to estimate animal density through transects is a widely used method (Burnham *et al.*, 1980; Leuteritz *et al.*, 2005; Sutherland, 2006a; Buckland *et al.*, 2010; Thomas *et al.*, 2010) Leuteritz *et al.* (2005) used this method to estimate radiated tortoise density in Madagascar and this was one of the confirming motives to use this method. Cowling (2006) provides the following description of the method: In a line transect, an observer moves along a transect line and notes the location of all animals detected relative to the line (perpendicular distance) (Figure 2.4). It is assumed that not all animals are detected (hence underestimation). Factors affecting detectability include distance from the line, habitat, and weather conditions. In the conventional approach to line transect sampling, it is assumed that all animals on the line are detected, and that the probability of detection decreases with distance from the line (Cowling, 2006). Density estimates are calculated using the DISTANCE 6.2 software. The specific details and calculations to estimate density by hand can be found in Buckland *et al.* (2012).

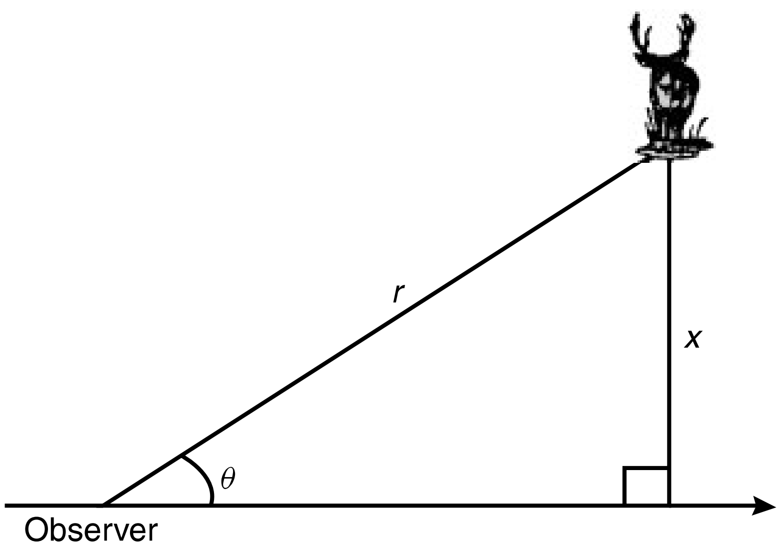

Figure 2.4. Perpendicular distance
If sighting distance r and sighting angle θ are recorded, then perpendicular distance x of the animal from the line is found as x =r sin ϑ. Figure and legend source: Buckland *et al.* (2012).

2.4. Research framework

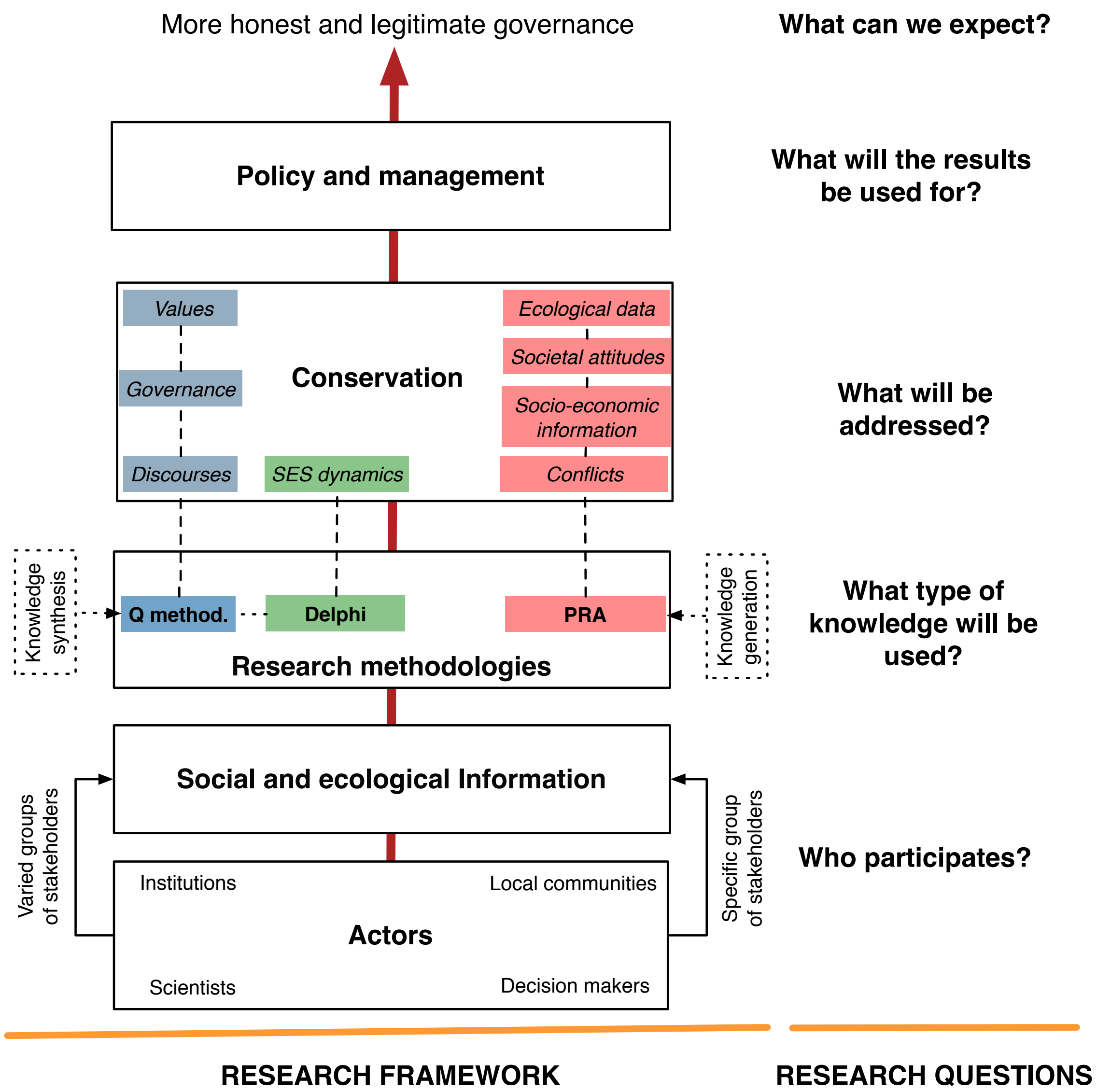

Figure 2.5. Research framework and questions

Chapter 3

THE DELPHI METHODOLOGY TO STUDY SOCIAL-ECOLOGICAL DYNAMICS IN THE GALAPAGOS ISLANDS

Modified from "Environmental impacts on the Galapagos Islands: identification of interactions, perceptions and steps ahead". (2014). Francisco Benitez-Capistros[1,2], Jean Hugé[2] and Nico Koedam[1]. *Ecological indicators,* 38: 113-123.

Reference citation: Benitez-Capistros et al. (2014).

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Contributions to this paper: FBC and JH originally formulated the idea and conceptual design of the study. FBC collected, analysed and interpreted the data. FBC wrote the manuscript. JH and NK provided critical revisions for the finalised version of the article.

3.1. Abstract

In the Galapagos Islands human activities such as fisheries and tourism, have boosted the islands' economy at the cost of ecological losses and constant pressures to the fragile insular ecosystems. Hence the evaluation of environmental impacts is essential and requires multiple indicators, appropriate for measuring the state and the interactions of the interrelated social and environmental variables and its relation to ecosystem services. The present research proposes a participatory approach to understand the perception of environmental impacts and its relation to ecosystem services to develop responsive impact mitigation strategies in the Galapagos Islands. The Drivers-Pressures-State-Impact-Responses (DPSIR) framework provided an analytical lens, while the Delphi method was chosen to involve selected Galapagos experts in the indicator selection process. The Delphi method consists of an iterative set of questionnaire surveys, interspersed with feedback from earlier response rounds. According to our results, 37/55 statistical consent indicators ($qi \geq 3.5$ and $Q \leq 0.5$) and 7/28 relevant interactions of environmental impacts (Mean≥0.5 and CV≤0.5) explain a cascade of social-ecological interconnectivity that generates environmental impacts on the Galapagos Islands. Hence, first the socio-economic-cultural and institutional forces (drivers) that include: the increase of tourism and migration, economic growth, continental lifestyles, lack of education and weak management of institutions. These drivers place stress on the environment (pressures). The pressures include: the importation of goods, land clearing for agriculture/abandonment and urban zone extension. Subsequently, these pressures generate changes in the environmental functions (impacts). The identification of impacts and their interactions indicate a close relationship between eight impacts in Galapagos: introduction of species, biodiversity loss, land use change, loss of biological resources, habitat fragmentation, landscape alterations, water basin overexploitation and decrease of water quality. Lastly, scientifically sound solutions and alternatives to deal with the Galapagos' social, economical, political, managerial and technical problems are also provided (responses). This study is an applicable useful systemic reference for Galapagos' decision makers to deliver policies in order to move towards proper conservation management.

3.2. Introduction

Since Charles Darwin visited the Galapagos Islands in 1835, this oceanic Pacific Ecuadorian archipelago has been at the focus of interest of many natural science and evolutionary researchers. However, rapid social development and the impacts of globalisation have triggered complex social-ecological change (Gonzalez *et al.*, 2008) that affect the island's ecosystem services (ES). ES are defined as "benefits that humans recognise as obtained from ecosystems that support, directly or indirectly, their survival and quality of life" (Harrington *et al.*, 2010). Hence, Galapagos' human well-being depends on ES direct consumptive use values (i.e. fisheries) and non-consumptive values (i.e. tourism) (Goulder and Kennedy, 1997, 2011; Seddon *et al.*, 2011). Today more than 25000 people inhabit four of the 19 largest islands Isabela (4670 km^2), Santa Cruz (986 km^2), San Cristobal (557 km^2) and Floreana (173 km^2) (INEC, 2010). Direct consumptive uses of land, removal of building materials such as sand, rock, and timber for use in housing and road construction are common; but, at the same time, generate related population demands for waste management, sewage disposal, water, electricity and goods to be transported to the island (Kerr *et al.*, 2004; Gonzalez *et al.*, 2008). These transported goods carry the risk of introduction of invasive species, today recognised as the largest single threat to Galapagos biodiversity in the short term (Gonzalez *et al.*, 2008; Guézou *et al.*, 2010).

As mentioned by Goulder and Kennedy (1997, 2011) the other direct consumptive use value corresponds to Galapagos' marine ecosystem. Since 1990 there has been a significant fishery for economically important trade species. The illegal fishing activities, mostly for shark fins (Reyes and Murillo, 2008), overexploitation of sea cucumbers especially *Isostichopus fuscus* (Hearn *et al.*, 2005; Toral-Granda, 2005; Toral-Granda, 2008) and lobsters *Scyllarides astori, Panulirus penicillatus* and *Panulirus gracilis* (Hearn, 2006, 2008) are recognised as the major threats for these local marine resources and wildlife (Baine, 2007; Baine *et al.*, 2007; Toral-Granda, 2008).

Against these direct consumptive use values is the non-consumptive value of tourism. In Galapagos there are 66 terrestrial visiting points distributed over 15 islands and 74 marine visiting sites distributed around 19 islands where certain activities such as scuba diving, snorkelling, kayak and panga rides are allowed (GNP, 2013). With more than 180000 that visiting Galapagos (GNP, 2012), tourism is a cultural ecosystem service that can easily be captured in economic terms due to its iconic aesthetic measurable value (Satz *et al.*, 2013). The revenues received from tourism generate more than 65% of Galapagos GDP with 85 million USD/year (Epler, 2007). Hence, tourism is the sector that provides the most employment (33%), followed by trade (21,5%), the public sector (11,6%), domestic jobs (8,7%), agriculture (5,9%) and construction (5,7%) (CGREG, 2010). Paradoxically, this process often poses a direct threat to the nature values that lie at the basis of tourism and economic prosperity itself (Samways *et al.*, 2008) and makes Galapagos' economy crucially dependent on successful conservation strategies. The loss of wildlife would cause the loss of tourism and hence the rapid decline of the economy and vice-versa. Ideally tourism brings money and could be invested in conservation efforts. In reality most revenues flow to tour operators, most of them non-Ecuadorian, and to other off-island entities; consequently, conflicts over resources (in particular of sea cucumber fisheries), the indirect use values of tourism by locals; and biodiversity conservation have arisen (Goulder and Kennedy, 2011).

Retrieving basic information on the dynamics of the interconnections between the social and ecological systems and the relationship of ecosystem services to human well-being is of sum importance (Carpenter *et al.*, 2009). Sustainability is a concept that offers a solution to these problems by providing decision makers with strategies to guide their decisions so as to allow to present and future generations to meet their needs within the limits of the earth's carrying capacity (Rockstrom *et al.*, 2009; Waas *et al.*, 2011). However, in order to translate sustainability from a concept to a tangible strategy, indicators are key tools. Generically indicators could be defined as 'sign or signals that relay a complex message, from potentially numerous sources, in a simple and useful manner' (Kurtz *et al.*, 2001) and are designed to communicate a property or trend of a system to decision makers (Miller, 2001; Hak *et al.*, 2007; Bell and Morse, 2008). Hence when extended, sustainability indicators would be described as a set of indicators that measure characteristics or processes of the social-ecological systems to ensure its continuity and functionality far into the future.

In the present research, the Drivers-Pressures-State-Impact-Responses (DPSIR) framework was used to structure our analysis and develop sustainability indicators. DPSIR is an approach that allows identifying the role of humans in nature by representing a system that includes societal (human) and ecological (biophysical) subsystems in mutual interactions (Elliott, 2002; Scheren *et al.*, 2004; Rogers and Greenaway, 2005; Omann *et al.*, 2009). The main goal of this paper is to identify and characterise environmental impacts[9] and their interconnections associated with human activities and the ecosystem services on the Galapagos Islands. The DPSIR framework was used as an analytical lens to provide a sequential list of sustainability indicators, while the Delphi method was used to determine which indicators are perceived as more relevant according to a selected group of participants. Delphi is an iterative questionnaire designed to elicit expert's knowledge. The study also investigated whether crucial environmental information was lacking, how impacts interact with each other, the relation with ecosystem services, how multiple stakeholders in Galapagos perceive these impacts and what solutions they have to offer to further guide and facilitate a sustainable development and protection of the archipelago.

3.3. Materials and methods

Delphi is defined as 'a method of structuring a group communication process so that the process is effective in allowing a group of individuals as a whole to deal with a complex problems' (Hugé *et al.*, 2010). It has been frequently used in many research areas ranging from medicine (Thangaratinam and Redman, 2005; Hwang *et al.*, 2006) to environmental, scientific and policy evaluations and scenarios (Miller, 2001; Turoff and Linstone, 2002; Kuo *et al.*, 2005; Wright, 2006; Nowack *et al.*, 2011; Swor and Canter, 2011) and conservation management (James *et al.*, 2009; Eycott *et al.*, 2011; Mehnen *et al.*, 2012).

The method is a structured and iterative survey of 'experts' or participants intended to generate unbiased opinions and transforming such opinions into one or more collective notion(s) through a feedback process. After completing the surveys each participant is given a communal feedback on the group responses. With this information in hand, the

[9] Environmental impacts are defined as the effect of human-made activity, change or development on the natural environment (Oxford dictionary, 2004)

participants complete the survey form again. Then (s)he can change or not his opinion based on the information provided by the other participants. The process can be repeated several times in several rounds until consensus increases or is reached. The reasons to use Delphi in this research were numerous and include the following considerations:

- *Rigorous for expert and stakeholder queries*. Opposed to other surveys and group techniques the Delphi method is stronger for a rigorous query of experts and stakeholders (Okoli and Pawlowski, 2004; Dalal *et al.*, 2011; Landeta and Barrutia, 2011).
- *Inclusion.* As a group technique it makes possible the inclusion of individuals in the group who are directly involved with the problems to be resolved. Often used for decision making purposes (Landeta and Barrutia, 2011; Mukherjee *et al.*, 2015).
- *Flexible design* amenable to use in combination with other methodologies like scenarios, technology list or others that can be interesting (Elmer *et al.*, 2010).
- *Gap filling of incomplete knowledge.* It fills the gaps of the incomplete knowledge available and whereby expert panels seek to achieve consensus (Dalal *et al.*, 2011).
- *Structured information flow*. Delphi characteristics allow a structure of information flow, feedback to the participants and anonymity (Elliott *et al.*, 2005).
- *Anonymity* makes it is possible to develop a group process using experts who do not meet in either time or space, and also seeks to avoid the negative influences that individual responses might be subject to owing to factors associated with the personalities or statuses of the experts participating (Landeta and Barrutia, 2011).
- *Statistical group response* is achieved and allows all of the opinions to form part of the final answer. The questions are formulated so that a quantitative and statistical treatment of the answers can be carried out. In addition, it offers synthetic, quantitative or hierarchised results from the whole human spectrum under examination, analysed in terms of collectives, which ought to lubricate both the making of decisions and the evaluation of their later consequences (Landeta and Barrutia, 2011).

In the present study, the Delphi method was used in an online environment. The web-based survey tool used for this particular study was OSuCre online survey creator (see http://www.osucre.be/). The online-based Delphi was used to overcome limitations in the Delphi process using paper-based surveys and space limitations as observed on other Delphi studies (Cam *et al.*, 2002; Steyaert and Lisoir, 2005).

3.3.1. Selection and identification of Delphi participants

Delphi is an expert elicitation method that has been used since the 1950s. Delphi is not a social quantitative data collection technique (e.g. questionnaires) that tests research hypotheses derived from a sample human target population. Instead the aim of the Delphi is to retrieve valuable and consensus based information from 'experts' to deal with complex issues. Hence, Delphi representative samples are assessed based on the qualities of the participants rather than its numbers (Powell, 2003). However, what constitutes an optimal number of subjects in a Delphi study never reaches a consensus in the literature (Ziglio, 1996; Turoff and Linstone, 2002). This has redirected the issue to focus on the selection and qualification of the experts. An expert is a person who is particularly competent as authority on a certain matter of facts (Flick, 2009). However, defining what or who is an expert and the interrelated expertise and knowledge is challenging (Failing *et al.*, 2007; Burgman *et al.*, 2011). For instance, in the case of interactions with stakeholders that are designed to foster the acceptance of proposed actions, expertise should include the ability of an effective communication (Burgman *et al.*, 2011). However, the separation of experts and stakeholders might be unrealistic and counter-productive as it can prevent the social capital resulting from co-generation of knowledge in a stakeholder group (Krueger *et al.*, 2012). Moreover, knowledge is contextual and it depends on the interests it serves, the purpose for which it is harnessed, or the manner in which it is generated (Burgman *et al.*, 2011). Thus, the selection of the participants in Delphi is critical and must be performed rigorously so that the group composition reflects the diversity of valuable knowledge (Okoli and Pawlowski, 2004; Steyaert and Lisoir, 2005). For this research we considered an 'expert' as a person or participant who, by a verifiable mean (particular job position, expertise/knowledge, publications), is known to have information or that has access to information, which concerns the issues under investigation. To properly identify Delphi participants and to minimise possible known biases (Frewer *et al.*, 2011) and generate groups with similar size of participants, we decided to follow four steps described by Okoli and Pawlowski (2004). Hence, the final group of participants was established as follows:

1. *Government officials*: Besides the officials of the Galapagos National Park (GNP) directory, which at time was the most influential governmental body in charge of policies regulation and management of both the Galapagos National Park and Marine Reserve (GMR), officials from the GMR and officials from the municipalities of Santa Cruz, San Cristobal and Isabela islands, were also selected.

2. *Scientists/academics*: The group was covered by scientists related to natural and exact sciences (e.g. biology, ecology), social and policy related sciences (e.g. economy, sociology, environmental management) and interdisciplinary sciences (e.g. social-ecological modelling). All scientists were identified by their publication record over the past 15 years.

3. *Local residents:* The group was formed by residents involved in education, fishery and tourism activities, whereby both public and private sectors were selected.

4. *Officials of Non-Governmental Organisations (NGOs)*: This category mainly involves groups with a long history in the Galapagos Islands. The Charles Darwin Foundation, Galapagos Conservancy, WWF, Conservation International among the most renowned ones. However, many other officials of NGOs that contribute or have contributed to Galapagos protection and development were also invited.

3.3.2. Preparation and distribution of Delphi questionnaires

First, documents explaining the aim and purpose of Delphi were distributed to 42 potential participants. Second, an interactive bilingual (English-Spanish) web page platform (http://student.vub.ac.be/~fbenitez/) to upload any necessary documents (e.g. reports, procedures, links, and contact information) and to facilitate communication and visualisation of the results among the participants anonymously was also created. Electronic invitation letters were sent for each of the three consecutive rounds. The online questionnaires were first created in an MS Excel (XLS) environment, which were then uploaded to a hypertext preprocessor (PHP) server provided by OSuCre (http://survey.osucre.be/fjb) where all three questionnaires were uploaded and the obtained data was kept and could be downloaded in a comma separated value (CSV) format for statistical analysis. Reports describing the results of each questionnaire were sent via email and uploaded to the main webpage after each of the three Delphi rounds in this research. The time frame given to respond to each of the three consecutive rounds was of four weeks. The time elapsed between the delivery of the first questionnaire in round 1 and round 3 was approximately five months.

3.3.3. The DPSIR framework

The DPSIR framework logic was used to structure the second round questionnaire based on the generated responses provided by the participants in the first round, especially of the open-ended questions. The DPSIR was chosen because of its proven suitability in the context of describing linkages between human pressures and environmental issues and because of its usefulness in multidisciplinary perspectives and because it fills in science and policy gaps (Tscherning *et al.*, 2012). Furthermore, it was used as a base mechanism to standarise concepts and terminology for participants and to understand what the local perceptions are about environmental impacts and their broader DPSIR-context through the Delphi method. Describing the causal chain drivers to impacts and responses is a complex task, and usually needs to be broken down into sub-tasks (Kristensen, 2004; Skoulikidis, 2009). In this case the ‘state of the environment’ and ‘impacts’ components have been merged into one denominate ‘environmental impacts’. As a result, a generic DPSIR framework for Galapagos was generated (Figure 3.1). A section that focuses on ecosystem services and the results of the DPSIR for Galapagos will be analysed in section 3.5.2.

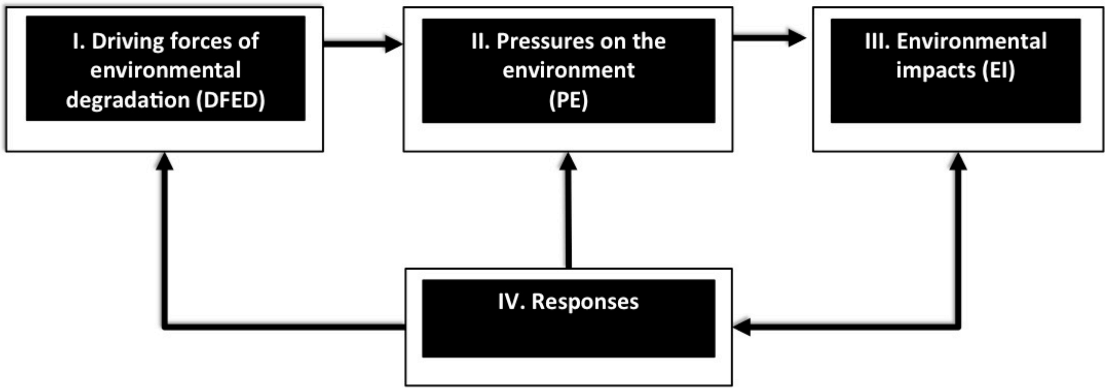

Figure 3.1. Modified DPSIR framework for the Galapagos Islands

3.3.4. Data analysis

The data analysis of each round was based on descriptive statistics. For close-ended questions (Yes/No type) of round 1, the results were indicated in percentages. However, the methodology used for the evaluation of the 5 point Likert scaled questions (1= not important to 5=very important) as of round 2 was described with descriptive statistics of the ratings: Rating Mean (*qi)*, rating median (*Md),* standard deviation (*SD*), inter quartile *(IQ*) and quartile deviation (*Q*). The statistical validation was measured in accordance to (Chu and Hwang, 2008), where a consensus is reached when $Q \leq 0.5$ and when the rating mean is $(qi) \geq 3.5$ or $(qi) \leq 3.5$. This differentiation allows splitting the consensus in two directions: When consensus is reached and the question is considered as relevant ($qi \geq 3.5$ and $Q \leq 0.5$) or not relevant ($qi < 3.5$ and $Q \leq 0.5$); and when there is no consensus (dissensus) then $Q > 0.5$. Furthermore, a Spearman's rank order correlation was run to determine whether a positive or negative correlation existed between the selection of the listed impact's interaction in round 2 and round 3 matrices.

3.4. Results

3.4.1. The Delphi sample characteristics

The total number of contacted and invited participants was 42. However, approximately one-fourth of those invited took part in the first round (n=10); and of those, approximately three-fourths responded to the second (n=7) and third round (n=5), consecutively (Table

3.1). For a more detailed qualification of the participants see also Appendix A1. Similar rates of attrition are reported in other Delphi studies (Wentholt *et al.*, 2009; Frewer *et al.*, 2011). The number of Delphi participants is very varied, usually with a minimum of four participants (Thangaratinam and Redman, 2005). Similar number of experts have been used in expert elicitation methods and Delphi's of related fields: Ecology (Pearce *et al.*, 2001; Seoane *et al.*, 2005; Wooldridge *et al.*, 2005; Marcot, 2006; Smith *et al.*, 2007), biology (Ahmadi-Nedushan *et al.*, 2008), conservation biology (Murray *et al.*, 2009; Garcia-Melon *et al.*, 2012).

Table 3.1. Participant for the Galapagos Delphi study

Categorical Groups	Invited	Round 1	Round 2	Round 3
Government officials	10	2 (20%)	1 (50%)	0 (0%)
Academics/scientists	12	2 (17%)	2 (100%)	2 (100%)
Local residents	10	3 (30%)	2 (67%)	2 (100%)
NGOs officials	10	3 (30%)	2 (67%)	1 (50%)
Total	42	10 (24%)	7 (70%)	5 (71%)

3.4.2. Delphi round 1

The first round was organised in two main sections. The first section included a list of impacts that are known to generate degradation on the environment. Table 3.2 shows the participants' selection in a descending order. The inclusion of land use change in the higher parts of the islands and introduction of species was proposed as other impacts to cause environmental degradation. Additionally, a related open question (How do these impacts interact?) was asked consecutively (see question 2 of Table 3.3). It is important to note that the identified impacts were later used to elaborate an environmental impact interaction matrix during the second and third rounds (see section 3.4.3.2).

Table 3. 2. List of environmental impacts. Delphi round 1

List of impacts	*f*(n=8)	%
Biodiversity loss	8	100
Habitat fragmentation	6	75
Landscape alterations	4	50
Loss of biological resources	3	38
Decreased water quality	2	25
Soil degradation	2	25

The second section of this round consisted in five open questions. The open-ended questions (Table 3.3) are valuable because they allow the Delphi participants to provide their own input and to explore and complement the diverse topics presented in the first round. Table 3.3 presents the five open questions, which through the respective obtained responses constituted the core information of the Delphi. This information was used to structure the DPSIR framework for Galapagos in the second round. All the participants' qualitative answers were analysed and summarised for the second round of the Delphi method.

Table 3.3. The Open-ended questions. Delphi round 1

1	What are the main driving forces of environmental degradation in the Galapagos Islands?
2	How do these impacts interact?
3	How can we propose adequate management strategies to mitigate environmental impacts?
4	Which mechanism or strategies would you suggest for controlling population growth?
5	Which mechanism or strategies would you suggest for controlling tourism?

3.4.3. Delphi round 2

3.4.3.1. The DPSIR framework for Galapagos

The second round was elaborated and based on the results of the first round open questions and organised in the DPSIR framework as indicated in Table 3.4 and Figure 3.2. The themes and sub-themes, which emerged from the open questions, were organised in a DPSIR framework in 55 Likert scale questions. In total, 31/55 (56%) reached relevant consensus (qi ≥3.5 and Q≤ 0.5), and 24/55 (44%) had no statistical consensus (Q>0.5). The participants' individual ratings description is provided in Appendix A2.

3.4.3.2. Impacts interactions

This section was obtained from a symmetric eight by eight matrix that included the following eight impacts: Introduction of species (IS), biodiversity loss (BL), loss of biological resources (LBR), land use change (LUC), landscape alterations (LA), decrease of water quality (DWQ), habitat fragmentation (HF) and water basin overexploitation (WBO). Participants had to select between the interactions of two of these mentioned impacts. In total there were twenty-eight paired possible interactions to select. In this second round, three were highly selected by the seven participants of the second round (n=7): (1) LUC-HF (86 %), (2) IS-BL and (3) LBR-LA each with 71%. Five more interactions had also a considerable high selection (57%) and were: IS-LA, LBR-BL, LUC-LA, and DWQ-WBO. The same symmetric matrix was also included in round 3 of the Delphi method to corroborate this first selection. This will be further detailed in section 3.4.4.2.

3.4.4. Delphi round 3: Final results

3.4.4.1. The DPSIR framework for Galapagos: Final ratings

The main purpose of round 3 was to achieve a higher consensus among the generated answers of the Delphi process over the second round 31/55 (56%). This final round consisted in re-voting twenty-four indicators of the second round, which did not reach consensus. Thus 13/24 (54%) reached consensus ($3.5<qi \geq 3.5$; $Q \leq 0.5$) and 11 (46%) remained with no statistical consensus ($Q>0.5$). Ultimately after this round consensus was reached on 44 indicators (80%), of the initial set of 55 indicators. From these 44 indicators with consensus 37 (67%) achieved relevant consensus ($qi \geq 3.5$ and $Q \leq 0.5$) and formed the final set of indicators (Figure 3.2). Seven were eliminated as considered irrelevant by participants ($qi<3.5$ and $Q \leq 0.5$) and eleven did not reach consensus ($Q \geq 0.5$) (Table 3.4). Likewise, the impact interaction matrix of round 2 was uploaded and sent to consider for re-voting (Appendix A3). After this round the process came to an end.

3.4.4.2. Final set of interactions of environmental impacts

In the third round the same matrix of twenty-eight different paired environmental impacts had similar results as in the second round (Appendix A3). A Spearman's rank order correlation was run to determine the relationship between the twenty eight paired environmental impacts interactions between round 2 and round 3 scores. There was a strong, positive correlation between round 2 and round 3 scores, which was statistically significant ($r_s(8) = 0.698$, $P = 0.000$). The comparison between round 2 and round 3 has allowed the identification of different groups in accordance to the participants' selection in both rounds. Therefore, and as observed in Figure 3.3, seven interactions of at least two set environmental impacts (EI) and their interaction on the environment in Galapagos were also found to be the most relevant (Mean≥0.50; CV≤0.5). The mean and the coefficient of variation (CV) between the two rounds were calculated and thus the interaction of environmental impacts which resulted to have mean>0.5 and CV≤0.5 were considered to have a higher degree of importance according to the participants' selection.

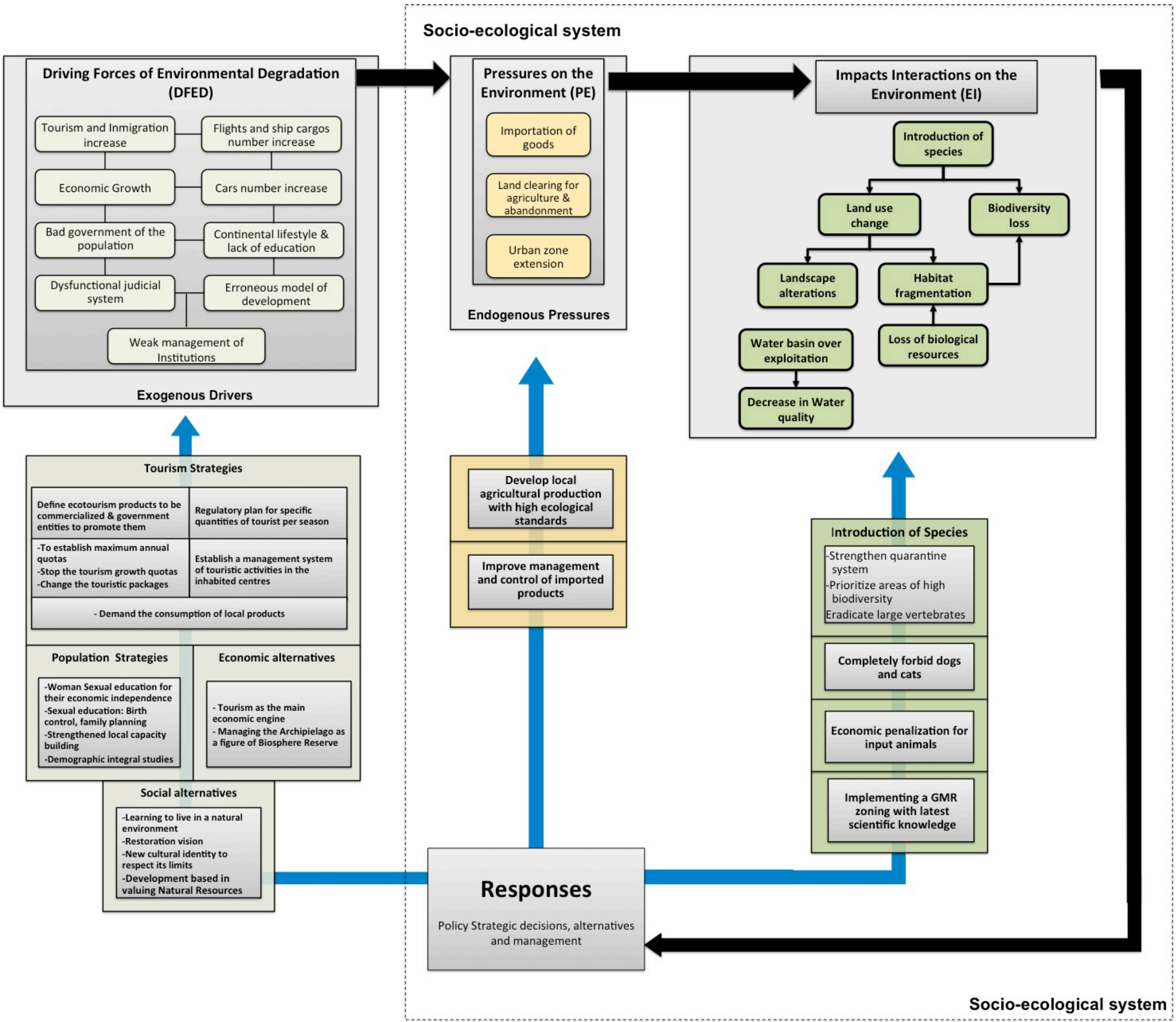

Figure 3.2. The DPSIR framework for the Galapagos Islands.
The black and blue arrows represent the causal and systemic chains of events between the different levels of the DPSIR framework that reached consensus for 37 relevant indicators (qi ≥3.5 and Q≤ 0.5) (Table 3.4) and 7 relevant interactions of environmental impacts (Mean≥0.5 and CV≤0.5).

Table 3.4. Final results of the DPSIR framework for Galapagos

DPSIR framework	Consensus for relevant indicators *qi* ≥3.5 and *Q*≤ 0.5	Consensus for not relevant indicators *qi*<3.5 and *Q*≤ 0.5	No consensus (dissensus) *Q*≥ 0.5
Driving forces of environmental degradation (**DFED**)	Increase in tourism & high migration from continent (**DFED1**), economic growth (**DFED2**), flights and ship cargos number increase (**DFED3**), increase in the number of vehicles (**DFED4**), continental lifestyle & lack of education (**DFED5**), inappropriate model of development does not integrate ecosystems resilience (**DFED6**), weak management of institutions (**DFED10**), dysfunctional judicial system (**DFED11**), bad government of the population (**DFED13**)	Erroneous local tourism development (**DFED7**)	Tourism monopolisation (**DFED8**), no proper regulation of tourism activities (**DFED9**), complicity between local people (**DFED12**)
Pressures on the environment (**PE**)	Importation of goods (**PE1**), land clearing for agriculture & abandonment (**PE2**), urban zone extension and higher pressure towards natural resources (**PE3**)	-	Illegal fishing (**PE4**)
Responses DFED: Tourism growth strategies (**R_TS**)	Define ecotourism products to be commercialised & government entities to promote them (**R_TS2**), regulatory plan for specific quantities of tourist per season (**R_TS3**), establish a management system of touristic activities in the inhabited centres (**R_TS4**), establish maximum annual quotas (**R_TS5**), stop the tourism growth quotas (**R_TS6**), change the touristic packages (**R_TS7**), demand the consumption of local products (**R_TS9**)	Certify operations and tourism enterprises (**R_TS10**), decrease number of planes arrivals & define new visit itineraries (**R_TS12**)	Develop an ecological tourism (**R_TS1**), Increase the minimum staying time to 7 days (**R_TS8**), control materials and process of hotels constructions (**R_TS11**)
Responses DFED: Population growth strategies (**R_PS**)	Woman sex education leading to their economic independence (**R_PS1**), sex education: Birth control, family planning (**R_PS2**), demographic integral studies (**R_PS5**), strengthened local capacity building (**R_PS6**)	One child per couple policies (**R_PS3**), abortion approval (**R_PS4**)	Reinforce and be stricter with migratory restrictions (**R_PS7**), fasten approval of temp residents (**R_PS8**), penalize if illegal people is hired (**R_PS9**)
Responses DFED: Economic alternatives (**R_Ec**)	Tourism as the main economic engine (**R_Ec1**), managing the archipelago as a figure of biosphere reserve (**R_Ec4**)	Stop foreign investment (**R_Ec3**)	Improve the redistribution of incomes derived from tourism (**R_Ec2**)
Responses DFED: Social alternatives (**R_So**)	Learning to live in a natural environment (**R_So1**), restoration vision (**R_So2**), new cultural identity to respect its limits (**R_So3**), development based in valuing natural resources (**R_So4**)	-	-
Responses to pressures on the environment (**R_PE**)	Develop local agricultural production with high ecological standards (**R_PE1**), Improve management and control of imported products (**R_PE2**)	Control material used for construction & penalisation (**R_PE3**)	-
Responses to environmental impacts(**R_EI**)	Strengthen quarantine system for introduced species (**R_EI1**), priorisation of areas with high biodiversity (**R_EI2**), eradication large vertebrates (**R_EI3**), completely forbid dogs and cats (**R_EI4**), economic penalisation for importing animals (**R_EI5**), implement a GMR zoning with latest scientific knowledge (**R_EI6**)	-	-
Total	**37**	**7**	**11**

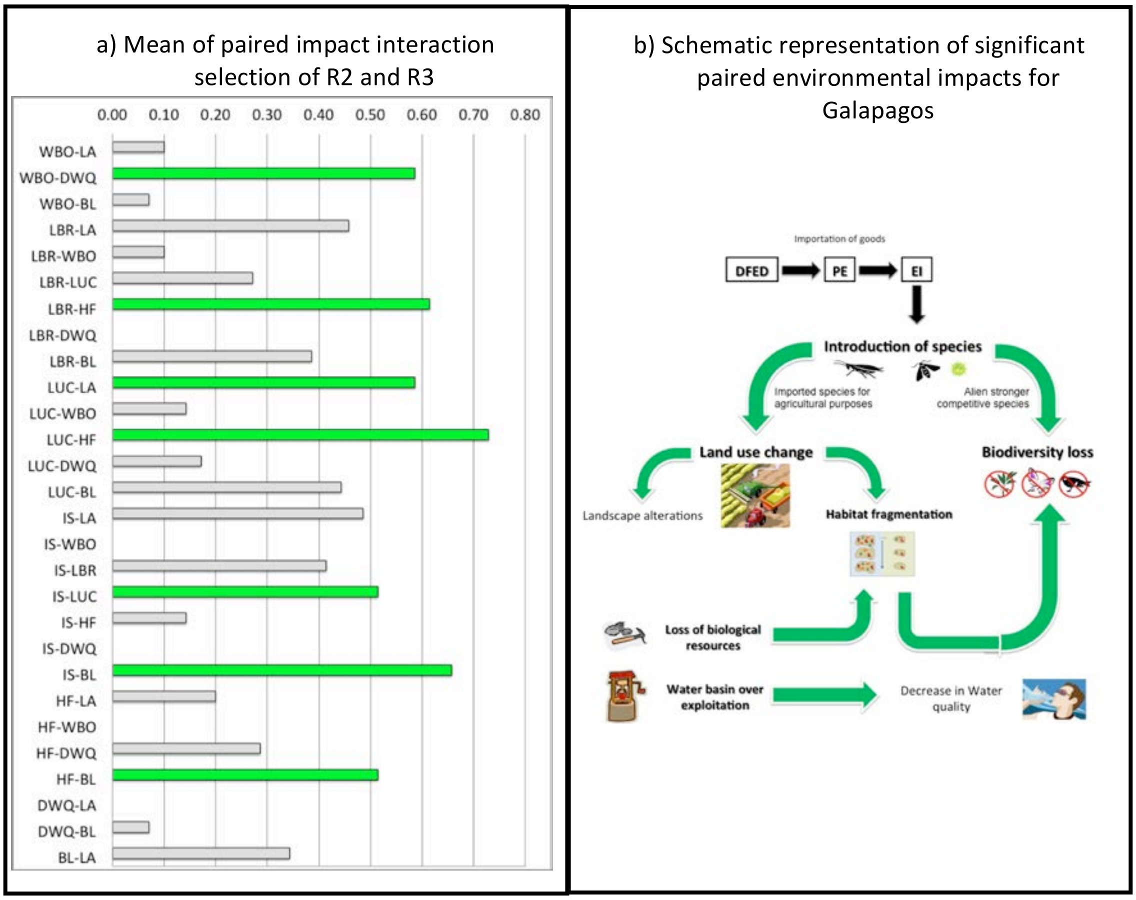

Figure 3.3. Relevant interactions of environmental impacts

a) On the vertical axis, the paired impact chosen by the participants is represented. The horizontal axis represents the percentage of selection calculated by the mean between round 2 (n=7) and round 3 (n=5). The bright green bars represent the seven paired environmental impacts which fulfilled the condition Mean≥0.50; CV≤0.5 over round 2 and round 3. **b)** The green arrows represent the flow of interactions of the environmental impacts obtained as selected by participants, which represents the interaction of two impacts (i.e. introduction of species causing: biodiversity loss with mean=0.66 and CV=0.12 and land use change with mean=0.51, CV=0.24).

3.5. Discussion

3.5.1. Analysis of the DPSIR framework for the Galapagos Islands

The potential of the DPSIR framework to organise and structure complex information (Kristensen, 2003) was evident as the qualitative complex information retrieved in round 1 of the Delphi (from the questions in Tables 3.2 and Table 3.3) was organised and structured using the DPSIR framework logic during the second round of the Delphi. The DPSIR framework has allowed describing the linkages of human pressures and environmental issues (Tscherning *et al.*, 2012). In this research this was even statistically verified in each of the levels of the DPSIR. As observed in Table 3.4 of the Delphi final round (round 3), an elevated consensus was reached (80%) with 44/55 DPSIR question indicators, of which 37/55 (67%) reached relevant consensus (3.5<qi≥3.5; Q≤0.5). This sequential list of 37 DPSIR indicators with relevant consensus (Table 3.4) and the seven interaction of environmental impacts (Figure 3.3) have allowed a description of the interconnections between environmental impacts and anthropogenic activities, starting from driving forces of environmental degradation (DFED) to pressures on the environment (PE) down to environmental impacts (EI) and their interactions on the environment and responses (Figure 2). It is important to note that although we have grouped all the DPSIR results as indicators, the last response compartment (R) is intended to provide with policy solutions (Responses) to the Drivers, Pressures and Impacts of the framework. Hence, strictly speaking the responses in this work should not be interpreted as indicators since they do not provide information that describes properties or trends of a system.

However, in order to translate sustainability from a concept to a tangible strategy, indicators are key tools. Generically indicators could be defined as 'sign or signals that relay a complex message, from potentially numerous sources, in a simple and useful manner' (Kurtz *et al.*, 2001) and are designed to communicate a property or trend of a system to decision makers (Miller, 2001; Hak *et al.*, 2007; Bell and Morse, 2008). Hence when extended, sustainability indicators would be described as a set of indicators that measure characteristics or processes of the social-ecological systems to ensure its continuity and functionality far into the future.

The non-linearity of environmental impacts is valuable because it allows an assessment of the human and environmental impacts on Galapagos' ecosystems services; and the related interpretation of the consensus of each of the categories of the DPSIR framework by the policy decision makers and stakeholder in Galapagos. In this regard, DPSIR can be a useful communication tool between scientists, policy makers and stakeholders (Svarstad *et al.*, 2008); although, special attention has to be paid by the policy makers and management decisions as to where to delimit the location of the social-ecological systems boundaries in particular for analysing ecosystem services. (Rounsevell *et al.*, 2010) argue that to properly suggest and address mitigation strategies it will be better to delimit drivers acting as exogenous drivers (outside the physical space in question); and pressures acting as endogenous pressures (inside the physical space in question). See Figure 3.2 for the suggested application on the DPSIR framework for Galapagos Islands.

3.5.2. DPSIR as an ecosystem service framework for the Galapagos Islands

Galapagos DPSIR framework allows an empirical demonstration of ecosystem services characterised by distinct social-ecological dynamics. For instance, the indicators that represent the exogenous driving forces of environmental degradation (DFED) show the dynamics and/or relationships between the interrelated socio-economic (DFED1, DFED2, DFED3, DFED4), socio-cultural activities (DFED5, DFED6) and institutional systems (DFED10, DFED11, DFED13). These DFEDs are the underlying forces of environmental change (Elliott, 2002; Omann *et al.*, 2009; Rounsevell *et al.*, 2010) which can be well thought-out as exogenous to the system or region (e.g. climate, social, economic changes), reflecting either the past, present or future conditions that cause change to the ecosystems (Rounsevell *et al.*, 2010).

Regarding the three out of four relevant pressures on the environment (PE1, PE2, PE3) that were considered as relevant by participants (qi ≥3.5, Q≤ 0.5), we see that in fact these pressures are the stresses that human activities place on the environment (Figure 3.2). However, it is clear that at this very initial step of the DPSIR the "*state of the environment*", which represents the sensitivity of the system to the pressure variables of the environment, already involves in one hand relevant elements to supply the ecosystems service by biological organisms (e.g. water supply for fauna and flora) and in the other hand a demand for ecosystems services from people (e.g. water supply, agricultural land). In the particular case of this research, and because of the extreme dependence on tourism in Galapagos (a part of DFED), we see that there are general social or ecological conditions that could change how ecosystem services are bundled (Raudsepp-Hearne *et al.*, 2010). For instance, tourism is a cultural ecosystem service that could, directly or indirectly, change the rest of known coastal ecosystem services: provision, support and regulation (van Beukering, 2013). This highlights the importance of measuring tourism as a cultural ecosystem service (Nahuelhual *et al.*, 2013) and the relationship between tourism and ecosystem services (Gossling, 2002; Williams and Shaw, 2009; Gee and Burkhard, 2010); however, this lies outside the scope of our research. We used DPSIR to make sense of the complex social-ecological system as a whole and to capture the perceived human and environmental impacts on the ecosystem service bundles**.**

Therefore, it is possible to see that although the 9 DFEDs are connected to 3 PEs and those are connected to the 7 paired interrelated environmental impacts (EI) there are several dynamics involved that can affect the provision of ecosystem services (consumptive or non consumptive use values) in the archipelago. For example, although fisheries were an important direct consumptive use value since 1990 (Goulder and Kennedy, 1997, 2011); the results in this research (PE4) show that fisheries might not be a relevant, additional, cause of environmental impacts. On the contrary, PE2 and PE3 could be identified as direct consumptive use values. The endogenous pressures *land clearing for agriculture and land abandonment* (PE2) are associated with DFED1 and DFED2. Land clearing for agriculture is the consequence of local food production to supply the increasing population and tourist demand on the islands (DFED1); whereas, land abandonment can be attributed as the consequence of the exogenous driver *economic growth* (DFED2), as farmers attracted by better profitable economic opportunities in other activities abandoned agricultural lands (Villa and Segarra, 2010). PE2 is then bundled to impacts such as: *land use change* (LUC) *habitat fragmentation* (HF) and *biodiversity loss* (BL) (Figure 3.3b).

The endogenous pressure *urban zone extension and higher pressure towards natural resources* (PE3) is similarly in direct connection with DFED1 and DFED2. PE3 explains the increase in the touristic in-land infrastructure in San Cristobal, Isabela and Santa Cruz. From 1991 to 2006 the number of hotels doubled (25 to 65); and restaurants and bars tripled (31 to 114) (Epler and Proaño, 2008). The increase in the construction sector, so far with few ecological regulation, brings impacts related to resources extraction (loss of biological resources), such as rocks, sand, wood, water and volcanic stones extracted from beneath the soil (Jimbo and Grenier, 2010). Also, PE3 creates an increase in the energy and fresh water demand. Related to this is the result in EI, that indicate the interaction of the consumptive use values for the ecosystem services with the impact interaction between water basin overexploitation (WBO) and decrease of water quality (DWQ) (Figure 3.3b).

In our research the analysis of the results of the interaction of environmental impacts (EI) allowed us to identify recurrent paired impacts. For example, introduction of species (IS) and biodiversity loss (BL) bundle (IS-BL) easily reflect the serious situation that this interaction of environmental impacts generates in Galapagos (Gonzalez *et al.*, 2008; Guézou *et al.*, 2010). Moreover, BL could be considered the ultimate impact indicator that represents the "*state of the environment*" and which generates visible impacts. BL reflects changes in the environmental functions that can, in turn, affect the social and economic dimensions by affecting tourism. For example, fewer tourists would be attracted to Galapagos if its iconic wildlife were lost. Hence, BL could impact tourism and generate a cascading social and economic effect in Galapagos. So, tourism is a non-consumptive value that extremely depends on biodiversity conservation, and hence if affected will ultimately generate responses for management decisions towards biodiversity conservation policies. In this regards, attention needs to be paid in DPSIR frameworks since the driving forces are perceived as external forces damaging the area or species that need protection rather than socio-economic and cultural processes that are integrated with developments in biodiversity (Svarstad *et al.*, 2008). We consider that future assessments on biodiversity in the Galapagos Islands should address linkages between ecosystem change and human well-being and sustainability (Sachs and Reid, 2006).

Finally, it is clear that the ecosystem services bundles in Galapagos involve multiple trade-offs and synergies involved in management decisions. The DPSIR response section (box IV Figure 3.2) is critical since it can provide 'policy actions initiated by institutions or groups (politicians, managers, consensus group) which are directly or indirectly triggered by (societal perceptions of) impacts and which attempts to prevent, eliminate, compensate, reduce or adapt to them and their consequences' (Omann *et al.*, 2009). These characteristics aim to contribute to the mitigation (and to the prevention) of environmental impacts and its relation to the ecosystem services and consequent well-being of its local population. In the following section a detailed discussion on the findings will be provided.

3.5.3. Policy responses

In DPSIR frameworks, a response is considered as 'a policy action, initiated by institutions or groups (politicians, managers, consensus group) which is directly or indirectly triggered by (societal perceptions of) impacts and which attempts to prevent, eliminate, compensate, reduce or adapt to them and their consequences' (Omann *et al.*, 2009). These characteristics are reflected in the set of responses of the present research, and are important as they aim to contribute to the mitigation (and to the prevention) of environmental impacts of the islands. These responses suggest a stronger implementation and attention to the policies and common practices being developed by the local community and major decision makers in Galapagos. Nevertheless, as observed along this research the mitigation of environmental impacts will require several routes (social, economical, political, technological) passing by driving forces and pressures to specific recognized environmental impacts. Three important groups of responses that enclose the social-ecological situation in Galapagos were identified (see Figure 3.2) and will be detailed in the following subsections.

3.5.3.1. Responses for driving forces of environmental degradation

3.5.3.1.1. Responses for DFED: Tourism strategies (R_TS)

As mentioned in the introduction, tourism could be considered as a major triggering forces of environmental degradation in Galapagos. The participants' strategies given in this section addressed two important management and policy aspects to control tourism. First, *define ecotourism products to be commercialised and government entities to promote them* (R_TS2) and *establish a management system of touristic activities in the inhabited centres* (R_TS4) reflect one key aspect in the two types of tourism that is promoted in Galapagos: luxury or cheaper local tourism base (Grenier, 2007).

Thus, R_TS2 and R_TS4 suggest a complete change in Galapagos tourism practices that will have to pass by changing the conception of other type of tourism and controlling its activities under ecotourism parameters that respect Galapagos natural limits. In this regard, it is important to realize that throughout the Delphi process, participants referred to a change in the conception of tourism towards an ecotourism type. Generically, ecotourism can be simply described as a 'type of tourism founded primarily on a specific interest in the natural history of a region' (Kitchin and Thrift, 2009). Many other definition exist and commonly include: natural setting, conservation, culture, benefits to locals, and education as important components (Krider *et al.*, 2010). In the past decades much has been debated about ecotourism and the real advantages it has in terms of conservation, social and economic benefits (Weaver and Lawton, 2007). It is a controversial topic because on the one hand, ecotourism can stimulate the development and empowerment of local communities (Scheyvens, 1999) and has proved to be an effective tool to counteract implementation of other destructive forms of tourism (mass tourism) to build local and international support for protected areas (Brightsmith *et al.*, 2008). However, in many cases ecotourism also contributes to environmental degradation in particular because of the waste generated to accommodate the increasing number of visitors and where local communities are not prepared to implemented adequate waste management facilities. Furthermore, in wildlife destinations ecotourism has also proved to cause stress and reduce survival responses of determined animals (e.g. ornithofauna) (Müllner *et al.*, 2004). Additionally, ecotourism has also be used as a way of reaching financial benefits at the cost of losing natural resources, especially involving communities that have not embraced nature conservation ideals; and also with the tourists and local communities who have little behavioural environmental ethics (Weaver and Lawton, 2007). This last, is critical for Galapagos as the implementation of 'real ecotourism' will not only have to pass by regulations and implementations but also by a change in the behavioural attitudes of its local community. The second set of responses suggests the imminent regulation to control the number of visitors: *Regulatory plan for specific quantities of tourist per season* (R_TS3), *establish maximum annual quotas* (R_TS5), *stop the tourism growth quotas* (R_TS6) and *change the touristic packages* (R_TS7). *To demand tourists' consumption of local products* (R_TS9) is an interesting proposal aiming to incentive a controlled agricultural production on the islands causing at the same time a possible reduction of goods importation (specially organic food) and thus decreasing the risk of future introduction of alien species. However, agriculture will have to be restructured under quality and ecological parameters that do not affect the native fragile ecosystems (see discussion in section 3.5.3.2). In conclusion, it is clear that the promotion of ecotourism as the only type of tourism and the proposed control of specific number per tourism per year will definitely mitigate the generated impacts related to tourism. However, it will also involve a strong political and societal commitment to diminish the development of different touristic trends others than ecotourism and important regulatory policies to establish a maximum quantity of tourists. This implementation will have to pass by several of the institution in charge of the tourism sector within the inhabited centres. This task has to be addressed by the involved instituions at local level (GCG, representatives of Galapagos municipalities), and at a national level with the Provincial State Directions of the Ministries of Tourism and Environment.

3.5.3.1.2. Responses for DFED: Population growth control strategies (R_PS)

The responses in this section refer basically to three important topics. First, *woman sexual education leading to their economic independence* (R_PS1) and *sexual education: birth control and family planning* (R_PS2). Education will play a crucial role for the future of Galapagos. R_PS1 clearly puts into light gender inequality, something not surprising around the world, and especially in developing countries, where women have usually been marginalised. The role of woman in societies and now of gender equity in any organization and human society is recognized as an impending need for achieving sustainable development (Johnsson-Latham, 2007). The reinforcement of sexual education and its consequent birth control and family planning are interesting tools to propose to reduce the high annual growth rates in Galapagos, which averaged 5,1% from 2001 to 2010 (León and Salazar, 2012). Without any doubt extreme policies such as *one child per couple* (R_PS3) considered as non-relevant by participants (q<3.5, Q>0.5) are not thought-through solutions and have proven to fail and even to cause other social and demographic problems, with as a most evident example China (Hesketh *et al.*, 2005).

Second, suggesting *demographic integral studies,* (R_PS5) is a call for more relevant and needed social studies and information in Galapagos (Ospina, 2006), but also the quality of the demographic data, at the moment not accurately reported by the National Institute of Census of Ecuador (INEC.). Third, *strengthening the local capacity building* (R_PS6) is a very important suggestion that is often taken for granted. Local communities must be integrated in the system to bring about social, political and judicial changes also in accordance with their own perspectives. Furthermore, it is interesting to note that no consensus was reached (Q>0.5) for any of the proposed strategies to improve migratory policies of the Galapagos Special Law (GSL) and its regulation (R_PS7, R_PS8, R_PS9). This dissensus perhaps still reflects the opposing views about the benefits that GSL has given to Galapagos: government subsidies for the locals and certain regulation for immigrations control. But, that has also been used also by some to promote tourism, fishery exploitation and extension of the urban areas (Grenier, 2007).

3.5.3.1.3. Responses for DFED: Economic alternatives (R_Ec)

The following responses generated by participants still embrace two important aspects directly related to DFED6. First, *to maintain tourism as the main economic engine* (R_Ec1) which suggest that participants acknowledge that tourism, though causing environmental degradation, is the most important source of economic income for the islands. Nonetheless, and as suggested in the R_TS section, ecotourism will have to be implemented as the only possible tourism allowed in Galapagos, and even then it will have to integrate important considerations such as the Geographic Print Indexes (Grenier, 2010) for measuring the carrying capacity of the touristic and inhabited islands. *Managing the archipelago as a figure of Biosphere reserve* (R_Ec4) is a call that would require the unification of the Management in Galapagos of its more important public organizations (GNP, GMR, GGC, Municipalities). Furthermore, it can offer international benefits by addressing international agreements such as with the IPBES, the Convention on Biological Diversity and the UN 2030 Sustainable Development Agenda (SDG).

3.5.3.1.4. Responses for DFED: Social alternatives (R_So)

The responses covered a very important part of the whole behavioural and societal changes. These four responses were: *Learning to live in a natural environment* (R_So1), *restoration* *vision* (R_So2), *new cultural identity to respecting the ecosystem limits* (R_So3) and *development based in valuing natural resources* (R_So4). All are a direct responses to the *continental lifestyle and lack of education* (DFED5). Lifestyle is today being looked at as a determinant societal behaviour responsible for major environmental changes worldwide (Omann *et al.*, 2009). It can be defined as a way of living that influences and reflects individual consumption behaviour (Bin and Dowlatabadi, 2005), linked to positive or negative effects towards the environment (Roy and Pal, 2009). DFED5 is an important underlying socio-cultural force that reflects the composition of the Galapagos society. Galapagos inhabitants are today a mix of people with split identities that have, in a large proportion, moved to the islands for reasons beyond specific natural interests. Several authors have detailed these identities and movements along its recent history. (Kerr *et al.*, 2004; Ospina, 2006) It is interesting to note that the islanders' identities differentiation clearly puts in evidence the consumptions patterns and lifestyles associated in two groups: Isleños and Insulares. Isleños are descendants from the first waves of colonists and who exhibit more care and respect to nature and resources (Ospina, 2006; Grenier, 2007). Insulares are the new immigrants of the past 20 years and who exhibit more typical consumption patterns derived from the continent (Ospina, 2006; Grenier, 2007). But, differentiation among local communities must be looked at with caution, as segregation of any type can lead to devastating societal results when exacerbated conditions take place (Diamond, 2005). What is evident however is that both identities and migratory movements occurred as a result of some sort of interest in economic welfare, which was even promoted by the government and local industries (fishing, tourism, agriculture). Therefore, it is easy to see why the majority of Galapagos inhabitants coming from the continent would adopt a continental lifestyle. A lifestyle that mostly bases its values in monetary terms and consumerism. Remarkably this lifestyle is apparently spreading to everyone on the islands, coming or not from the continent. Of course this can also attributed to globalization and capitalism models implemented, not only deriving from the mainland country (Ecuador) but in the whole world. Consumerism as a lifestyle in small islands with limited resources availability and fragile ecosystems is something perhaps more serious; especially if the education of its local community does not address the importance of the natural values. The paths to change these behavioural consumption trends will be very important for Galapagos ecosystem resilience and a related sustainable future.

3.5.3.2. Responses to pressures on the environment (R_PE)

A second important aspect found in these sets of responses gives answer to important environmental pressures (PE1, PE2). The *development of local agricultural production with high ecological standards* (R_PE1) is perhaps a very interesting suggestion as ecological agriculture is recognized to be very advantageous especially for conservation of wildlife habitats (Mander *et al.*, 1999; Green *et al.*, 2005; Gabriel *et al.*, 2013). However, it is important to mention that the common conservation ideal in Galapagos goes against agricultural production. Gardener *et al.* (2010) suggest that perhaps it would be important to start a new vision where the ecosystem services such as land uses for an ecological agriculture, are considered as an essential part for the maintenance or restoration of the Galapagos ecosystem functions. This approach refers to the idea that hybrid systems with native and exotic species would have a better capacity to recover from possible new invasions than do pristine ecosystems. Gardener *et al.* (2010) also argue that the investment and effort to try to return to pristine states of the natural ecosystems in Galapagos in the agricultural highlands is practically unachievable due to several societal and economic considerations (e.g. very expensive to eliminate pastoral fields) (Gardener *et al.*, 2010).

Improve management and control of imported products (R_PE2) is a call for the local authorities in charge of its control the GGC and the GBA (Galapagos Biosecurity Agency). The GCG made important advances and have proposed a new optimisation plan for the maritime transport of organic food. A plan that includes important elements such as two new ships (offered by the Ecuadorian Government) with the required infrastructure (cooling and frozen chambers) to transport and optimize cargo management of organic food, food packaging regulations, labelling and identification of major providers and commercial buyers in Galapagos (CDF *et al.*, 2010).

3.5.3.3. Responses to diminish environmental impacts (R_EI)

As it has been presented in the present research, introduction of species is one of the most serious problems that Galapagos is facing and causing severe biodiversity loss. In fact three responses were considered as relevant (qi ≥3.5, Q ≤ 0.5) strategies to deal with this important threat. First, the *strengthening of the quarantine system for introduced species*

(R_EI1) which in Galapagos was carried out by the Quarantine Inspection Systems (SICGAL) created in 1999 to prevent new species and organisms from being introduced into the Galapagos Islands. However, SICGAL was technically ineffective and inefficient because of the lack in capacity resources to respond to the increasing demand of services generated by the importation of goods by new planes or ships arriving (Zapata, 2006). Today it has been strengthened and officially replaced by the Galapagos Biosecurity Agency (GBA) in 2012. We see that R_EI1 is related to the suggestion by Peck (2006). Peck already suggested that the control and monitoring of further introduction of terrestrial invertebrates in a synanthropic environment will have to be tackled, particularly around ports, towns and farms (Peck, 2006).
Second, the *prioritisation of areas of high biodiversity* (R_EI2) is also very important in terms of conservation strategies. The location of specific areas that harbour a high abundance in relative number of species per area is usually a sort of strategy that has given expected outcomes in terms of conservation (Pressey *et al.*, 2003; Burgess *et al.*, 2006). However, the delimitation of what will be considered as 'high biodiversity' will need to be further evaluated.

Third, to *eradicate large vertebrates* (R_EI3) and to *completely forbid dogs and cats in the islands* (R_EI4) are two responses that reflect the known threats that large vertebrates such as cats, dogs, rats and goats represent for the endemic and native flora and fauna. These large vertebrates threaten several species in Galapagos. For example, dogs (*Canis lupus familiaris*), wild cats (*Felis catus*) and rats (*Rattus* spp.) represent serious threats to: the land iguana (*Conolophus subcristatus*), flightless cormorant (*Phalacrocorax harrisi*), and the Galapagos penguin (*Spheniscus mendiculus*). The cactus *Opuntia megasperma* is threatened by goats (*Capra hircus*) (Jiménez-Uzcátegui *et al.*, 2006). Furthermore, one important related policy response was the *economic penalisation for bringing in animals* (R_EI5). R_EI5 should be considered together with all R_EI as it could help discouraging people from bringing more animals to islands. Finally, *implementing Galapagos Marine Reserve (GMR) zoning schemes with the latest scientific knowledge* (R_EI6) was the last response indicator for environmental impacts that reached consensus by participants in this response section. R_EI6, though not related to in-land introduced species, is indeed an important suggestion for improving the management of Galapagos Marine Reserve (GMR) and to search for an adequate balance between the fishing sector and GMR conservation action plans. This also encloses some of the missing elements, which were not easily brought about by participants during the Delphi exercise as discussed in the following section. R_EI6 can be interpreted as confidence-response in the ongoing technical-scientific studies for the improvement of the management of the Galapagos Marine Reserve. (Viteri and Chávez, 2007; Reyes and Murillo, 2008; Castrejón *et al.*, 2014).

3.5.4. Suitability of the Delphi as a method

Expert opinion is often the only source of evidence when no data are available and when data are difficult to attain at affordable costs, time and due to given the complexity of environmental systems (Brooks *et al.*, 2006; Burgman *et al.*, 2011; Krueger *et al.*, 2012; Vrana *et al.*, 2012). In this research Delphi was chosen not only because of its expert elicitation capabilities for complex systems, but also because it is a method that was developed to avoid the problems of freely interacting groups such as the dominant individuals and the pressures to conform the majority of opinions. As indicated in the introduction "*conflicts in Galapagos have risen over the dispute between conservation and the use of natural resources/tourism*." In Delphi, these sources of conflict that in an elicitation process can generate "process loss" are removed through anonymity and control feedback. The feedback from each round (in this research called Delphi reports), is usually individualised or indicated in-group percentages (Steyaert and Lisoir, 2005) where the majority of opinions can be apparent; and this can cause that the minority position change their opinions (Bolger and Wright, 2011). Due to its iterative nature and controlled feedback, forging, avoiding conflicts and consensus increases after each round, although it is not always evident (Orsi *et al.*, 2011). In this research, several elements might have contributed to generate consensus: 1) the use of Chu and Hwang's (2008) five point Likert scale which proved to be efficient to measure consensus; 2) because consensus is easily achieved with participants that have similar societal perspectives (particularly towards biodiversity conservation); 3) because small groups tend to reach consensus faster (Tan *et al.*, 1995); and 4) because the best argument determines the outcome (Habermas, 2006). In this regard, Bolger and Wright (2011) argue that in social decision scheme theory (SDST)… "– the best argument wins – in which it is assumed that if there is a group member who actually knows the best argument, then she or he will be able to persuade the rest of the group of this fact. The probability that the groups will choose the correct alternative is therefore equal to the probability that someone in the group will know the best argument."

The Delphi's participatory nature and the rigorous queries enabled close collaboration with local stakeholders and decision makers and this enhanced the policy relevance of the DPSIR structured results. We highlight the use of the DPSIR as an instrumental approach to be used with the Delphi method for similar future environmental related research. Interestingly, although DPSIR critics suggest that the framework demonstrates narrow scoping, generates non-neutral knowledge (favouring biodiversity conservation) and suffers from inadequate communication channels between scientists, stakeholders and decision makers (Svarstad *et al.*, 2008), in this research these shortcomings of the DPSIR might have been overpassed due to the Delphi method and its anonymity, statistical consensus approach and its iterative nature. In this sense Delphi favours a critical verifiable generation of group communication and information.

However, despite the fact that the Delphi method for addressing environmental impacts in the Galapagos Islands was conducted following the recommendations of Delphi studies to minimise errors and possible biases, certain shortcomings were noted. For instance, eliciting experts' knowledge with Delphi will clearly tend towards subjectivity, in particular when dealing with environmental systems (Krueger *et al.*, 2012). As explained in section 3.3.1, this situation is linked to the inherent difficulty to determine who is an "expert", what is "expertise" and what is "knowledge". Even the use of the word "expert" to recruit participants is not straightforward, as some important participants might not feel confident enough to participate and give important opinions (Burgman *et al.*, 2011). In this research, this was specified by some of the invited participants.

Related to this is the difficulty to recruit participants and avoiding drop-outs in each round. Knol *et al.* (2010) suggest that *"for expert elicitation there is no guideline on which to base the number experts to be invited; and that even beyond 12 experts, the benefit of including additional experts begins to drop off*". To ensure diversity of opinion, viewpoints, credibility and result reliability, a minimum sample size of 3 participants would be robust enough

(Krueger *et al.*, 2012). This fact is corroborated by Clemen and Winkler (1999) who demonstrated diminishing marginal returns associated with large numbers of experts. In Delphi studies and because its iterative nature and possible drop-out situation during each round, similar threshold are found. For instance, Ziglio (1996) suggests a minimum of 10 participants in the first round and others such as Linstone and Turoff (1975b) suggest a minimum of 7 participants. Therefore, although we expected more participants, our research sample size in the three Delphi rounds (10, 7, 5) is within the limits of an adequate expert elicitation process and Delphi method. Similar number of experts have been used in many other expert elicitation and/or Delphi studies in related fields: Ecology (Pearce *et al.*, 2001; Seoane *et al.*, 2005; Wooldridge *et al.*, 2005; Marcot, 2006; Smith *et al.*, 2007), biology (Ahmadi-Nedushan *et al.*, 2008), conservation biology (Murray *et al.*, 2009; Garcia-Melon *et al.*, 2012). Suggestions to avoid drop-outs is by giving some kind of incentives to the participants (Bolger and Wright, 2011); however, this should be further analysed and investigated. In our research we detected personal and motivational aspects, timing, long questionnaires and the exhausting iteration processes, as the main factors that contributed to the dropouts.

We argue that those participants who participated along the whole Delphi process might have had a higher motivations because: 1) felt that they have no voice in the official dialogue in Galapagos; 2) they feel they should engage in a scientific study because it will grant them more credibility; or 3) just that they hoped to have an issue introduced and taken upon by experts. However, all these are just hypotheses. The fact that certain interests drive the experts is difficult to know and requires another type of discussion that is out of the scope in this paper. While opinions were given by the participants, other opinions were noted to be missing or did not match the latest scientific knowledge either related to environmental impacts or conservation. For example, little attention was paid by participants to waste burden and degradation of the vegetation, disturbances, pollution and noise in the Islands or even to loss of genetic diversity, which are all recognised as key conservation issues (Grove, 1992; Samways *et al.*, 2008; Sanaa and Fadhel, 2010). Attention has to be paid to the use of some terms and concepts by participants, as they can have various interpretations (ecotourism/nature tourism or biological resources and biodiversity).

These ambiguities are recognised as a general problem in ecological science, and Delphi applications are no exception (Orsi *et al.*, 2011).

Finally, although the results tend to favour a biodiversity conservation criteria which generates a “bias” in relation to the problems and proposed solutions, we may with some reason be expected to work in a framework where rational arguments dictate that the Galapagos Islands should be in a good state of conservation in order to be economically viable, more so than in some other places. Tourism alone represents 65% of Galapagos GDP (85 million USD/year) (Epler, 2007). Hence, nature tourism is the main productive activity on the islands and the main economic driver of the islands. Galapagos’ economy is a “revenue system” anchored to tourism (Ciccozzi, 2013a). In this sense, Galapagos future has two alternatives. Either it heads towards a model of “nature conservation and sustainability” with the maintenance of its unique natural diversity and a moderate thriving economy, or it heads towards a model of “business as usual” with a rapid impoverished natural diversity and “temporary thriving economy”.

Next to the realisation of the economic importance of nature, is the need for a sense of shared ownership of the islands’ ecosystems, as well as a sense of belonging to the community. So far, “*the participatory management currently in play in the islands has shown the limits arising from the absence of institutions able to reassure the respect of regulations, both in terms of positive incentives as of the repression of the transgression”* (Ciccozzi, 2013a). New or existing –environmental– governance mechanisms need to be perceived by everyone as being legitimate. If this is the case, then an explicit knowledge of the importance of nature for the Galapagos Islands’ economy is not even necessary as long as ‘everyone’ agrees with the regulations, recommendations in place, not –only– by fear of being fined/punished, but also because they perceive the regulations in place to be legitimate. Then, the Galapagos Islands’ ecosystems can survive, and hopefully thrive. The participatory development of indicators, and the participatory development/improvement of environmental governance mechanisms will ideally contribute to both a better understanding, and an increased legitimacy of ‘institutions’ required to protect the unique ecosystems in Galapagos.

3.6. Conclusions

The aim of this study was to identify and characterise environmental impacts and their interconnections associated with anthropogenic activities, through the development of sustainability indicators. This goal was achieved through combined use of the participatory Delphi method and the DPSIR analytical framework. The identification of DPSIR sustainability indicators allowed retrieving basic information that is able to describe and measure the function of the complex social-ecological system and of the ecosystem and services of the Galapagos Islands. Moreover, it was not only possible to specifically integrate each indicator into an analysis of its own DPSIR level where internal interconnections were present (i.e. tourism growth- economic growth); but also, at a broader level, between each level within the DPSIR going from driving forces of environmental degradation, pressures on the environment, environmental impacts and responses. Therefore, Galapagos DPSIR interpretable framework and its sustainability indicators are potentially suited for opening discussions on policy alternatives by Galapagos' decision makers and stakeholders. We consider that the research results can be used as a way to improve the implementation of mitigation processes in the archipelago. This study has proved that the participatory approach –through the Delphi method– is a tool to gather opinions and forge group consensus. Delphi has demonstrated to be an efficient, versatile method capable of integrating knowledge of varied groups of stakeholders. The mitigation of environmental impacts in Galapagos will require several routes (social, economic, political, technological) passing by driving forces and pressures to specific recognised environmental impacts. Although, the research results have been presented to local stakeholders, who have demonstrated great interest and expectations about the outcomes of this research, the final indicator sets will benefit from further discussions based on different perceptions of different groups in Galapagos. We recommend the use of this research by policy and decision makers in Galapagos to implement management policies and strategies that will contribute to the mitigation of environmental impacts and to the consequent well-being of its local population. The research has endeavoured to contribute and complement the understanding of the underlying causes of environmental problems in Galapagos.

Chapter 4

THE Q METHODOLOGY TO STUDY CONSERVATION DISCOURSES IN THE GALAPAGOS ISLANDS

Modified from "Exploring conservation discourses in the Galapagos Islands: A case study of the Galapagos giant tortoises". (2016). Francisco Benitez-Capistros[1,2], Jean Hugé[2], Farid Dahdouh-Guebas[1,2] and Nico Koedam[1]. *Ambio,* 45(3): 1-19.

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* Contributions to this paper: FBC and NK originally formulated the idea and FBC the conceptual design of the study. FBC collected, analysed and interpreted the data. FBC wrote the manuscript. JH, FDG and NK provided critical revisions for the finalised version of the article.

4.1. Abstract

Conservation discourses change rapidly both at global and local scales. These changes are related to the different and evolving understanding of the human-nature relationships. To be able to understand the relationships between humans and nature, we focused on a local and iconic conservation case: the Galapagos giant tortoises (*Chelonoidis* spp.). We used the Q methodology to contextualise conservation for science and decision-making and to explore the multidimensionality of the conservation concept in Galapagos. The results indicate four prevailing discourses: (1) Multi-actor governance; (2) giant tortoise and ecosystems conservation; (3) community governance; and (4) market and tourism centred. These findings allow us to identify foreseeable points of disagreement, as well as areas of consensus, and to discuss the implication of the findings to address social-ecological conservation and sustainability challenges. This can help the different involved stakeholders (managers, scientists and local communities) to design and apply contextualised conservation actions and policies to contribute to a better sustainable management of the archipelago.

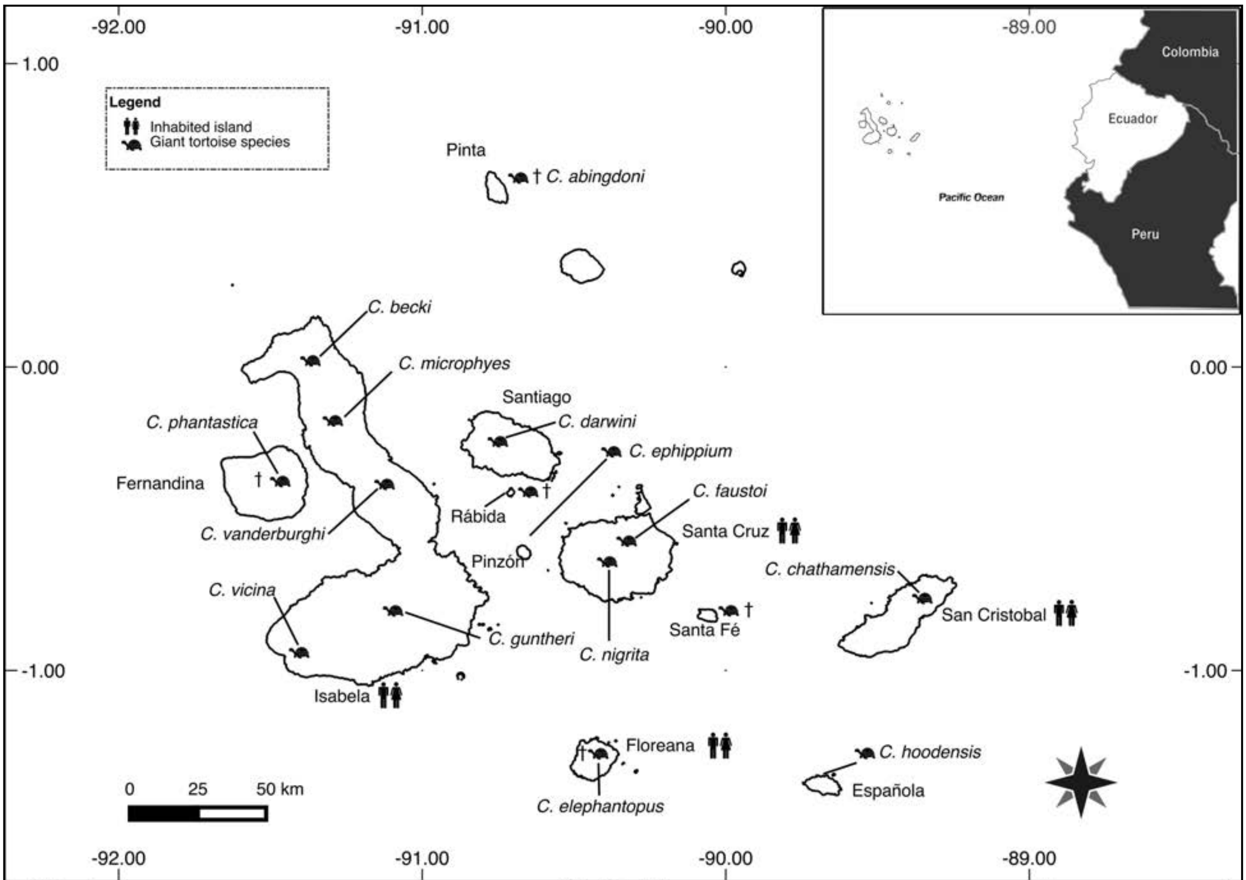
4.2. Introduction

Conservation is a transdisciplinary science and practice that addresses the protection of species, communities, ecosystems, biodiversity, and human wellbeing (Soule, 1985; Kareiva and Marvier, 2012). Conservation is however also influenced by social and geopolitical dynamics such as the politicisation of conservation in protected areas (Chamberlain *et al.*, 2012) or the different views, values and attitudes of local communities over conservation that affect and modify conservation framings, discourses and actions (Hutton *et al.*, 2005). Conservation framings are never static and they transform and shift according to political-economic contexts (Jepson and Barua, 2015). Henceforth, understanding conservation framings and discourses can allow us to contextualise shared assumptions occurring at a particular place. Discourses are structured ways of representation that evoke particular understandings (e.g. framings) and may subsequently enable particular types of actions to be envisaged (Hugé *et al.*, 2013). Therefore, the way the relationship between human and nature is viewed will influence how conservation is framed and practiced. Although at a global scale, major trends in conservation discourses have shifted from nature-centred discourses (1960s -1990s) to more human-nature oriented discourses (2000-present) (Mace, 2014), at local and contextualised scales these shifts might not be so evident. In order to understand and capture these shifts and the relationship between humans and nature, we focused on the iconic Galapagos giant tortoises (*Chelonoidis* spp.) to explore conservation discourses on the Galapagos Islands, a place that on a very limited geographical scale has a strong focus on conservation and elicits strong interests from the international community. Iconic species are 'charismatic species that serve as a symbol or focus point to raise environmental consciousness' (Caro, 2010). They have been used as means to promote conservation management strategies (Simberloff, 1998), public interest, economic development and international political agendas (Buckingham *et al.*, 2013). Moreover, iconic species have a strong potential to mobilise social actions within the political and economic contexts of conservation where politics and economics usually shape and favour certain conservation interventions that are related to public and private interests (Jepson and Barua, 2015).

In Galapagos, the history of the relationship between humans and giant tortoises dates from the late 18th century when buccaneers, whalers and seal hunters stopped in the islands for water and food. Giant tortoises were especially important due to their long-standing ability to live during months without water and food (Townsend, 1925; Nicholls, 2006). Once the first human settlements were established in 1832, giant tortoises were affected by excessive hunting and by introduced species, particularly by rats eating giant tortoises' eggs (Froyd *et al.*, 2014). With the establishment of the Galapagos National Park (GNP) and the Charles Darwin Foundation (CDF) in 1959, a giant tortoise status review revealed that only 11 of the original 15 species (Poulakakis *et al.*, 2015) remained, most of which were endangered or at the brink of extinction (Cayot, 2008). These extant 11 species are distributed over 6 islands; four of which (Santa Cruz, San Cristobal, Isabela and Floreana) have a history of human settlement and colonisation (Figure 4.1).

The iconic characteristics of giant tortoises (e.g. endangered, charismatic, keystone species) made them a conservation priority (Cayot, 2008; Edwards *et al.*, 2013). With time, giant tortoise representations have become ubiquitous in the archipelago. They are used as names in shops, restaurants, NGOs, schools and even as a political party logo. The successful captive breeding centres, restoration and repatriation programmes (Gibbs *et al.*, 2014), promoted tourism and conservation awareness in the four inhabited islands (Cayot, 2008). However, issues have emerged such as the occasional killing of giant tortoises on Isabela Island due to local beliefs (needs for post-parturition mothers) and retaliations against GNP and conservationists (Márquez *et al.*, 2007).

The dynamics of conservation discourses are especially relevant in long-lasting conservation challenges centred on iconic species such as giant tortoises. This is inherently related to the different perspectives on the values of nature that co-exist in a society where iconic species have been assumed to have an intrinsic value, assuming that nature is inherently valued by the public (Home *et al.*, 2009). However, it must also be understood that the quality of being an iconic species does not imply effective and widely accepted conservation measures. For instance, in 2002, the popularity of giant tortoises was used by protesters who threatened to kill them if fishing quotas were not increased (Pablo Gordillo, mayor of Isabela, pers. comm.). This led to a shift in discourse from the influential stakeholders (e.g GNP, CDF, WWF), from a 'nature despite people' to a 'nature for people' discourse where ecosystems became a priority and community-based tourism was promoted as the consensus solution. Lately, the increasing human pressure from tourism (200 000 visitors per year) and local population (25 000 inhabitants) rapidly shifted discourses to a more pronounced 'people and nature' discourse with the aim of involving all local communities in conservation (Tapia *et al.*, 2012; Cairns *et al.*, 2013). Conservation challenges centred on iconic species demand insight in the various dimensions of conservation, as well as an exploration of the differences in perceptions among stakeholders (Reed *et al.*, 2009). This research aims at mapping and positioning the discourses underlying the role of giant tortoises in conservation, social development, science and cultural identity in the Galapagos archipelago. We use a scientific approach to study human subjectivity and inter-subjectivity (Q methodology), to contextualise conservation for science and decision-making and to explore the multidimensionality of the conservation concept in Galapagos. We highlight the differences in perceptions among different stakeholder groups, we identify local conservation discourses and analyse the degree to which these have been influenced by global conservation governance, and we relate our findings to other local cases of conservation conflicts with iconic species.



Island	Giant tortoises		Humans
	Species	Population estimates	Population census
Española	C. hoodensis	20 – 30	
Fernandina	C. phantastica	†	
Floreana*	C. elephantopus	†	145
Isabela	C. becki	1000 – 2000	2256
	C. microphyes	500 – 1000	
	C. vandenburghi	3000 – 5000	
	C. guntheri	200 – 300	
	C. vicina	400 – 600	
Pinta*	C. abingdoni	†	
Pinzón	C. ephippium	150 – 200	
Rábida*	C. wallacei	†	
San Cristobal	C. chathamensis	500 – 700	7330
Santa Cruz	C. faustoi	n.a	15393
	C. nigrita	2000 – 3000	
Santa Fe*	Undescribed	†	
Santiago	C. darwini	500 – 700	
Total	15 species	8270 – 13530	25000

Figure 4.1. Giant tortoises (GT) distribution and human settlements in the Galapagos Islands

The total human population reaches 25000 inhabitants in the four inhabited islands. Giant tortoises *(Chelonoidis* sp.) population estimates are between 8270 and 13530 (Márquez *et al.*, 2007; Poulakakis *et al.*, 2015). † extinct species; * giant tortoise restoration initiative

4.3. Materials and methods

Developed by the physicist and psychologist William Stephenson in the 1930s, Q methodology is a scientific approach to the study of human subjectivity and inter-subjectivity in an organised, structured and statistically interpretable form. It combines the qualitative study of attitudes with the statistical rigour of quantitative research techniques (Barry and Proops, 1999; Watts and Stenner, 2012). The method is widely used in social science research and is increasingly used in conservation biology and policy-related research (Addams and Proops, 2000; Davies and Hodge, 2007; Sandbrook *et al.*, 2011; Rastogi *et al.*, 2013). Q attempts to elicit a variety of accounts or discourses about or around a particular discourse domain, theme, issue or topic (Barry and Proops, 1999). Q is used as a discourse analysis tool because participants' responses are consistently comparable and limited to a number of ordered patterns (factors or discourses) that are revealed in a structured and interpretable form. Q is, therefore, particularly suited to studying those social phenomena around which there is much debate, conflict and contestation, such as the environment, for its explicit aim is to elicit a range of voices, accounts and understandings (Barry and Proops, 1999).

4.3.1. Data collection

Q data are collected through several continuous steps starting with the *concourse*, which is the body of information about a research topic (here gathered throughout 54 interviews in the four inhabited Islands and through a literature review) from which a *Q-sample* (entailing a list of key statements derived from the Q concourse, n=60) is generated (Table 4.1). Then, *Q-participants* are selected (Table 4.2) and asked to rank the statements of the *Q-sample* according to specific instructions in what is called a *Q-sort (n=28)*. This is followed by a qualitative discussion/explanation of the participants' reactions to the statements that they most agree or disagree with (audio-recorded). When each Q-sort from each Q-participant is collected, statistical techniques of correlation and factor analysis are applied to reveal patterns with which people associate opinions. In the factor interpretation and result section, we have added this qualitative information in quotes, followed by the Q-participant's number (i.e. –Qsort15–). Each statistically extracted pattern (factor) is interpreted and the discursive framework of the research is identified. In Figure 4.2, we summarise the Q process followed and in Appendix B1 we detail each specific step as conducted in this research.

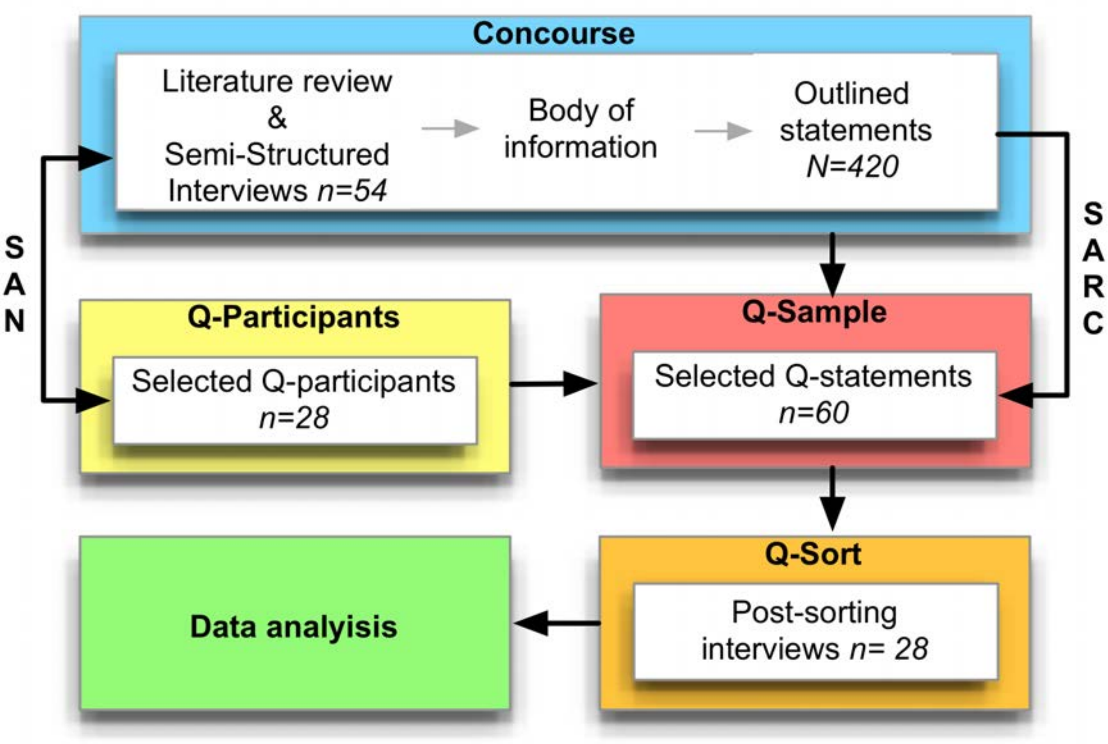


Figure 4.2. Diagram flow for gathering data in Q methodology.
From the top left to right: a stakeholder analysis **(SAN)** was used to identify and capture the spectrum of opinions occurring in Galapagos (Appendix B1) and to further identify relevant Q-participants. A structured approach to reduce the concourse **(SARC)** from 420 to 60 statements was used to generate the Q-sample. Q-participants ranked the Q-statements according to her/his preferences (agreement or disagreement) over a forced Gaussian distribution from -6 to +6 (Figure 4.3). Post-sorting interviews were conducted to record participants' reactions to particular statement(s) of their interest, upon Q-sort completion.

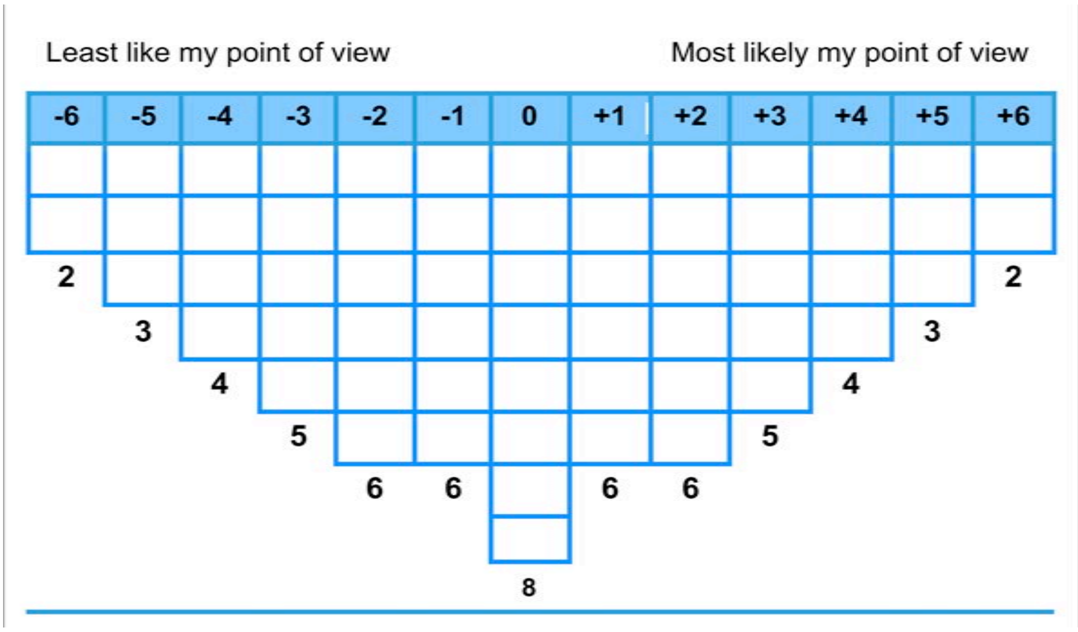


Figure 4.3. Example of pyramidal quasi normal distribution used to sort and rank the Q-sample.

The black bold numbers indicate the total number of Q statements that needed to be placed on each ranking category.

4.3.2. Data analysis

From the entire set of Q-sorts (n=28), each conducted by a different Q-participant (Figure 4.4c-d, Table 2), factor analysis or principal component analysis (PCA) was used to reduce the diverse points of view to a smaller set of factors that reflect shared ways of thinking (Sandbrook *et al.*, 2011). The data was analysed with PQ method, a software specifically designed for Q methodology (Schmolck, 2014), and with the qmethod package in R software (Zabala, 2014). Both allowed us to have an in depth analysis, in particular due to R's online resources accessibility and varied data analysis packages that can complement Q analysis (i.e. nFactors, FactoMineR packages).

Figure 4.4. Major research steps for the collection of data with Q-methodology.
(a) Iconic Galapagos giant tortoise (*Chelonoidis* sp.) at a touristic farm in Isabela island, **(b)** interviewee from touristic farm in Isabela island, **(c)** scientist; and **(d)** decision maker, completing the *Q-sorts* in Santa Cruz island (photographs by F. Benitez-Capistros, 8 February, 2014).

The statistical analysis had three statistical procedures: 1) calculation of a correlation matrix, 2) extraction and rotation of significant factors; and 3) the computation of a set of factor scores for each factor (Addams and Proops, 2000; Watts and Stenner, 2012). The first procedure involved a correlation analysis among all Q sorts; a 28 by 28 correlation matrix was generated. The second procedure involved a principal component analysis (PCA) of the correlation matrix with the aim of identifying which participants' Q sorts clustered in a number of explanatory factors (Cairns *et al.*, 2013). Initially there were 9 factors with an eigenvalue (EV) >1. Although there is no precise mathematical based decision rules regarding the number of factors that should emerge in a Q study, statistical calculations are nevertheless used to support the decision on the number of factors to extract. Therefore, we calculated those Q-sorts that loaded significantly with a factor at > ±0.33 which is significant at a level of p <0.01 (Brown, 1980). If at least two loaders in each factor had higher values than ±0.33, then those factors could be considered for extraction.

$$x = 2.58\ \left(\frac{1}{\sqrt{n}}\right); x = \ 2.58\ \left(\frac{1}{\sqrt{60}}\right);\ \ x = \ \pm 0.33 \qquad \text{(Eq.1)}$$

As a result seven factors had more than two loaders at > ±0.33 p <0.01. Among those seven factors, most loaders were confounders (loading in more than one factor), which is not ideal for factor interpretation (Appendix B4). To reduce the number of factors, we used the *Castell scree test* with *parallels analysis* to help in the decision on how many factors to extract (Watts and Stenner, 2012). Taking the advantage of working with R, we used the nFactor package and run these tests (Raichem and Magis, 2011). Figure 4.5 suggests that the factor extraction leads to the selection of two to four factors. We decided to keep four factors based on the results obtained with parallel analysis since its selection criteria are stricter (Appendix B5). To decide which four factors to extract we used Hampreys' rule of extraction (HRE), which considers that a factor is significant if the cross-product of its two highest loadings exceeds twice the standard error (Brown, 1980).

$$SE = 1 \div \sqrt{No}.of\ Q\ statements$$

$$SE = 1 \div \sqrt{60}$$

$$SE = 0.13$$

$$2 \times SE(0.13) = 0.26 \qquad \text{(Eq.2)}$$

After retrieving the four factors in the adequate threshold for extraction according to the HRE (Appendix B4), we proceeded to the last and third part which involved the varimax rotation of the four factors. We used a varimax rotation to ensure that factors were positioned so that the overall solution maximises the amount of the study variance explained (see Figure 4.6 and Figure 4.7) (Watts and Stenner, 2012). Each rotated factor had a particular weighted average of the Q-sorts that defined each factor. Again, the Q-sorts that significantly correlated with a factor at > ±0.33 were considered representative of that view (Appendix B6). After the comparison of factors, we sought a solution that maximised the number of participants loading on just one factor, ensuring that each factor contained at least three Q-sorts that loaded on one factor alone. The degree of correlation between factors (Appendix B7) and the weighted average of the loaders' sort patterns for a factor were used to calculate an idealised sorting pattern per factor along the original response scale (–6 to +6). Examining these idealised sorting patterns (factor arrays) and analysing the post-sorting comments made by some of those participants, we drafted narrative descriptions of each factor.

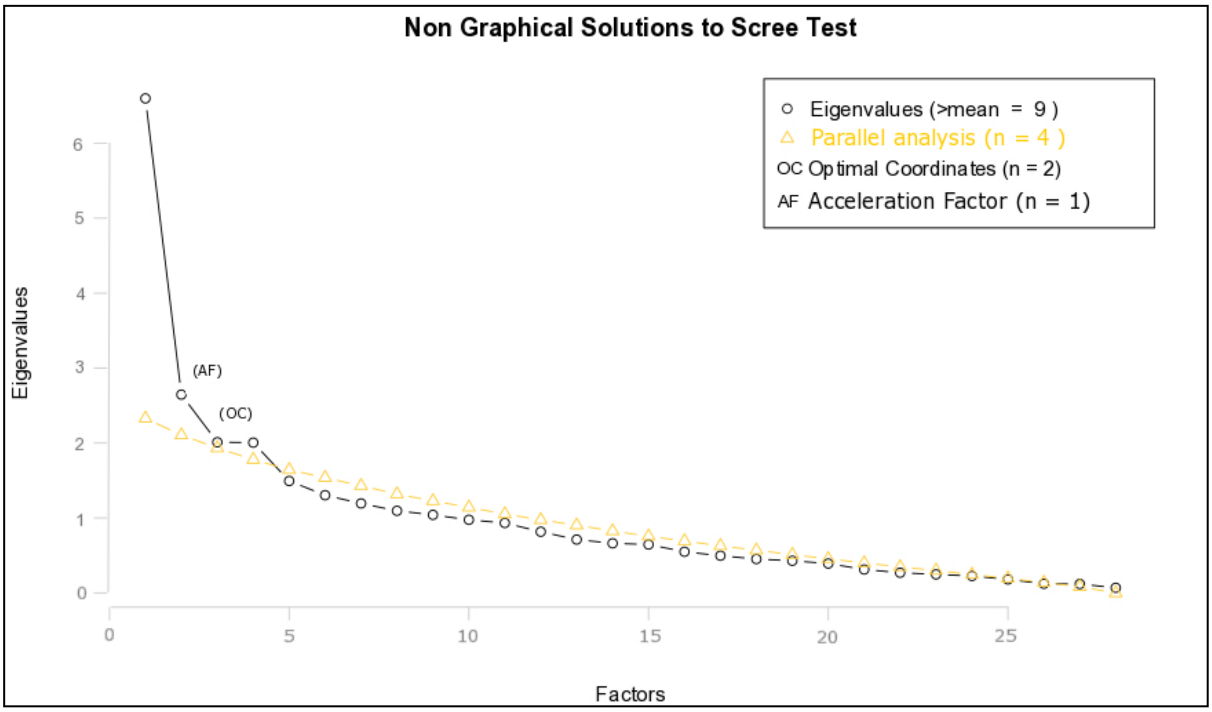


Figure 4.5. Non graphical solutions to the Cattell subjective scree test.
EVs as major factor extraction decision criteria. An acceleration factor (*af*) and the optimal coordinates index (*oc*). The *af* indicates where the elbow of the scree plot appears. It corresponds to the acceleration of the curve. The *oc* are the extrapolated coordinates of the previous eigenvalue that allow the observed eigenvalue to go beyond this extrapolation (made by a linear regression using the last eigenvalue coordinates and the k + 1 eigenvalue coordinates) (Raichem and Magis, 2011). See also Appendix B5.

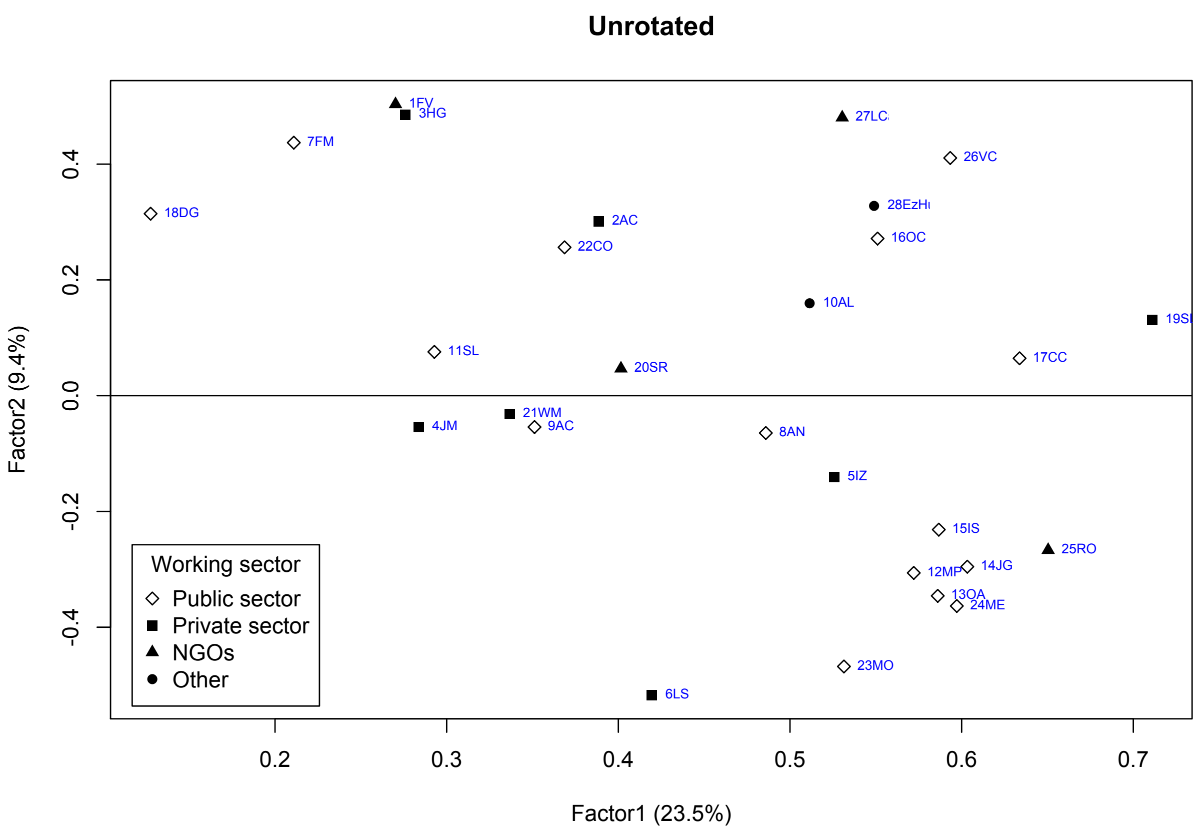


Figure 4.6. Unrotated plot of Factor 1 and Factor 2
Q-sorts are labelled according to their main working sector (legend). Q-sort id-code is indicated in blue.

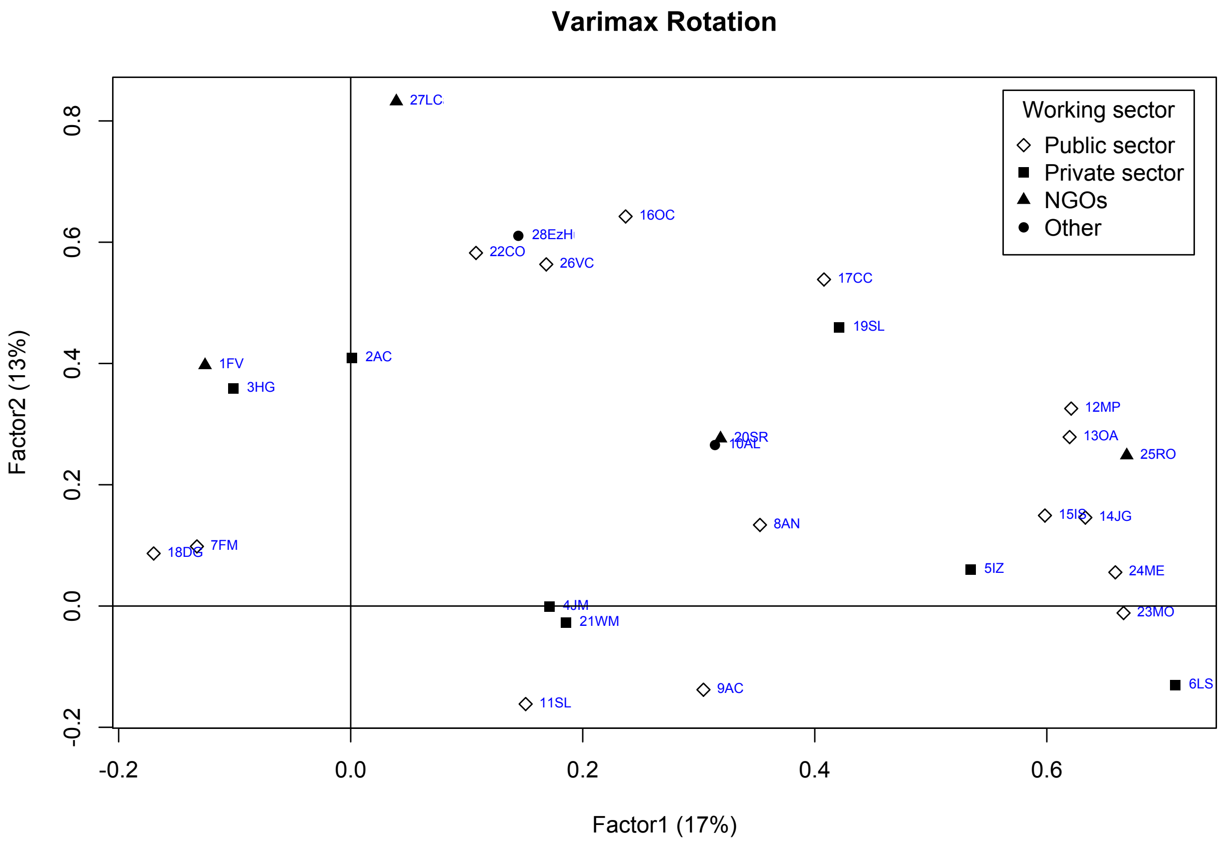


Figure 4.7. Varimax rotation plot of Factor 1 and Factor 2
Q-sorts are labelled according to their main working sector (legend). Q-sort id-code is indicated in blue.

4.4. Results

A factor is a condensed statement of the relationship between variables (Kline, 1994). Although it can be argued that all 9 factors (EV>1) could emerge as different discourses, our extraction selection factor criterion (Hampreys' rule of extraction, number of loaders on each factor), allow us to discard 5 of the 9 factors, as they were lacking explanatory power in the study.

4.4.1. Factor interpretation and description

The interpretation of the factors was based on a systematic analysis using the crib sheet approach that examines the factor array (z-scores and rankings) in detail, through a systematic and consistent process that helps understanding the participants' viewpoints at a qualitative level (Watts and Stenner, 2012). Therefore, it is the combination of the statistical/quantitative information from each statement in each factor (z-scores and rankings), the qualitative information from the post-sorting interviews; and our understanding of the current debates regarding giant tortoises, policies, conservation and socio-economic development in the Galapagos Islands, that allow us to generate each narrative or discourse. Table 4.3 summarises each discourse by key statements and stakeholder's characteristics; whereas Table 4.4 presents a synthesis of the results in with the consensus and dissensus by statements and discourses.

4.4.1.1. Discourse 1: Multi-actor governance

Adherents of discourse 1 focus on social and governance issues by emphasising changes in the Galapagos political model (S45), by breaking the webs of corruption and cronyism (S40), and by strengthening institutions (S39). It considers that there has been an overlap of institutional competences in particular within the GNP, an institution that has well performed in conservation issues (S38), but that still requires more scientific and technical criteria on which to base their decisions (S44). The adherents of this discourse agree on an ecosystem approach to conservation (S2) but conservation should also be economically profitable (S13). Conversely, market-oriented points of view with regard to giant tortoises (S21, S26) are rejected and although this discourse values giant tortoises as important symbols of evolution (S56), they consider that they have been extensively and sufficiently studied (S5). In discourse 1, giant tortoise conservation is not of primary importance for the economy (S22). The adherents of discourse 1 strongly support the promotion of alternative productive sectors besides tourism (S27, S24). “*It is precisely in the diversification of activities that we will find a sustainable development. Not by basing our activities only on tourism*” –Qsort 14-.

The adherents of discourse 1 strongly agree that human settlements were not adequately managed (S16) and that there is little conservation awareness in the local community (S20, S33, S31). For the adherents of this discourse conservation will work only with the involvement of the community and other actors (S47, S14) and thus prioritising policies on environmental education is mandatory (S34). “*There is a governance component that for me is not working. This is why governance and environmental education and in general social issues are mandatory, if you correct this then everyone including giant tortoises have a chance to thriv*e" -Qsort 25-.

4.4.1.2. Discourse 2: Giant tortoise and ecosystem conservation

Adherents of discourse 2 focus on giant tortoise conservation as a priority because of their ecological, scientific and socio-economic value (S9, S11). Giant tortoises need to be protected (S57, S54) which is related to the ecological role that giant tortoises have (S1, S8). “*Giant tortoises have a key role in the ecological restoration of the islands, they are the ecosystem engineers of Galapagos-creating opening, dispersing seeds, etc. They are a critical component of the ecosystems of the larger islands*” –Qsort27-.However, an ecosystem approach to conservation (S2) is also considered relevant. “*All components of ecosystems are important for maintaining self-sustaining populations of individual species (including giant tortoises*)”-Qsort27-. Positioning humans over other species (S36) and framing conservation as a mean to use species is rejected (S13, S26). Adherents of this discourse considers that the efforts invested in the conservation of Lonesome George, the last known purebred individual of the species *Chelonoidis abingdoni* native to Pinta Island (Edwards *et al.*, 2013), as with the rest of giant tortoises (S28), is the result of hard work on conservation (S58) and should be an example for the archipelago as whole (S53). "*Lonesome George was an icon for conservation, and his death is a reminder of how hard we have to work in order to prevent extinctions*" -Qsort28-. Moreover, the adherents of this discourse consider that giant tortoises are not central to the identity of *galapagueños* (S59) even if giant tortoises have been extensively studied and are iconic in Galapagos (S5). "*Giant tortoises have been abundantly studied, but the problem is that the information is not being transmitted, or has not been disclosed and this is why people do not know what's being done* -Qsort16-.

Similar to the adherents of discourse 1, adherents of discourse 2 agree that human settlements were not adequately managed (S16) and that there is little conservation awareness in the local community (S20, S19) but that the economic benefits from tourism are raising awareness (S25). This discourse supports the re-enforcement on environmental education policies by the major decision making institutions (S34) and supports the GNP work and decision making (S44). However, adherents of discourse 2 disagree with the idea of managing the archipelago only with local people (S29): "*Thinking that only the galapagueños know the reality of the islands is also a myth! It is always positive to count on the experience on what is being done in other parts of the world and that people from the outside give us a hand. Not that they do our job but that they can guide us*" -Qsort22-.

Adherents of discourse 2 agree that there is a positive environmentalism in Galapagos (S35) and that the success in conservation in Galapagos is a consequence of public policies for conservation, the hard work of several institutions in favour of conservation (S37). Hence, promoting a sense of responsibility for conservation within all institutions in Galapagos is considered more important (S41) than political or institutional changes (S36, S39, S40, S43). As one of the loaders clarified: "*It is useless that only the GNP protects the protected areas when inside the urban and rural areas there is a chaos. Everything done in the urban or rural areas affects the protected areas and vice-versa. We have to break the scheme that the GNP is the only responsible for conservation*" -Qsort22-.

Table 4.1. List of Q statements, Z-score and rank associated with each factor, and Eigenvalues (GGT = Galapagos giant tortoise)

		Factors							
		1		2		3		4	
Statements		**Z-score**	**Rank**	**Z-score**	**Rank**	**Z-score**	**Rank**	**Z-score**	**Rank**
S1	GGTs have a key role in the ecological restoration of the islands	-0.11	-1	1.88*	6*	-0.15	-1	-0.96*	-3*
S2	Work in conservation should be on ecosystems and not only on iconic species such as the GGT	1.35	5	1.59	5	0.43*	1*	-0.76*	-2*
S3	GGTs are living examples of evolution that deserve to be studied	-0.04	0	0.23	1	1.03*	4*	-0.92*	-3*
S4	It is sad that certain individuals such as Lonesome George disappear; they are a loss both for humanity and science	0.54	2	0.00	0	-0.03	0	0.07	0
S5	Despite the fact that GGT are so iconic, they have been studied very little	-0.67*	-2*	-1.37*	-4*	0.51	1	0.20	1
S6	Scientists coming to Galapagos should change their way of researching from not only doing science IN Galapagos but also FOR Galapagos	1.09*	3*	-0.44	-2	0.60	2	-0.39	-1
S7	Scientific knowledge about GGTs and their natural history must be generated and disseminated so that people can understand what is being done	0.40	1	0.78	2	1.68*	5*	-0.38*	-1*
S8	Genetic and migratory studies about GGTs are key for ecological restoration of their population	0.29	1	1.43*	5*	0.39	1	0.16	0
S9	GGT conservation is a priority for the archipelago because of its social, economic, cultural and scientific value	0.02	0	1.16*	4*	0.23	0	1.85*	6*
S10	GGTs conservation and breeding programmes serve two purposes: ecological restoration and tourism	0.17	0	0.49	1	0.60	2	0.81*	3*
S11	The success in conservation with GGTs maintains public interest in conservation, which is essential to raise funding and influence political or community organisations	0.10	0	1.20*	4*	-0.92*	-2*	-0.10	0
S12	Conservation is the best business that exists, it is the capital that sustains activities in Galapagos	-0.30	-1	0.11*	0*	-0.36	-1	-0.71	-2
S13	Conservation means protecting species but also making use of those species, natural resources and landscapes	0.69*	3*	-1.56*	-4*	-0.60	-2	-0.34	-1
S14	The efforts from the GNP to relate to the community are very isolated and specific. A holistic approach spanning the growing and dynamic community of the islands is needed	1.25	4	-0.23*	-1*	0.95	3	0.19*	1*
S15	Much has been invested in conservation and little in social issues such as health, mobility and environmental education	0.58*	2*	-0.32	-1	0.42	1	-0.99*	-4*
S16	The State and institutions have adequately managed human settlement in Galapagos	-2.30	-6*	-1.69*	-5*	-1.13	-4	-2.39*	-6*
S17	Introduced species are a great threat for the conservation of GGTs	-0.01	0	1.29	4	1.94	6	0.10	0
S18	Politicians in Galapagos demonise conservation	-0.63	-2	-0.30	-1	1.13*	4*	-1.46*	-5*
S19	At present, the local community understand recycling as a synonym of conservation	-1.41	-4	-0.41*	-1*	-1.28	-4	-1.15	-4
S20	The majority of the local community is aware about conservation and protect, care and they respect nature	-1.00	-3	-1.26	-4	-1.37	-4	-0.76	-2
S21	GGT is a wonderful animal because it attracts many tourists	-1.32*	-4*	-0.12	0	1.26*	4*	0.31	1
S22	To a large degree the Galapagos economy is based on tourism and consequently in the conservation of GGTs	-1.02*	-4*	0.82	2	-0.62*	-2*	0.99	3

Table 4.1. List of Q statements, Z-score and rank associated with each factor, and Eigenvalues (GGT = Galapagos giant tortoise)

S23	Economically one GGT is worth more alive than dead	0.69	2	0.71	2	0.49	1	0.22	1
S24	Tourism is the only productive activity in Galapagos	-2.38*	-6*	-1.70	-5	0.43*	1*	-1.73	-6
S25	Tourism has generated economic benefits to the local community; and at the same time, locals have begun to realize the benefits of conservation	0.18	0*	0.93*	3	-0.08	0	-0.60	-1
S26	GGTs are convenient because they are another product that can be promoted, as long as the rules and codes of conduct established by the GNP are followed	-1.04	-4	-1.19	-3	-0.66*	-2*	-1.03	-4
S27	Handicrafts, fisheries and agro-production should be promoted as alternative productive sectors and of identity in Galapagos	1.85*	6*	-0.63*	-3*	0.15*	0*	1.09*	3*
S28	Lonesome George was a commercial flagship individual that represented very little to conservation	-0.84	-3	-1.68*	-5*	-0.51	-2	-0.05	0
S29	Galapagos needs to be managed socially, economically and environmentally by all the galapagueños and people that live on the archipelago	-0.47	-2	-0.61	-2	1.63*	5*	2.48*	6*
S30	The Galapagos Islands that are visited by tourists are usually completely unknown by a large proportion of the local community	0.52	2	0.96*	3*	0.98	4	0.03	0
S31	The physical and emotional connection with nature is very low in the local community	-0.23	-1	-0.45	-2	-0.98	-3	-0.70	-2
S32	The touristic attraction of GGTs is a synonym of respect for nature by tourists and the community	-0.49	-2	-0.60	-2	0.54*	2*	0.54*	2*
S33	Fishermen and farmers respect nature equally	-1.63	-5	-0.70	-3	-1.38	-5	-1.26	-5
S34	Environmental education in the archipelago must be established as a policy priority for the decision makers": Galapagos Governing Council (GGC).Municipalities, Galapagos National Park (GNP) and ministries	1.22	4	0.60*	2*	-0.33*	-1*	1.59	5
S35	In Galapagos there is a negative environmentalism, everything is prohibited. There should be opportunities in accordance with the islands' reality	0.58	2	-1.94*	-6*	0.37	0	-0.86*	-3*
S36	Nature has rights but the human race is the one that needs to survive over all the rest	-0.30*	-1*	-1.95	-6	-2.12	-6	0.90*	3*
S37	The successful conservation of the Galapagos Islands is a result of the hard work of different organisations and a public policy for the conservation of the archipelago	0.48	1	1.20	4	-1.13*	-4*	0.58	2
S38	The GNP has done a good job in conservation issues, but has sought to intervene in things that are not within its competence	1.39*	5*	-0.31	-1	-0.91	-3	-0.65	-1
S39	The strengthening of the Galapagos Governing Council (GGC) is key to helping all parts to coordinate and establish planning policies in the short and long term	1.84*	6*	0.34	1	-0.39*	-1*	0.87	3
S40	The web of corruption and cronyism needs to be broken, it prevents Galapagos from raising	1.62	5	-0.93*	-3*	1.96	6	1.12	4
S41	All institutions in Galapagos have a responsibility in conservation	1.15*	4*	1.95	6	0.31*	0*	-0.68*	-2*
S42	The sponsorship (godparenting) of GGTs following all the established regulations from the GNP is an interesting proposal for the development of community tourism	-0.52	-2	-0.01	0	0.79	3	1.24	4
S43	Municipalities should be empowered and the excessive number of governmental institutions should be reduced	0.64*	2*	-0.02*	0*	-2.18*	-6*	-0.86*	-3*
S44	GNP decision-making is based on many scientific and technical criteria	-1.68	-5	0.63*	2*	-1.42	-5	-0.71	-2
S45	Galapagos' political model is a replica of the continent (Ecuador) but geographically and socio-	1.18*	4*	0.02	0	-0.25	-1	-0.65	-1

Table 4.1. List of Q statements, Z-score and rank associated with each factor, and Eigenvalues (GGT = Galapagos giant tortoise)

	economically the archipelago reality is very different								
S46	Galapagos' economic model needs to be rethought towards a model of fair community tourism	-0.17	-1	-0.57	-2	0.80*	3*	-1.18	-4
S47	More support from the communities towards the institutions is needed (i.e. locals respecting, promoting biosecurity restrictions to prevent the introduction of invasive species)	-0.75	-3	0.65*	2*	-0.15	-1	-0.85	-3
S48	Galapagos belongs to its original inhabitants, this means": the tortoises and all its flora and fauna	-1.01*	-3*	0.02*	0*	0.86	3	0.78	2
S49	Human activities in the archipelago are directly and indirectly related to the GGT	-2.18	-5	-1.04*	-3*	-1.81	-5	1.59*	5*
S50	GGT is the name that represents the islands globally and that has achieved that Ecuador positions itself as a country and owner of the archipelago	0.43	1	-0.20	0	0.18	0	1.82*	5*
S51	Beyond the economic benefits that GGTs can generate, there is also the advantage of living surrounded by Galapagos' natural wonders	1.08	3	0.34	1	0.77	2	0.66	2
S52	GGTs are animals that help us to understand and value the complex and interconnected world we live	-0.36	-2	0.13	1	-0.45	-1	1.27*	4*
S53	GGTs are the example of what has to be done with the archipelago, this means": protecting and conserving it so that it can last for many generations	-0.23	-1	1.39	5	0.69	2	0.29	1
S54	GGTs are unique and endemic species and this is why we all should contribute to their conservation in order to avoid their extinction	0.75	3	1.13	3	0.75	2	0.54	2
S55	GGT is a charismatic and harmless species with which man can peacefully live side by side	0.37	1	0.33	1	0.83	3	0.41	1
S56	GGT symbolises the survival and adaptation of all the species of the world to different circumstances	0.73*	3*	-0.57	-2	-1.02	-3	-0.02	0
S57	GGTs were one of the most affected species by mankind and this is the reason we currently need to protect them	-0.72*	-3*	0.96	3	1.41	5	0.52	2
S58	The GGT symbolises the work being done on the conservation of the archipelago	0.27*	0*	1.16	3	-1.00*	-3*	1.23	4
S59	GGT is what identifies galapagueños (local people from Galapagos)	-0.06	0	-1.24	-4	-0.68	-2	0.10	0
S60	Despite the fact of living on a the day to day basis surrounded by Galapagos natural environment, the influence of globalisation and consumerism generates a loss of wonder and respect for nature	0.41*	1*	-0.41*	-1*	-1.21	-4	-1.44	-5
	Eigen values	4,68		3,63		2,58		2,37	

* Statements significance at $p< 0.01$ level

Table 4.2. Summary of the Q-participants' demographic elements

Sex	Female	12
	Male	16
Average years lived in Galapagos		24
Place of birth	Santa Cruz	4
	San Cristobal	2
	Isabela	1
	Floreana	2
	Ecuador mainland	16
	Foreign country	3
Working sector	Public	14
	Private	8
	NGO	4
	Other	2
Working area	Conservation	
	Scientist giant tortoises	3
	Conservation giant tortoises	1
	Restoration of island's ecosystems	1
	Conservation and sustainable development	2
	Environmental management	1
	Policy and decision makers	
	Parrish board	1
	Tourism in Santa Cruz	1
	Giant tortoises	1
	Science ecology	1
	Agriculture	1
	Galapagos Governing Council	1
	GNP-San Cristobal	1
	Tourism in San Cristobal	1
	Sustainable development Santa Cruz	1
	Tourism	
	Giant tortoises ranches	5
	Hotel	1
	Restaurant	1
	Guide	1
	Biosecurity	2
	Fisheries	1
Total		28

4.4.1.3. Discourse 3: Community governance

Adherents of discourse 3 reflect concerns of the local communities, particularly in terms of social needs and inclusion emphasising community empowerment over institutional change. Adherents of this discourse agree that institutions have not adequately managed the archipelago, neither socially nor environmentally (S16, S37, S38, S44), and expresses distrust for politics and politicians (S18) "*If politics would not be involved we could do a much better work in conservation. Many themes have been left aside because maybe politically it is not convenient to show internationally the state of Galapagos to the world*" -Qsort10-.

Therefore, adherents of this discourse disagree with empowering municipal and governmental institutions (S43, S39). "*I would agree to empower municipalities if they were to serve the community. However, empowering the municipalities will only serve the same people, and that needs to change*" -Qsort7-. Adherents of this discourse 3 consider that what Galapagos needs is to break the web of corruption and cronyism (S40) and let the *galapagueños* and the people that live in the islands -who in a large proportion do not even know their homeland (S30)- to manage the archipelago socially, environmentally and economically (S29). "*I am aware that we need help, we still do not have the capacity, but for me it would be ideal*" -Qsort9-.

Adherents of this discourse 3 also agree that the community is not aware of conservation (S20, S33) but differentiate among local groups: "*Galapagueños are more aware of conservation but it is the people coming from outside who are not really aware. There are some that assume the responsibility but others just come to Galapagos to do business and there is no respect*" –Qsort7-. Interestingly, adherents of this discourse disagree with the promotion of environmental education as a policy priority (S34) but do consider that the GNP needs to make an effort to better relate to the community (S14). Adherents of this discourse consider humans and nature as equals (S36) and state that there is a moral duty to protect giant tortoises (S57), but emphasise the importance of controlling introduced invasive species (S17). "*The eradication of invasive species and the restoration of endemic species must go together. Unfortunately this is not happening because the political parties affect this process and do not let us improve*" -Qsort 10-. Moreover, adherents of discourse 3 do not consider that the giant tortoise symbolises work in conservation (S58) or that it is even successful (S11). Adherents of this discourse disagree that giant tortoises have a relation with human activities in Galapagos (S49) but consider them a charismatic species (S55) and important for attracting tourists (S21). Although there is an agreement that giant tortoises need to be studied because of their evolutionary importance (S3), adherents of this discourse consider that there is no disclosure of scientific knowledge about giant tortoises (S7). "*Scientific knowledge of giant tortoises should be disclosed so that people know what is being done. This is important because many people complain that they do not know what scientists are doing and if it is going to work or be useful for something*" -Q sort 7-.

Table 4.3. Discourses by key statements and stakeholders characteristics

		Stakeholder's characteristics			
Discourse	**Key statements***	**Q-sort**	**Sector**	**Work area**	**Agency/institution**
1. Multi-actor governance	45, 40, 39, 38, 44, 2, 13, 21, 26, 56, 5, 22, 27, 24, 16, 20, 33, 31, 47, 14, 34	6	Private	Tourism	Hotel owner
		12	Public	Sustainable development	Municipality
		13	Public	Tourism	Municipality
		14	Public	Agriculture	Ministry of Agriculture (MAGAP)
		15	Public	Government	Galapagos Governing Council (GGC)
		23	Public	Tourism	Municipality
		24	Public	Fisheries	Fishermen association
		25	NGO	Conservation & S. development	Conservation international
2. Giant tortoise & ecosystems conservation	9, 11, 57, 54, 1, 8, 2, 36, 13, 26, 28, 53, 59, 5, 16, 20, 19, 25, 34, 44, 39, 35, 37, 41, 36, 39, 40, 43	16	Public	Giant tortoises	GNP
		22	Public	Decision maker	GNP
		27	Scientist	Conservation giant tortoises	University of Georgia
		28	NGO	Conservation giant tortoises	Galapagos Conservancy
3. Community governance	16, 37, 38, 44, 18, 43, 39, 40, 30, 29, 20, 33, 34 14, 36, 57, 17, 58, 11, 49, 55, 21, 3, 7	7	Public	Restoration islands ecosystems	GNP
		9	Private	Tourism	Restaurant owner
		10	Independent	Conservation giant tortoises	No affiliation
4. Market & tourism centred	16, 40, 35, 15, 1, 2, 3, 9, 49, 22, 58, 50, 26, 36, 29, 20, 33, 60, 34, 47, 41, 39, 43, 27, 24, 42	4	Private	Tourism giant tortoises	Tourism lodge
		18	Public	Biosecurity and farming	Galapagos Biosecurity Agency (GBA)
		21	Private	Tourism giant tortoises	Giant tortoises touristic ranch

* Statements significance at $p < 0.01$ level

4.4.1.4. Discourse 4: Market and tourism centred

Adherents of discourse 4 reflect a discourse that acknowledges institutional deficiencies (S16, S40) but see a positive environmentalism in Galapagos (S35). They state that politicians do not demonise conservation and that investment in conservation and social issues is similar (S15). Contrary to the adherents of discourse 1 and 2, adherents of discourse 4 agree that conservation should be focused on iconic species (S2). Giant tortoises' conservation is considered a priority not because of ecological or evolutionary reasons (S3, S1) but because human activities are related to them (S49): tourism, economy (S22) and science (S9). For the adherents of this discourse giant tortoises represent the hard work in conservation (S58) and this represents the archipelago at a global scale (S50). Although adherents of this discourse consider that giant tortoises should not be looked at as commercial products (S26), they support the god-parenting of giant tortoises (a pilot programme developed in Isabela island with the idea of giving farmers the chance to protect giant tortoises in their farmlands for later restoration; which at the same time allowed some eco-tourism chances) (Cameron, 2005): "*God-parenting is interesting, because on the one hand you help generating awareness about conservation, you protect giant tortoises; and on the other hand you can have an economic benefit. For example, you can have a restaurant and this also promotes the local economy*"-Qsort 18-.

Adherents of discourse 4 agree that humans are more important than any other life forms over nature (S36) and like those adhering to discourse 3, agree that Galapagos needs to be managed by local people (S29): "*I have seen many cases that people just come to Galapagos to take advantage of it, to make money and they pass over conservation, laws and they just do not care about anything, people that come here only see the dollar sign*"-Qsort4-. As with the rest of discourses, the adherents of discourse 4 agree that there is little conservation awareness within the local community (S20, S33); but consider that it is not caused by global external influences (globalisation and consumerism) (S60) but by the lack of environmental education programmes that need to be established as a policy priority by all the decision makers (S34). The adherents of this discourse disagree with locals supporting institutions (S47) and with the statement that all institutions in Galapagos share responsibility regarding conservation (S41). Institutionally, adherents of discourse 4 agree with institutional strengthening of the Galapagos Governing Council (GGC) (S39) but not with empowering municipalities (S43): "*Municipalities are not working; they only see what is in the interest for them. They do not give sanctions to the people because they don't want to make enemies and because they win votes*" -Qsort18-. Adherents of discourse 4 disagree with changing the current economic model but, as with discourse 1, support the promotion of alternative productive sectors (S27) besides tourism (S24): "*Of course not only tourism. There are people that also work in fisheries. This sector should be promoted because sometimes tourism decreases and the economy of the islands, which relies on tourism, is affected and then everyone here is affected. So, if there are other activities, it can help to compensate a little*" -Qsort4-.

4.4.2. Consensus and dissensus statements among discourses

The analysis of the results with R, also indicated that there were 6 consensus statements significant at *p>0.01* and *p>0.05* (S4, S20, S23, S26, S54 and S55). Three statements (S20, S26, S54) generated the strongest consensus to the extremes of our rating scale (Med≥± 2,5) and were considered as relevant. The three remaining statements (S4, S23, S55) were considered non relevant (-2,5≤ Med≤ ± 2,5) because of their central ranking tendency. Statements 27, 41, 43 are significantly the most different among each factor comparison (*p<0.05* or p<0.01** levels*), suggesting these statements to be most controversial.

Table 4.4. Synthesis of results with identified category, forming statement (FS), discourse(s) agreement (A) or disagreement (D) and the identified consensus (CN) or dissensus (DS)

Identified category	FS	A	D	CN/DS
CONSERVATION				
Ecosystem conservation	S2	1,2	4	DS
Conservation–profitability	S13	1	2	DS
Giant tortoises' market-oriented views	S21	1		
	S26*		1, 4	CN
Positioning humans over other species	S36	1,4	2	DS
Giant tortoises conservation priorities	S1		2, 4	CN
	S3		4	
	S8	2		
	S9	2		

Table 4.4. Synthesis of results with identified category, forming statement (FS), discourse(s) agreement (A) or disagreement (D) and the identified consensus (CN) or dissensus (DS)

	S11	2		
	S22	1		
	S54*	2		
	S57	2		
Actors' inclusion in conservation	S14	1		
	S47	1		
Control of invasive species	S17	3		
GOVERNANCE				
Institutional strengthening	S39	1,4	2, 3	DS
	S43**		2, 3, 4	CN
	S14	3		
	S44	1,2		
Institutional involvement in conservation	S41**	2	4	DS
Political/economic changes	S45	1	4	DS
Breaking webs of corruption	S40	1, 3, 4		CN
Alternative productive sectors	S24*	1,4		CN
	S27*	1,4		CN
Adequate public policies of conservation	S37	1		
Environmental education prioritisation	S34	1,4	2	DS
MANAGEMENT				
Effective management of human settlements	S16		1, 2, 3, 4	CN
Only by locals (galapagueños)	S40	3, 4		CN
COMMUNITY RELATED				
Conservation awareness	S19	2		
	S20*	1, 2, 4		CN
	S33	1, 3, 4		CN
	S31	1		
	S25	2		

Consensual and differential statements is based on the absolute differences between factor z-scores being larger than the standard error of differences for a given pair of factors Most consensual. Differences that are significant at $p<0.05$ level (*) and differences significant at $p<0.01$ levels $p<0.01$ level (**) (Zabala, 2014)

4.5. Discussion

Q-methodology (Q) has proven to be a strong method to map discourses around sustainability and conservation (Barry and Proops, 1999; Addams and Proops, 2000). Although Q does not allow to make quantitative generalisations, our results confirm that diverse views and values -ranging from the intrinsic value of species to the use-values of nature to humans- exist across a wide range of individuals and organisations in Galapagos. We see that influential managers and decision makers from the local government and authorities (municipalities, ministries, GNP) and NGOs represent discourse 1 and 2; whereas locals with no managerial influence represent discourse 3 and 4. Moreover, we could map different points of view about several relevant conservation and sustainability issues that can be related to known conservation discourses that have emerged over the past decades and have influenced Galapagos' conservation perspectives over time. Moreover, it is important to note that no discourse questions the importance of giant tortoises. This might be related to the fact that giant tortoises are positioned in the worldview and local views on conservation because the Galapagos archipelago has a role (leading image) in conservation conflicts around the world. The importance of giant tortoises in Galapagos can thus be argued to be intrinsically recognised at different levels of organisation and prioritisation in society, which allows to think that prolonged conservation of iconic species has the potential to shape values and favour conservation.

In our research we can trace Mace's conservation framings into four discourses. For example, we see that all four discourses share elements of the 'nature for people' discourse where an ecosystem approach to conservation (discourse 1, 2, 3), ecosystem services and economic value are prioritised (discourses 1, 4). However, we can also see that discourse 2 shares more elements of both 'nature for itself' and the 'nature despite people' discourses, where species, wilderness, protected areas, habitat loss and threatened species are prioritised. Discourse 3, on the other hand, is related to the 'people and nature' where social-ecological systems and resilience and adaptability are prioritised. Mace's (2014) conservation discourses are interesting as a global temporal structure but her analysis was not intended to give the detail and context of a specific place and conservation case. Each discourse reflects differences that not only relate to conservation framings but also to modern environmental and conservation governance theory (Lemos and Agrawal, 2006; Dressler and Roth, 2011; Jepson and Ladle, 2011).

4.5.1. Situating discourses in conservation governance theory

Governance in Galapagos has been often coined as inefficient and weak (Ciccozzi, 2013a; Benitez-Capistros *et al.*, 2014). This has also been pointed out in the four discourses in particular with statements S16 and S40. Governance challenges in Galapagos can be related to different views on conservation governance that we identified in each of our four discourses. In recent years, international scholarly and policy debate concerning the appropriate approach to conservation has led to the re-emergence of a variety of approaches such as: protectionist approaches, participatory community based conservation (CBC), regulatory; and, non-state market-driven approaches (Fletcher, 2010; Dressler and Roth, 2011; Jepson and Ladle, 2011). The last two contrasting approaches: i) regulatory and ii) non-state market-driven conservation, are increasingly interdependent. Although certain elements of these two approaches can be traced in all four identified discourses, they surface most clearly in the 'multi-actor governance framework' (Discourse 1); and in the 'market tourism-centred' discourse (discourse 4).

Regulatory conservation governance is intended to control any harvest and/or trade of species at risk of extinction by unifying international regulatory regimes (i.e. CITES), supporting institutions (i.e. WWF), and domestic legislation (Jepson and Ladle 2011). Discourse 1 is closely related to this approach as it focuses on strengthening governance and institutional components (S40, S43, S39), prioritisation of social development issues (S34, S27, S44), the involvement of the community and other actors (S47, S14) and prioritising policies on environmental education (S34). A similar finding, framed under this regulatory conservation governance is also highlighted in one of Cairns *et al.* (2013) discourses, where the power and control of the natural resources in Galapagos absconds to the regulations by international community (e.g. UNESCO). Jepson and Ladle (2011) warn that its effectiveness depends on the existence of sufficient political and bureaucratic will, on the resources to enforce policies on the ground, on an accurate and up-to date knowledge of species population trends, and on responses to target species and on the willingness and ability of the public to abide by conservation regulations. This last issue requires special attention, since the lack of conservation awareness in the local community (S20) has been repeatedly highlighted in conservation discourses research in Galapagos (Cairns *et al.*, 2013). It might be one of the reasons why trusting in the regulatory conservation governance in Galapagos can prove to be misleading in practice.

The non-state, market-driven approach entails the enrolment of market forces to embed environmental and social values within supply chains and within the process of production

(Jepson and Ladle, 2011). Discourse 4 has a clear market-driven approach. It is not concerned about political or economic changes (S45, S46), although it does support social development issues (S34, S27) in line with discourse 1. Conservation-tourism-economy is strongly symbiotic in this group, a consequence of the multiple ‘nature for people’ framings that promote resourcist approaches to conservation (Buscher and Whande, 2007; Dressler and Roth, 2011). Moreover, contrary to discourse 1 and 2, adherents of discourse 4 consider that conservation should focus on iconic species (S2). Giant tortoises have an iconic symbolic connotation (S58, S50) in terms of conservation, in relation to human activities (S53, S49, S22, S9) and in relation to their importance for touristic purposes (S42). This non-state, market-driven approach to conservation has been criticised for the exacerbation of social, political and economy inequality and warrants some attention in the sense that the non-state, market-driven approach to conservation lacks regulatory strength, favour certain consumers and producers, lack a systematic focus or targeting and at worst are little more than marketing tools that support corporate “greenwashing” (Gulbrandsen, 2004). It is important to note that although the market-driven conservation governance can be thought to be equal to resourcist approaches conservation governance (e.g. neoliberal); they are distinctively different in character, impact and outcome. A resourcist conservation might refer to an increased co-production of capitalism and conservation; where a variety of actors adopt markets as a panacea to solve environmental crisis (Buscher and Whande, 2007).

Giant tortoise and ecosystem conservation (discourse 2) can be contextualised with the protectionist paradigm of conservation governance. Discourse 2 reflects the so-called 'deep ecology’ perspective that claims an essential human need for connection with pristine ‘wild’ spaces (Fletcher, 2010). This approach is reflecting the discourses of an epistemic community of knowledge-based experts who aim at influencing governance towards more radical conservation approaches. Hence, adherent of discourse 2 focus more on science, conservation (S35, S37, S38) and giant tortoises (S10, S57, S54, S17) than on social, governance and political issues (S29, S36, S39, S40, S43, S45, S35). In fact this discourse considers that the conservation of the giant tortoises is relevant for scientific and socio-economic reasons (S9, S11). Discourse 2 is strongly rooted in science and in functional ecological theory, and the effectiveness of research-discourse-action in Galapagos. The iconic giant tortoises have been used to bridge research, conservation discourses and actions throughout practical and successful conservation actions and interventions (Blake *et al.*, 2013; Hennessy, 2013; Gibbs *et al.*, 2014). Yet, although giant tortoises are considered scientifically successful (e.g. abundantly studied and well conserved), an ecosystem approach to conservation (S2) is considered important in order not to ignore other ecosystem priorities.

Finally the community-centred discourse (discourse 3) is closely related to the community based conservation (CBC) governance literature. Emerging in the 1990s, it was based on the idea of achieving conservation and sustainable development simultaneously (Berkes, 2004). Adherents to discourse 3 consider giant tortoises charismatic (S55) and important for tourism (S21), but not for conservation (S28, S11, S58). Discourse 3 is more concerned about the redistribution of benefits and community empowerment and involvement (S42, S46, S29). In line with what Chase et al. (2004) state, discourse 3 reflects the contestation by local users dissatisfied with institutions and with management, frustrated with insufficient opportunities for participation and involvement in conservation and wildlife management (Chase *et al.*, 2004). In this sense, it is important to note that although discourse 3 is also concerned about species and protected areas (S36), it is also confronted with valuing biophysical processes that are provided by nature (e.g. form, adaptability and resilience), which span long-term temporal, physical and spatial scales with which human management cannot cope (Mace, 2014). In fact community governance approaches have been widely criticised by the broad biodiversity conservation agents that features conflicting objectives such as species protection and sustainable development (Wilshusen *et al.*, 2002), by its implications with resourcist ideologies which disenfranchise marginal communities from their local resources as these become incorporated into extended market structures; and by the increased influence over local resources by corporations and international agencies (Fletcher, 2010).

4.5.2. Consensus, dissensus and controversial statements

Consensus, dissensus and controversial statements allow us to propose shared conservation/management practices supported by different group of stakeholders, which have key practical hands-on implications. The three most significant consensus statements

(S20, S26, S54) ($p>0.01$) refer to interrelated societal attitudes and values with giant tortoises. S20 indicating the recurrent low conservation awareness in the community in Galapagos (Cairns *et al.*, 2013) and S26 and S54 reflecting the intrinsic valorisation of giant tortoises: a moral-duty conservation discourse commonly identified in the context of iconic species conservation (see Rastogi *et al.,* 2013). However, this intrinsic valorisation of giant tortoises can be contrasted with other elements of the four identified conservation discourses in this research; in particular the more utilitarian ones (discourse 1 and 4). The effects of valuing a species as a product (e.g. natural capital) in a society with low conservation awareness and mainly driven by economic pursuit, could have detrimental ecological effects that need to be considered. The three statements that proved to be most controversial (S27, S41, S43) referred to the type of expected economic and institutional changes. The most contrasting views from discourse 1 and 2 reflect different approaches to conservation (market and tourism vs. giant tortoises and ecosystem conservation). S27, the promotion of other productive sectors, was argued to be the solution for avoiding the importation of goods and controlling introduced species (Q-sort13). However, S27 could be outweighed by the implications that the promotion of agro-production could have at the various levels; in particular at the ecological level due to the high fragility of islands ecosystem. Hence, S27 could become a true 'wicked problem' meaning that the solution to a problem could become an even bigger problem.

The other two controversial statements (S41, S43) refer to institutional power-based changes. After analysing z-scores and rankings (Table 4.1) we noted similarities between discourse groups. However, we see that a separation between stakeholders with formal, institutionalised and decision making power (influential stakeholders) and those with none or less influence (non-influential stakeholders), is determined by their institutional affiliation, which explains the groups discourse 1-2 and discourse 3-4 (Table 4.3). These controversial statements show how language reflects the existing power relationships that are constructing Galapagos society and that are being shaped by recent political changes locally (Ecuador) and regionally (South America). Power bases in Galapagos have shifted from dominant private institutions and NGOs (i.e. Charles Darwin Foundation) to local governmental institutions (e.g. GNP, CGG) (Pennisi, 2014).

We highlight the importance of discourse analysis through Q methodology to understand the different values of different stakeholders regarding conservation with the use of iconic species. As we have identified here, the role of iconic species in conservation (beyond the ecological, intrinsic values) relies on the pervasiveness of environmental representations they are able to generate which we consider essential for a correct interpretation of context specific conservation and how this can facilitate the comparison across different conservation contexts.

4.5.3. Policy and conservation planning implications

As we have detailed, the four identified discourses of this study share elements of conservation governance and global conservation framings, which require to be assessed in the context of policies. For example, Table 4.3 indicates that discourse 1 (multi-actor governance) can certainly have more "immediate" policy implications because decision makers mostly populate this discourse category. If this regulatory discourse is to be reinforced by policy makers in Galapagos, then we suggest that it should also be challenged with the inclusion, or at least the acknowledgement of all the rest of discourses that we have found. For example, improving the relationship and inclusion of local communities in conservation and development interventions (discourse 3, 4); or the acknowledgment of the social-ecological importance of giant tortoises and ecosystems conservation in the archipelago (Discourse 2).

Nevertheless, we acknowledge that the disclosure of information about the four discourses is not a straightforward task, but communication channels such as workshops, public debates and the mandatory research talks at the GNP can strengthen the relevance of the identified discourses. This has the potential to be effectively transmitted to local actors and also to generate punctual debates and discussions about how different conservation discourses and views are shaping Galapagos politics and governance. We also want to highlight the importance of our results for both the policy makers or local residents in terms of dissensus and its implications. Dissensus statements such as S11 (success of giant tortoise conservation) or S2 (ecosystem approach to conservation) might seem to be based on disconnected but not necessarily conflicting views, which can be easily straightened by facts and possible changes of views and discourses.

Every discourse we identified reflected a particular worldview, and with it a particular way of imagining and consequently realising conservation or sustainable management which can certainly influence or have an effect on other species. Our study has shown how discourse analyses through Q methodology and the use of iconic species can identify the different views on local conservation discourses and can contribute to understand how these views are influenced by global conservation governance discourses. In this regard, we recognise the potential of Q methodology for studying local conservation discourses and their interconnection with global conservation governance.

Q methodology also proved adequate to identify and to work closely with policy makers and managers that are more likely to consider and acknowledge the different discourses for framing policy decisions. Although this is still difficult to assert; we see good indications of change. For example, one of the main objectives (No. 4) of the latest Galapagos management plan 2015 is to boost social participative and inclusive processes by relating the distant local communities to conservation or acknowledging the management of Galapagos as a socio-ecosystem. Although this is somehow reassuring, Galapagos decision and policy makers (e.g. GGC, GNP), ought to compare these policy intentions with the practical implementation in other protected areas around the world (Brooks, 2006; Benjaminsen and Svarstad, 2010; Witter, 2013) to avoid similar mistakes. In particular, we consider that any participatory process needs to expose open and honest views and opinions even if this can lead to confrontation rather than consensus building.

4.5.4. Galapagos case *vis-a-vis* other iconic species conservation conflicts

Although this study is focused in the iconic Galapagos giant tortoises, other species of both terrestrial and marine environments (i.e sea lions, Darwin finches) have a similar potential to mobilise social actions within economic and political contexts of protected areas. If compared to other conservation conflicts with other iconic species such as the African elephants and rhinos or tigers in India; we can note three major different conservation rationales:

1. Galapagos tortoises are arguably the best-known giant tortoises; and it appears to be of common knowledge that Galapagos were uninhabited until discovered. However, the scientific discovery by Charles Darwin contributed to the view of a spoilt paradise, of which giant tortoises are both the symbol and the victims (Hennessy, 2013). This may be different in comparison to the other iconic species, which are known or felt as having had long standing relations to human communities (Jepson and Barua, 2015).
2. Unlike predators (e.g. wolves and tigers), which have been historically configured in terms of 'disgust/fear' (Emel, 1995), giant tortoises and in general Galapagos' wildlife, has been historically and ecologically recognised as 'tame' and gentle (Cooper *et al.*, 2014). Although this could be similar for example with the recent case of the white rhino in South Africa (Brooks, 2006), the difference is the time people had to develop a particular stance towards a specie (i.e. respect, care) and which will imminently affect or favour a species' conservation over time.
3. The social-ecological and political structure relevant for giant tortoises conservation in Galapagos is different from other areas. Protected areas were delimited only since 1959 in the global frame of 'fortress/protectionist conservation', but allowing human settlements in 3% (4 islands) of the total island territory (7880 km^2). This situation gives Galapagos giant tortoises an advantage in terms of conservation conflicts with humans because 8 out of 11 extant species do not have a direct interference with human activities (Figure 4.1). However, this is not the case in many other (non-Galapagos) settings where the geographical limits of protected areas are in direct conflict with human boundaries. For example in Tanzania, despite the official community based conservation discourse, influential actors (NGOs and government officials) are extending conservation areas for African elephant over territories of local communities; which generates locals' reactions and retaliations (e.g. elephant killings) against the protected species (Benjaminsen and Svarstad, 2010; Witter, 2013).

Although, the case study with giant tortoises in this work has differences compared to other iconic species, parallels with similar research approaches using Q methodology and other iconic species are more straightforward. For example, in their research using the tiger as the iconic species, Rastogi *et al.* (2013) identified five discourses which all share elements with our results: 1) a 'community discourse' with shared elements such as: the empowerment and inclusion of local communities in conservation processes or the distrust of politics/policies. 2) An 'iconic species discourse (giant tortoises/tigers)' with shared elements such as: the support for government and public policies, and the unneeded role of local communities for giant tortoise/tiger conservation. 3) A 'top down institutional solver discourse' that shares: the role of governmental/non-governmental institutions as solvers in conservation conflicts, the acknowledgment of institutional weaknesses; and the importance of bridging conservation and community interests. Last but not least, 4) a 'wildlife intrinsic value discourse' that shares: human-nature equality and the moral duty to conserve giant tortoises/tigers.

Despite the differences, the parallels highlight the importance of using Q-methodology as a reliable methodology which can be replicated, for comparing and studying conservation discourses in different contexts; and possibly also as an approach to foster our understanding of how elements of global conservation discourses can strongly influence or even shape local conservation discourses. In fact, our research has parallels with Sandbrook *et al.* (2011) who studied conservation discourses at a global scale. We find that both studies identify bio/eco-centric approaches to conservation (usefulness for humans), ecosystem conservation priorities, economic approaches to conservation, species intrinsic values and the ecological roles of species. A distinctive difference is however that Sandbrook *et al.* (2011) investigated the diverse views on conservation across a wide range of individuals and organisations working in conservation. In our case, individuals were working in different sectors and institutions, regardless of their relation to conservation.

4.6. Conclusion

The different views expressed in each discourse reflect associated values with regard to giant tortoises, conservation dilemmas and socio-political issues that steer conservation actions in Galapagos. Iconic species such as giant tortoises are key for framing conservation discourses in well-known conservation hotspots such as the Galapagos Islands. Discourse mapping with Q-methodology has allowed us to identify consensus and dissensus among stakeholders and discourses. We see that discourse mapping has a direct relevance to conservation management actions. Shared views among stakeholders groups (i.e. discourses 1-4, discourses 2-3) can lead to consensual and potentially more effective debates over values that differentiate each group's aims and means. However, as also mentioned by Cairns *et al.* (2013), it is not an issue of increasing the amount of information about conservation in Galapagos, but rather acknowledging divergent perspectives about desired pathways of conservation and development that co-exist in Galapagos. We consider that understanding how or why stakeholders are adhering (consensus) or not (dissensus) to a specific discourse is very relevant in conservation. Shared consensual elements of different discourses among different societal actors can allow individuals' self-effort to be encouraged, can allow stakeholders realise collaborative actions towards common goals and increases the possibility for partnerships (Wallis, 2006). Although some shared elements of consensual and controversial statements have practical action-generating potential, and are good starting points for policy debates and stakeholder inclusion, they should not be imposed as a panacea to solve complex issues. As Sandbrook *et al.* (2011) argue, and this is where the consensus and dissensus are particularly relevant: in a set of circumstances shared policy strategies can be acceptable (consensus), but when circumstances change it is the different values/views that exist (dissensus) that can facilitate stakeholders to adopt different strategies. Conservation needs a plurality of views (not necessarily consensus) so that actors can build more honest, adaptable and effective relationships with each other and with the wider public (Sandbrook *et al.*, 2011).

Chapter 5

THE PRA APPROACH TO STUDY CONSERVATION CONFLICTS IN THE GALAPAGOS ISLANDS

To be submitted: "Emergent conservation conflicts in the Galapagos Islands. Human-giant tortoise interactions in the rural agricultural area of Santa Cruz Island." (2016). Francisco Benitez-Capistros[1,2], Giorgia Camperio-Ciani[1,2], Jean Hugé[2], Farid Dahdouh-Guebas[1,2] and Nico Koedam[1]. *Biological Conservation*

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Contributions to this paper: FBC originally formulated the idea and conceptual design of the study. GCC collected, analysed and interpreted the data of the first phase of this study. FBC and GCC collected, analysed and interpreted the data of the second phase of this study. FBC and GCC wrote the manuscript. JH, FDG and NK provided critical revisions for the finalised version of this manuscript.

5.1. Abstract

The conservation of important areas around the world has allowed protecting and recovering many endangered wildlife species. This has been the case for 11 species of Galapagos giant tortoises (*Chelonoidi*s spp.), that today are successfully maintained over six islands: Española, Santiago, Pinzon, Isabela, San Cristobal and Santa Cruz. Although all the islands are protected by the National Park, the last three islands have permanent human settlements in specific designated areas. In Santa Cruz Island, the development of the rural agricultural areas has encroached on the migratory routes of two species of giant tortoises: *C. donfaustoi* in the southeast, and *C. nigrita* in the southwest. Focusing on the southwest species *C. nigrita*, we investigated the social and ecological inter-linkages that are characterising this emergent conservation conflict. We used two methods framed under a participatory rural appraisal (PRA) approach: semi structured interviews and questionnaires to study farmers' perceptions and attitudinal factors regarding giant tortoises; as well as the associated socio-economic impacts of the conflict. Moreover, we coupled the PRA approach with an ecological assessment of giant tortoises' population density by using the transect method in the two corresponding yearly phases of giant tortoises' migration to the lowlands (January to June) and highlands (July to December). Our results indicate that farmers reporting damage and cultivating crops have higher odds of taking actions (fencing and physical actions) towards giant tortoises; regardless of having (or not) a negative perception towards the species. The economic losses for crops and fences averaged 2.8 USD/m^2 and 13USD/m, respectively; and provide an initial step to further analyse and characterise the direct and indirect damage costs. Finally, we estimated a density of 75 and 185 individuals of giant tortoises per km^2 in the rural area for the lowland and highland migratory phases, respectively. Our approach provides grounded scientific social and ecological information to effectively inform and aid managers, policy and decision makers in the selection of adequate social and ecological criteria to implement the best available options in the resolution of this emergent conservation conflict.

5.2. Introduction

Conservation challenges require new approaches to science and management. Social-ecological system (SES) research intends to integrate human and natural systems into one comprehensive system that can provide adequate and transmittable information to managers, policy and decision makers, and citizens (Folke, 2006; Ostrom, 2009; McGinnis and Ostrom, 2014). Currently, SES research is an important part of conservation research that aims at including cultural and societal structures, and institutions to develop sustainable and resilient interactions between humans and nature (Mace, 2014). A SES approach allows identification of complex inter-linkages between social and ecological variables. These interactions can lead to conflict if not addressed correctly (Vogt *et al.*, 2015; Rissman and Gillon, 2016). Persistent and unsolved conflicts in conservation can amplify the consequences for both wildlife and people. For example, when protected wildlife raids farmers' crops or when fencing and illegal hunting affect wildlife survival (Naughton-Treves and Treves, 2005; Anthony *et al.*, 2010). Although conflicts between humans and wildlife have been widely framed as human-wildlife conflict, the term is misleading as it suggests that species are conscious human antagonists (Hill and Webber, 2010; Peterson *et al.*, 2010). Therefore, this situations are better framed as conservation conflicts which are defined as: "situations that occur when two or more parties with strongly held opinions clash over conservation objectives and when one party is perceived to assert its interests at the expense of another" (Redpath *et al.*, 2013). This means that conservation conflicts require transdisciplinary approaches from the natural, social and humanity sciences (Redpath *et al.*, 2013) and this is where a SES approach is suited to understand and contribute to solve conservation conflicts.

Important progress in conservation has allowed legitimising and protecting important areas around the world (Lele *et al.*, 2010). However, Protected Areas (PAs) and their surroundings (rural or urban areas) are often the stage of conservation conflicts because the crucial habitats of the protected wildlife are often too reduced, forcing wildlife to incur into human territory where development or activities such as housing and agriculture are being developed or are expanding (Defries *et al.*, 2007; Hansen and Defries, 2007; Wood *et al.*, 2014). The effectiveness of PAs is being contested by its "fixed" or "static" structure in the landscape that does not comply with conservation stationary targets of both marine and terrestrial ecosystems (Defries *et al.*, 2007; Bull *et al.*, 2013). Moreover, PAs have often led to an exclusionary 'nature by itself' approach to conservation, where often local communities have been removed from their land with no consultation or adequate compensation, increasing conflicts between park managers and local communities undermining conservation strategies (Andrade and Rhodes, 2012).

In the Galapagos Islands the first human settlements were established in 1832 and more than a century later, in 1959, the National Park was established following an exclusionary 'nature by itself' approach to conservation, allowing human settlements on 4 islands: Isabela, Santa Cruz, San Cristobal and Floreana, in 3% of the total islands territory (7880 km²). At the time, giant tortoises (*Chelonoidis* spp.) were at the brink of extinction after centuries of depredation first by pirates, seal hunters and whalers during the 18th century, and later during the late 19th and early 20th century, by the excessive hunting. Introduced rats eating tortoises' eggs added to this problem (Froyd *et al.*, 2014). During the past 50 years, efforts to have tortoise populations recovering have been particularly successful. Through local captivity-breeding and restoration programmes (Godfrey, 1999; Gibbs *et al.*, 2014) today 11 of the 15 different species are conserved in 6 islands: Española, Santiago, Pinzon, Isabela, San Cristobal and Santa Cruz. This situation has given Galapagos giant tortoises an advantage in terms of conservation conflicts with humans because 8 out of 11 extant species do not have a direct interference with human activities (Benitez-Capistros *et al.*, 2016).

In this study we focus on one of the two species of Galapagos giant tortoises of Santa Cruz Island (*Chelonoidis nigrita*) to illustrate an important emergent conservation conflict. With an estimated total population of 3000 individuals (Márquez *et al.*, 2004), Santa Cruz' giant tortoises are divided by farmlands into two populations representing two species: in the south east (*Chelonoidis donfaustoi*) and in the south west (*Chelonoidis nigrita*) of the island (Blake *et al.*, 2012; Poulakakis *et al.*, 2015). As the only mega-herbivores to thrive in Galapagos, giant tortoises have a key ecological role as ecosystem engineers due to their seed dispersal capacity (Blake *et al.*, 2012; Blake *et al.*, 2013). However, human settlement has encroached on their migratory routes (Figure 5.1) where agriculture, farming and locally based ecotourism have been developed (Burnham *et al.*, 1980; Blake *et al.*, 2013). Agriculture and farming are among the most disruptive human activities to biological diversity (Balmford *et al.*, 2012) and together with urbanisation, are recognised as important threats especially to endemic biodiversity of insular ecosystems. These ecosystems are highly vulnerable and have to cope with the rapid land use changes and short-term vision planning of such anthropogenic activities (Lagabrielle *et al.*, 2011).

Although the lack of data for some islands and the coarse nature of existing maps have hampered efforts to quantify changes in vegetation in the archipelago (McCleary, 2013), it is estimated that 50% of the total rural agricultural areas of Santa Cruz Island (14841.9 ha) has had a significant land use change from 1986 to 2006 (Villa and Segarra, 2010). Similarly, Watson *et al.* (2010) estimated that 25% (3 121 ha), 88% (8 381ha) and 76% (1 765 ha) of the transition, humid and very humid vegetation zones respectively, had been modified by human impacts in Santa Cruz (Watson *et al.*, 2010). These vegetation changes correspond to the reduction of the island's endemic plant species such as *Scalesia pedunculata* and *Cyathea weatherbyana* and the propagation of invasive agricultural species such as guayava *Psidium guajava*, blackberry *Rubus niveus*, and cascarilla *Cinchona pubescens* (Jager *et al.*, 2007; Jäger *et al.*, 2009; Guézou *et al.*, 2010; Watson *et al.*, 2010). The increasing land abandonment from farmers attracted by better economic opportunities in other sectors such as tourism, has allowed the proliferation of these invasive species in the rural areas, in all four inhabited islands (Guzman and Poma, 2015). Although conservation policies protect giant tortoises in Galapagos, there are no studies on the interactions occurring when giant tortoises migrate from the protected areas to the rural areas. Preventive conservation management strategies are lacking and hence understanding the factors associated with this conflict and its social-ecological inter-linkages is urgent. Our goal is to study and characterise this conservation conflict by investigating its social and ecological inter-linkages. Inspired by similar studies on conservation conflicts (Zhang and Wang, 2003; Wilfred *et al.*, 2007; He *et al.*, 2011; He *et al.*, 2014) we used a participatory rural appraisal (PRA) as an overreaching methodological approach to study farmers' perceptions and attitudinal factors regarding giant tortoises; as well as the associated socio-economic impacts of the conflict (social factors). Furthermore, we coupled the PRA approach with an ecological assessment of giant tortoises' population density by using the transect method in the two corresponding yearly phases of giant tortoises' migration (April to June and October to December) from and to the national park and the rural area (ecological factors). In this paper we detail the links between the social and ecological dynamics of this conservation conflict. We provide a range of possible scenarios/recommendations/actions to effectively inform policy makers and managers to improve the social-ecological fit of conservation strategies (Bodin *et al.*, 2014), as well as key points and suggestions for the implementation of our findings which are also interlinked with the previously published works by the authors (Benitez-Capistros *et al.*, 2014; Benitez-Capistros *et al.*, 2016).

5.3. Material and methods

5.3.1. Study site

The rural area of Santa Cruz Island is the most extensive agricultural area of the Galapagos Islands. Covering 114 km² of the island's total surface of 985.22 km², it is almost entirely surrounded by the Galapagos National Park (GNP) with the exception of the urban area of Puerto Ayora (Figure. 5.1). The study area extends from 100 to 700 meters above sea level (masl) crossing two climatic zones and associated types of vegetation: the transition zone (between arid and humid zone) and the humid zone. Its over-all favourable climate allowed for agricultural development (Hamann, 1979; Trueman and d'Ozouville, 2010; Pryet *et al.*, 2012). The island's perennial crops (coffee and banana cultivars) and short-cycle crops (cassava, maize and watermelon) make up 60% of the total agricultural production of the archipelago; whereas the island's livestock makes up for 68% of the archipelago's meat and milk production (CGREG, 2014). Human population is estimated at 2 952 residing inhabitants (INEC, 2010) with 357 censed farmers and 384 landowners (CGREG, 2014). Moreover, the rural area is an important foraging and migratory route of the two giant tortoises species of Santa Cruz (Blake *et al.*, 2013).

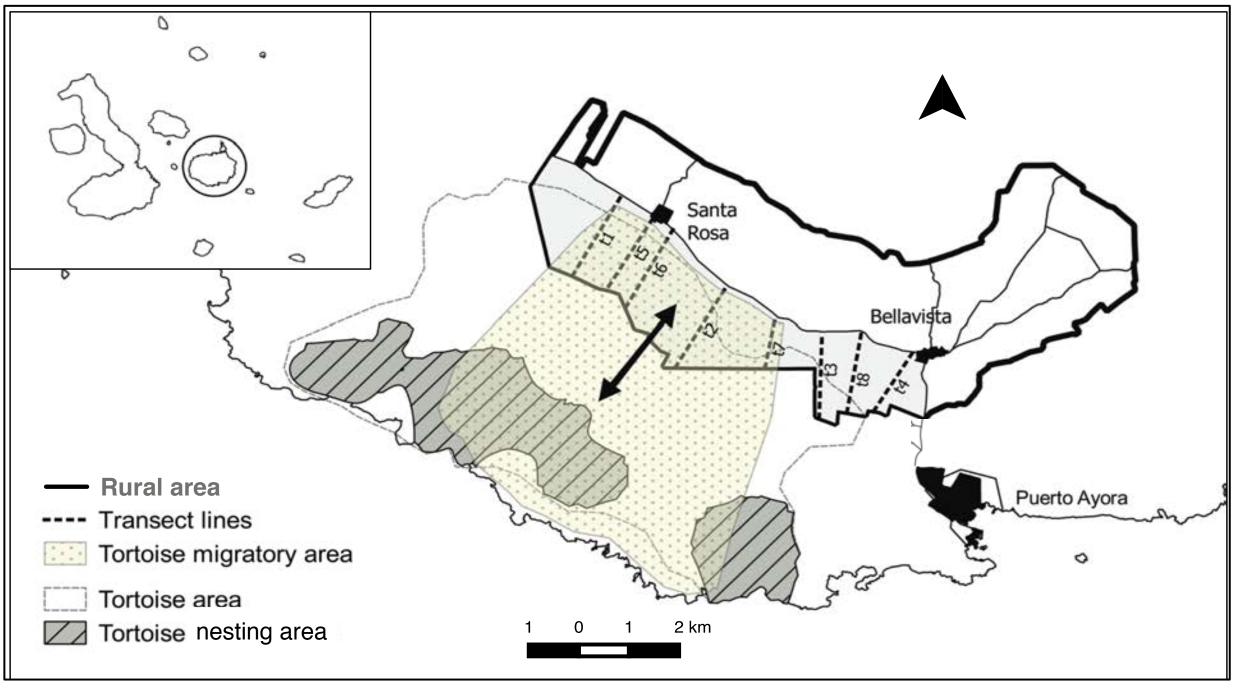

Figure 5.1. Study site area in Santa Cruz Island.
The transect lines of this study are indicated with dotted lines (**….**) and correspond to the two transect phases. First transect phase (t1, t2, t3, t4) and second transect phase (t1, t2, t3, t5, t6, t7, t8).

5.1.1. Methodological reflexions on plural realities in conservation

Conservation needs pluralities of views (Sandbrook *et al.*, 2011); more so when conflicts in conservation involve specific societal groups (Madden and McQuinn, 2014) and iconic species (Rastogi *et al.*, 2013; Benitez-Capistros *et al.*, 2016). In this research we used a participatory rural appraisal (PRA) as the overarching methodological approach to understand farmers' perceptions towards giant tortoise presence in the rural area. PRA is a family of methods that focuses on attitudes and behaviour, and enables local people to share, enhance and analyse their knowledge of life and conditions. PRA helps an outsider to quickly understand a system from the point of view of local stakeholders and actors (Chambers, 1994; Narayanasamy, 2009). Framed under the PRA-approach, we selected two methods: semi structured interviews and questionnaires, coupled to transect walks to estimate the density of giant tortoises in the rural area. Zhang and Wang (2003) used a similar approach to study human-elephant interaction in China. Perceptions of local people were assessed using PRA and coupled with ecological observations using transects. In our study, all interviewees and questionnaire respondents were informed about the purpose of the research, and agreed with the researchers' stated objective to disseminate subsequent research results.

5.1.2. Data collection

We collected data in two phases (Figure 5.2). In the first phase (April to June 2015) we conducted semi-structured interviews (n=18) and subsequently built a questionnaire to gather information on the perceptions and attitudinal factors of farmers (n=102) (from here on referred to as first phase questionnaire). In the second phase (October to December 2015) we built a socio-economic questionnaire to quantify giant tortoises damages on landowners (n=53). In both phases, we used the transect method (Figure 5.1) to estimate the population density of *Chelonoidis nigrita* during the corresponding migratory seasons (Blake *et al.*, 2013; Poulakakis *et al.*, 2015).

5.1.2.1. Semi-structured interviews (SSI)

Semi-structured interviews allowed us to gain insight on the subject to retrieve information about the study area, and the farmers' perceptions and attitudes towards the farmers-tortoise interactions by systematising interviews (Bogner *et al.*, 2009). The 18 semi-structured interviews were conducted between April and May 2015 (Appendix C1). All interviewed persons were informed about the purpose of the research. We obtained the identity of the interviewer and with the planned use of the information their agreement with this use. All the interviews were conducted in Spanish, the language spoken by all the interviewees and the interviewer's mother tongue. The interviews were recorded when allowed by the speakers; otherwise the interviews were manually transcribed on paper. Of the eighteen interviews, five were identified through a list of contacts provided by the Ministry of Agriculture (MAGAP), six were interviewed during casual encounters, one was approached at the local market, two were approached through snowballing, two were contacts established through the previous research (**Chapter 4**). In addition, we interviewed three non-farmers: two employees of the MAGAP, both responsible for the agricultural sector of the island of whom one was previously involved in a tortoise monitoring programme with the Charles Darwin Foundation and the National Park; and one employee of the National Park, involved in giant tortoises' management and monitoring. We conducted eleven of the interviews in the farmers' premises. During these visits we collected information regarding the areas and logistics which showed to be useful in the elaboration of the transects and the questionnaires.

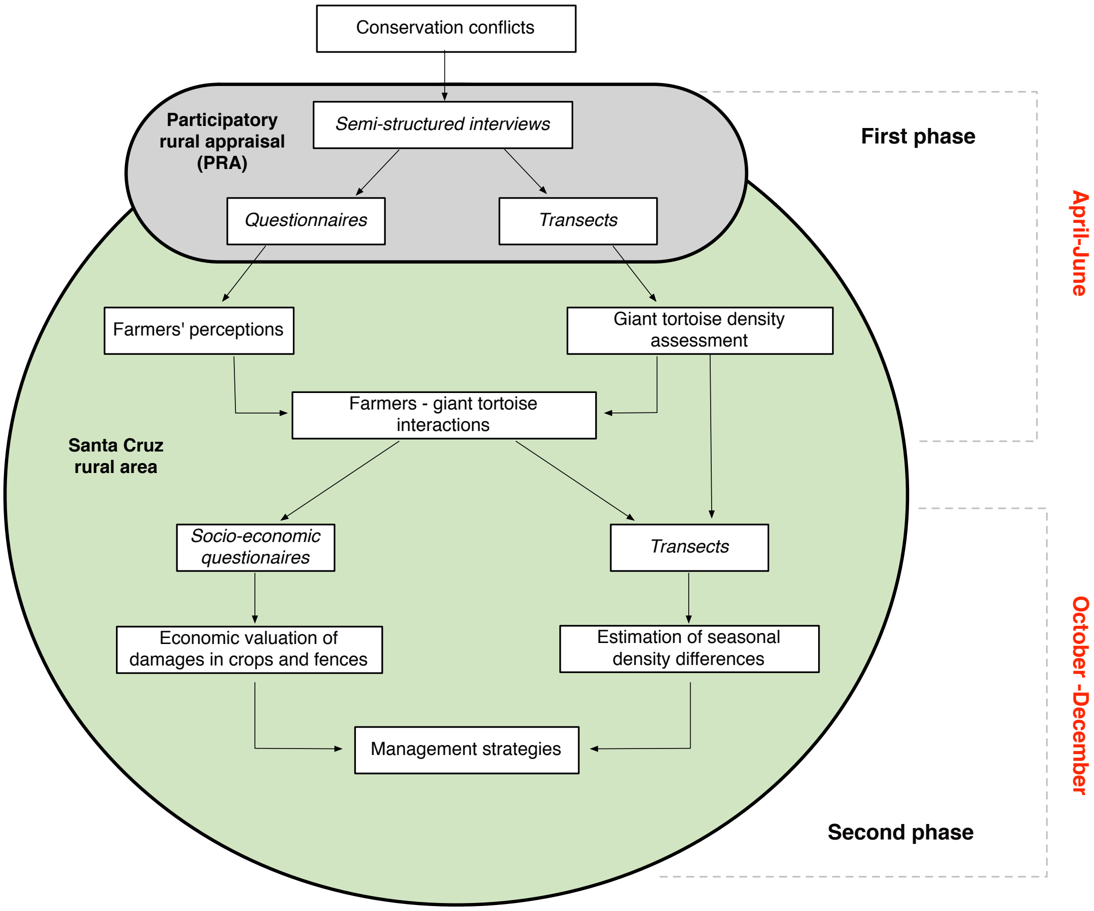

Figure 5.2. Research methodological framework during the two research phases.
Italics indicate the method used to collect data.

5.1.2.2. Questionnaires

In this research, questionnaires were used: 1) to gather quantitative data on farmers' perception on the presence of giant tortoises in the rural area; and 2) to retrieve baseline socio-economic information about damage caused by giant tortoises.

5.1.2.2.1. First phase questionnaire

With the information gathered through the semi-structured interviews, we built a close-ended and multiple-choice format questionnaire to gain baseline quantitative information. In total 102 questionnaires were fully completed between May and June 2015, and correspond to 29% of the total 357 censed farmers in Santa Cruz (CGREG, 2014). We approached the respondents whose farms were located in different zones of the rural areas in order to have an adequate sample of the area by covering a maximum of diversity, in terms of farm characteristics. The first seven completed questionnaires were used as a pilot test, to formulate the definitive version of the questionnaire by clarifications and improvements regarding the understanding of the interviewer's purpose. Questionnaires were conducted at the local market, while visiting the farms door to door, at recreational sites, outside churches, at local restaurants and on public transport. The questionnaire was divided into three main sections: 1) Questions to collect demographic information, 2) questions related to the characteristics of the farm type, and; 3) questions related to the farmers' perception on tortoises (Appendix C2). All respondents had to be minimum eighteen years old, and involved in the farm activities (owners, workers or relatives of these). As indicated earlier all questionnaire respondents were informed about the purpose of the survey, the identity of the surveyor and the planned use of the information we obtained and hence agreed with the use of the survey data.

5.1.2.2.2. Second phase: Socio-economic questionnaires

Based on the methodologies used in conservation conflicts (e.g. involving elephants (Karanth *et al.*, 2012)) we collected field data by means of a socio-economic questionnaire (Appendix C3). The results of the first phase questionnaire allowed us to make a distinction between 'non-damage visits' and 'visits causing damage' by the wildlife, which was derived by the presence of giant tortoises and the actual damage to crops and fences. Henceforth, our second phase socio-economic questionnaire was built to determine the presence of giant tortoises and occurrence of damages to crops and fences per month, season, and area (km^2).

We considered the area of damage (m^2) and frequency (years) as the baseline parameters for measuring crop damage (Hill *et al.*, 2002). However, to have a more reliable estimation and calculation of the respondents report (Osborn, 2002; Nyirenda *et al.*, 2013) we included three parameters to assess the crop damage: 1) Type of damage in 6 categories (1=<5%, 2=6-10%, 3=11-20%, 4=21-50%, 5=51-80%, 6=>80%), 2) crop quality, (good/medium/poor);

and, 3) the crop stage (seeding/intermediate/mature) (Appendix C3-III). Additionally, we included a section for the estimation of the damage to fences (highly reported in farmers with damage in the first phase questionnaire) including the height of the fences on their lands; and a final open question to investigate the local perspectives on alternatives to avoid damage by giant tortoises (Appendix C3-V).

To collect this data we first identified the areas with presence of giant tortoises from the results of the first phase questionnaire where farmers had reported damage in the southwest of the rural area (Figure 5.1). Secondly, with the GIS land maps 2015 provided by the Galapagos Governing Council (GGC), we selected landowners independently of their registered activity (i.e. agriculture, timber, and conservation) from the latest census (CGREG, 2014), as we identified inconsistencies in this census through preliminary questionnaire-based controls. For example, some of the landowners registered as having agriculture had abandoned lands, a common case and a problem in Galapagos since invasive plants (i.e. *Rubus niveus*) then proliferate rapidly (Jäger *et al.*, 2009; Guézou *et al.*, 2010). We randomly sampled 25% (N=95) of the total 384 registered landowners in the southwest area, in order to have a representative sample (Figure 5.5). In total we retrieved 53 fully completed socio-economic questionnaires. The remainder 42 landowners (44%) could not be sampled because they were not in Galapagos, had abandoned lands, had passed away, and/or were not interested.

5.1.2.3. Density estimation of giant tortoises in the rural area

We outlined and defined transects to evaluate relative density of tortoise in the rural area by means of distance sampling (Krebs, 1999; Thomas *et al.*, 2010; Buckland *et al.*, 2012). Estimating animal density through transects is a widely used method (Burnham *et al.*, 1980; Leuteritz *et al.*, 2005; Sutherland, 2006a; Buckland *et al.*, 2010; Thomas *et al.*, 2010) suited for large terrestrial herbivores (Jathanna *et al.*, 2003). Leuteritz *et al.* (2005) used this method to estimate radiated tortoise density in Madagascar. In Santa Cruz island migration of giant tortoises occurs in two periods which are associated to the foraging behaviour and seasonal weather patterns in the highlands: 1) a migration to the highlands from July to December; and, 2) a migration from the highlands to the lowlands in the rainy season from

January to July (Blake *et al.*, 2013). Therefore, transect surveys were conducted during these two phases (Figure 5.1).

5.1.2.3.1. First transect phase (April-June 2015)

In the first transect campaign we performed preliminary transects based on the information collected through the semi-structured interviews. Four transects (Figure 5.1) were selected based on the ease of access, the authorisation of the landowners, and the distribution in the selected study area (t1, t2, t3 and t4, the former was not included in the density estimates and not replicated in the second transect phase since it was crossing a densely inhabited area). Each transect was repeated three times. The first campaign was performed during the rainy season in the lowland (Blake *et al.*, 2013), thus we assessed tortoise density during the migration towards the lowlands. This allowed us to measure the minimum density of tortoises in the rural area, which could be considered as the period of ‘minimum potential interaction’ between tortoises and farmers. Each time a tortoise was encountered during the transect lines, we marked a GPS point of the location of the tortoise and visually estimated the perpendicular distance of the tortoise from the transect line (Buckland *et al.*, 2012).

5.1.2.3.2. Second transect phase (October – December 2015)

Following the same approach and methodology as in the first transect phase (April-June), we established six transect lines but approximately every 2 km (Figure 5.1) starting from the three established transects during the first season campaign (t1, t2, t3, t5, t6, t7, t8). Each transect was repeated four times. The period corresponded to the highland rainy season where tortoises migrate to the rural area for foraging (Blake *et al.*, 2013). This allowed us to measure the maximum density of tortoises in the rural area, which could be considered as the period of ‘maximum potential interaction’ between tortoises and farmers. We took GPS points (GPS GARMIN GPSMAP 62s) of each tortoise that we encountered along each transect and transect repetition. After taking the GPS position of each tortoise, we measured the perpendicular distance with the telemeter Nikon Aculon 911. Note that the approaches followed to estimate the density is not exactly the same in the two phases. This is due to both logistical (accessibility on transects) and methodological reasons such as an improved transect design, more accurate supporting materials (e.g. telemeter) and expert advice from Cruz Marquez (retired CDF giant tortoise scientist), Andrew Laurie (biodiversity consultant).

5.1.3. Data analysis

5.1.3.1. Analysis of variables and prediction model

After analysing the first phase questionnaire we retrieved six *ex-post* variables that explain the interaction between farmers and giant tortoises: 1) Farm production, 2) farm dimension (ha), 3) bordering the national park, 4) reported damage, 5) perception, and 6) actions. The variable farm production was grouped into farms that either reported crop cultivation (or not) and those that reported cattle rearing. We made this choice because mono-productive farms are almost inexistent in the rural area of Santa Cruz, and often its labourers set a small plot of land aside, dedicated to crop cultivation for family subsistence (chakra). Most of the farms in Santa Cruz are mixed usually presenting several concurring farming activities such as: crop cultivation, cattle rearing, coffee plantations and/or are farms dedicated to tourism. The variable perception was retrieved from three different questions in the first phase questionnaire (Q17-Q27-Q28) as a triple check, since we considered that the farmers would not report negative perception straightforwardly (Appendix C2). We considered a farmer as having a negative perception when at least one of the three questions was selected:

Q17) Multiple-choice type:
Which are the plagues that affect your farm? : tortoises (N = 6)
Q27) Multiple-choice type:
According to you tortoises are: a plague (N = 4), a nuisance (N = 14)
Q28) Yes/No question: type:
Do you consider tortoises in your farm to be a problem? : yes (N = 22)

The variable action consisted of indirect and direct actions taken by farmers to diminish/avoid interactions with tortoises. Indirect actions involved the use of fences, which were built to avoid tortoise entrance in the land. These fences had a height of ≤15 cm from the ground, five or more lines of barbed wire or fully obstructing structures (wood, rocks, walls), which are used to avoid giant tortoise or other large animals to enter (e.g. pigs, cows). Direct actions involved any physical interaction with giant tortoises to keep them out of the farm (e.g. chasing, displacing and turning tortoises downside up). All the variables except for farm dimension, were categorical variables with at least two categories, and met the assumptions of the Pearson's chi-square statistical test (sample size, independence of observations). Tests were two-tailed and results were considered statistically significant when $p<0.05$. The Wilcoxon-Mann-Whitney non-parametric tests were used to determine whether there were differences in farm dimensions in hectares (the only continuous variable) between the categories of the categorical variables. In this case median values described central tendency. For the prediction model we used a binary logistic regression to check for variables predicting the dependent variable "actions" to explain if a farmer was willing to take actions on giant tortoises. For this analysis we took into account the significant results of the Pearson chi-squares and run a model that could answer our question. All the assumptions of the logistic regression were met: independence of observations, dichotomous dependent variable, no important variables were omitted, no extraneous variables were included, the independent variables were measured without error, the independent variables were not linear combinations of each other (Table 5.2).

5.1.3.2. Socio-economic valuation

Damage to crops and fences were quantified throughout the second phase socio-economic questionnaire data using descriptive statistics *(frequencies, average and maximum costs).* Total costs estimates were provided by the respondent's own estimation of the damages in last event/year by area (m^2) for crops and length (m) for fences. We finally summarise the qualitative information on the reported alternatives to avoid damages by giant tortoises (Table 3).

5.1.3.3. Giant tortoises population densities

To estimate tortoise density in the rural area we used DISTANCE 6.2 software (Thomas *et al.*, 2010; Buckland *et al.*, 2012) to analyze data collected measuring the perpendicular distance of tortoises encountered along the transect lines in both research phases. According to Leuteritz *et al.* (2005) the application of this method fits perfectly for tortoise density estimates since the four main assumptions to assure the precision of the analysis are respected: i) all the objects encountered on the transect line were sighted, ii) objects do not move, iii) distance is measured or estimated with accuracy and 4) each animal observation is independent. Following Buckland *et al.* (2012) we first analysed the data checking for outliers and applying the due truncation required in order to find the best model that could describe the animal detection function. We chose the model best fitting the detection function based on the Akaike's Information Criterion (AIC) values and goodness-of-fit tests generated by the software DISTANCE.

5.2. Results

5.2.1. First phase questionnaire

5.2.1.1. Farmers and lands characteristics

Of the total 102 questionnaires, 21% (N = 21) did not report cultivating crops and almost half of these reported cattle rearing as the predominant activity (n=10). However, the majority of farmers reported cultivating crops (79%, N = 81). Of these 24% (n = 19) exclusively cultivated crops (short cycle crops and perennial banana cultivars), whereas the rest (n = 62) mixed it with other activities. These mixed activities included cattle rearing, perennial coffee plantations, touristic farming and other activities (i.e. tree, poultry and pig farming). The most frequently reported cultivated crops, as well as plant and animal plagues are shown in Figure 5.3. Plagues included the endemic Darwin finches (*Geospiza* spp., *Camarhynchus* spp., *Platyspiza crassirostris, Certhidea olivacea)*, and giant tortoises (*Chelonoidis nigrita*). The farms dimensions ranged from 0.2 ha to 400 ha (M = 54.01 ha, SD = 73.23), covering an area of 4 962.25 ha which accounts for half (51%) of the total rural area.

5.2.1.2. Analysis of variables

The presence of giant tortoises in the farms was reported by a majority of respondents (81%, N = 83) and was, as expected, associated with cattle rearing farms (χ^2 = 16.06, p < .001). More than half of the farmers (57%, n = 47) that reported the presence of giant tortoises reported damages, of which 95 % (N = 42) reported damages to crops (N = 32) and fences (*N* = 30). The 'damage' variable was significantly associated with farmers that cultivated crops (χ^2= 3.93, *p* = *.048*); as well as with smaller farms (*Mdn* = 16 ha) compared to larger farms (*Mdn* = 47.5 ha) (*U*= 526.5, *z* = -2.606, *p* = .009). A negative perception towards giant tortoises was found in 36 % (*N* = 37) of the total sampled farmer population. No significant relation was found between a negative perception and the presence of giant tortoises (χ^2 = 0.34, *p* = .558). However, a significant relation was found when considering the negative perception and the occurrence of damage, (χ^2 = 15.88, *p* < .001). Moreover, we could determine that a negative perception was significantly associated with smaller farms (*Mdn* = 20 ha) compared with larger farms (*Mdn* = 39.5 ha) (*U*= 567, *z* = - 2.064, *p* = .039).

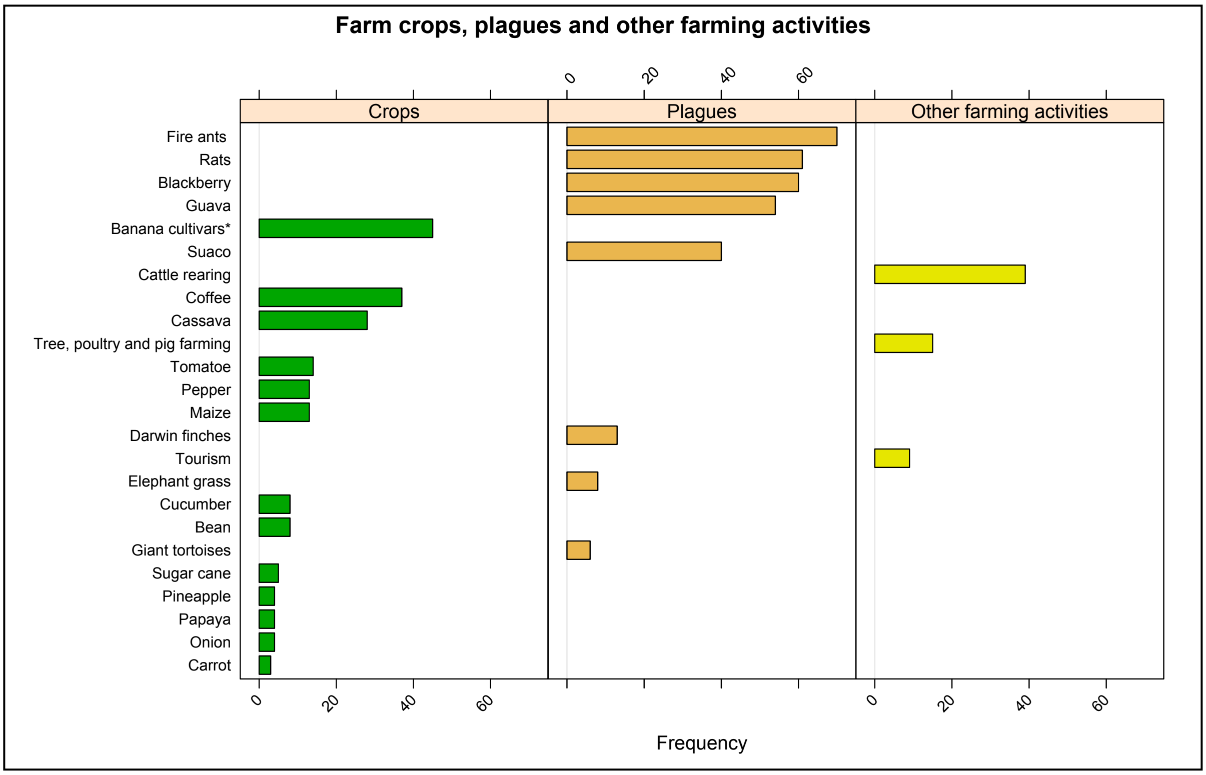

Figure 5.3. Main characteritics of the sampled farms including most frequent crops, plagues and other farming activities.
Animal plagues are fire ants (*Solenopsis geminata* and *Wasmannia auropunctata*) and rats (*Rattus rattus* and *Rattus norvegicus*); whereas plant plagues are blackberry (*Rubus* spp.), guava (*Psidium guajava),* elephant grass (*Pennisetum purpureum*) and sauco (*Cestrum auriculatum*). (*) Indicates a variety of grown banana cultivars (e.g. guinean, green bananas, plantain). Frequency refers to the absolute number of farmers reporting the respective characteritics over the total sample (*N* = 102).

More than half of the farmers that reported the presence of giant tortoises (58%, *N* = 48) took action against giant tortoises. Indirect actions were the most frequent ones (48%, *N* = 23), followed by farmers that took both type of actions (33%, *N* = 16). The remainder took exclusively direct actions (19%, N = 9). Actions were not associated with negative perception (χ^2 = 2.27, p = .132). However, both direct and indirect actions were associated with damages (χ^2 = 18.23, p < .001 and χ^2 =6.89, p = .009, respectively) and with the farmers that cultivated crops (χ^2 = 4.50, p = .034 and χ^2 = 9.63, p = .002, respectively). Only direct actions were significantly associated with smaller farms (*Mdn* = 35.64 ha) compared to larger farms (*Mdn* = 70.54 ha) (U= 457, z = -2.57, p = .010). There were 44 farms bordering the National Park (43%). When considering the presence of tortoises, this was significantly higher than in those farms that did not border with the National Park (χ^2 = 6.12, p = .013). Farmers whose properties were bordering the National Park reported less damage compared to those that did not bordered the park (χ^2 = 6.12, p = .013) and had a significantly lower negative perception (χ^2 = 8.38, p = .004). As well, these farmers were taking significantly less action towards tortoises (χ^2 = 6.45, p = .011). Farms bordering the national park had significantly lower crop cultivation (χ^2 = 6 8.63, p = .003) and significantly higher cattle rearing (χ^2 = 23.58, p < .001) and touristic activity (χ^2 = 6.93, p = .008). As well, farms bordering with the National Park were significantly larger (*Mdn* = 79 ha) than those that were not bordering the park (*Mdn* = 6 ha) (U = 2.202, z = 6.56, p < 001). A summary of the Pearson's chi- square and the Mann-Withney U test results is reported in Table 5.1.

Table 5.1. Summary of the significant (*) and non-significant (n.s.) relation between the variables.

	Tortoises	**Damage**	**Negative perception**	**Actions**	**Bordering NP**
Tortoises	\	\	n.s.	n.s.	* (+)
Damages	\	\	*(+)	*(+)	* (-)
Perception	n.s.	*(+)	\	n.s.	*(-)
Actions	\	* (+)	n.s.	\	*(-)
Small farm dimension	n.s.	*(+)	*(+)	*(+)	*(-)
Production	* CR(+)	*CC(+)	n.s.	* CC(+) * CR (-)	*CC(-)

The significant location is specified in brackets (+) and (-) indicates whether the significant interactions are positive or negative. Cattle rearing (CR), cultivated crops (CC).

5.2.1.3. Prediction model

A binary logistic regression was performed to ascertain the effects of the negative perception, the reported damage and the type of production on the likelihood that farmers took actions (direct and indirect) on giant tortoises. The logistic regression model was statistically significant ($\chi^2 = 26.29$, $p < .001$). The model explained 41.3% (Nagelkerke R^2) of the variance of the dependent variable "actions" and correctly classified 79.2% of cases. Positive predictive value (farmers taking actions) was 79% and negative predictive value (farmers not taking actions) was 71%. Two of the predictor variables were statistically significant: reporting damages and cultivating crops (Table 5.2). Both reporting damage and the cultivating crops were associated with an increased likelihood of taking actions. Farmers that cultivated crops had eight times higher odds to take an action (OR = 8.27 C.I. = [2.01 – 34.02]) on tortoise than the farmers that did not cultivate crops. As well, farmers reporting damage had almost seven times higher odds to take actions (OR = 6.84 C.I. = [2.05 – 22.83]). The large variation in the C.I is explained by the small sample size.

Table 5.2. Results of the binomial logistic regression predicting the likelihood of making an action on giant tortoises.

Independent variables	**B**	**SE**	**Wald**	**Df**	***p***	**Odds Ratio**	**95% CI for Odds Ratio**	
							Lower	**Upper**
Negative perception	-.16	.65	.06	1	.802	.848	.234	3.07
Damage	1.92	.615	9.78	1	.002	6.84	2.05	22.83
Cultivated crops	2.113	.721	8.59	1	.003	8.27	2.01	34.02
Coffee	-.58	.58	1.01	1	.314	.56	.18	1.74
Cattle rearing	-.91	.58	2.40	1	.12	.40	.13	1.27
Tourism	.322	.747	.185	1	.67	1.38	.32	5.97
Constant	-2.19	.683	10.33	1	.001	.111		

The B coefficient shows the change in the log odds (alternate way of expressing probability) for one unit change of the dependent variable. SE = standard error. The Wald test is used to determine statistical significance. Df = degrees of freedom. Odds ratio informs about the odds that the dependent variable would change for one unit change of the independent variable. Upper and lower Confident Intervals (CI) for the odds ratio.

5.2.2. Socio-economic valuation

Of the total 53 respondents 20% (n = 11) reported cultivating crops as their primary economic activity, 11% (n = 6) livestock rearing (cattle, poultry, piggery) and the remainder 69% (n = 36) reported other activities (mainly services). The majority of the respondents (86%, n = 46) reported to have a usable productive land (crop cultivation, cattle rearing, tree farming, mixed), with many (64%, n = 34) also reporting cultivating crops but not as their primary economic activity. Moreover, 70% (n = 37) of the lands did not border the National Park. The average land size was 20.82 ha. The most commonly cultivated crops were banana cultivars, citrus, cassava, coffee, pineapple, maize, pumpkin and papaya (Figure 5.4). The total number of landowners who reported giant tortoises entering their farms was 41 (77%), with 25 (47%) reporting damage to either fences or crops. Although 30% (n = 16) reported damage to crops; only 17% (n = 9) were able to provide an estimate of the economic costs of the damaged crops during the last event/year and 30% (n = 16) of the fencing costs (Table 5.3 and Figure 5.5).

5.2.2.1. Economic costs: damaged crops and fencing

Crop damage was reported from May to December; but the highest numbers of incidents (7 of 9) were reported for the months of November and December. Although our aim was to obtain the landowners report for the last year (2014-2015), this was only possible with 5 respondents. Conversely, with 2 of them we could verify the magnitude of losses (Appendix C4). The reported crop damages per area (ha) was varied from <5% to >80%. The majority of the lost crops were allegedly of good quality with varied aging stages (seedling, intermediate, mature) (Appendix C3-III). As indicated in Table 5.3, the average reported economic loss for crop damage was 1194 USD with an average cost of 2.8 USD/m² of unit land. Similarly, the fencing cost average was 1974 USD with an average cost per meter of fence of 13USD/m. Currently in Galapagos, the minimum net wage is 659 USD (1.8 times higher than in the mainland), which is 7908 USD per year.

Nevertheless, it is important to note that the averages costs, in particular of fencing costs, should be taken with caution. Although the different type of materials used in the construction of fences (e.g. barbed wire, porotillo[10], brick walls) might explain the large variation, the highest average cost (125 USD/m) seems to be an over-estimation of the respondents. In particular because the estimated construction cost in Galapagos is 552 USD/m^2 or 23.5 USD per meter (INEC, 2013). Thus, we can see that there is a mismatch of the information cost between what was reported by some participants and what might actually be the real cost. The tendency to overestimate cannot be explained on basis of the results, but it may be related to the fact that it is perceived as a net cost and not as an investment, hence carrying a negative perspective.

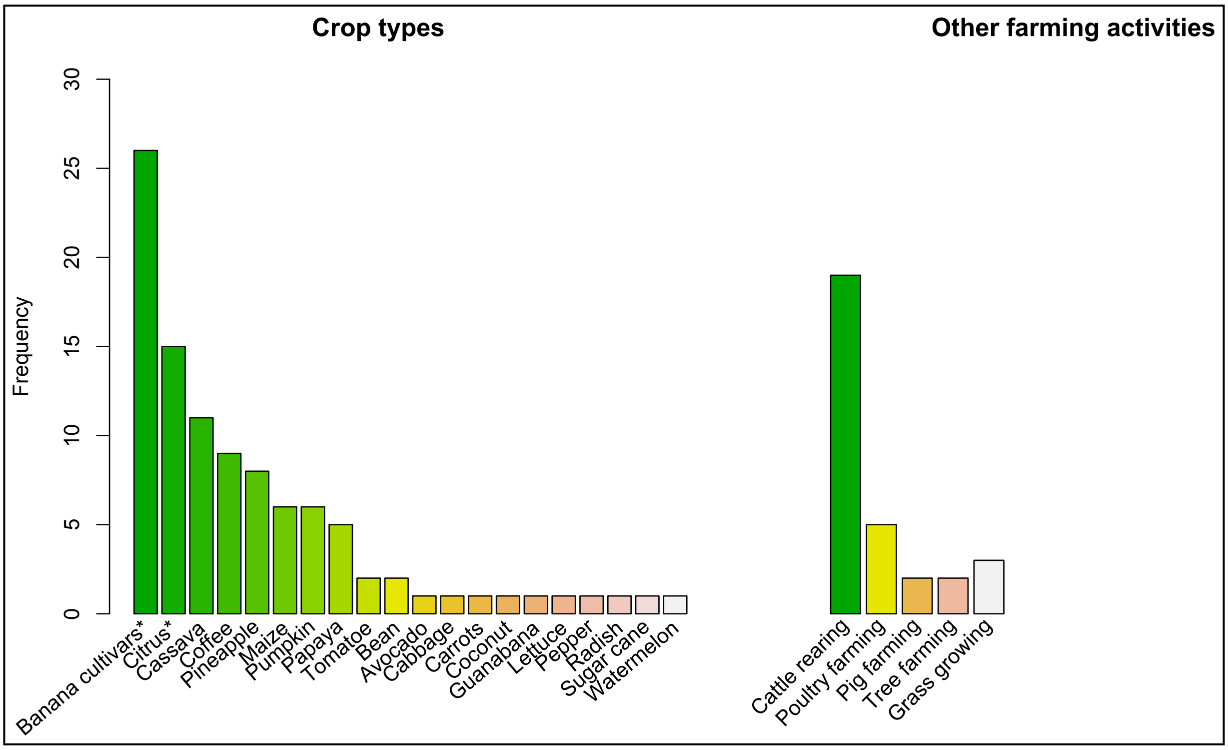

Figure 5.4. Main crop types and other farming activities as established during the PRA survey.

Total sample n=53. (*) Indicates a variety of grown banana cultivars (e.g. Guinean, green bananas, plantain) and citrus (e.g. oranges, lemons, mandarins).

[10] Porotillo (*Erythryna fusca*) is an introduced common flowering tree in Galapagos. It is one of the commercial tree species which can be extracted under the authorisation of the GNP (DGNP, 2013).

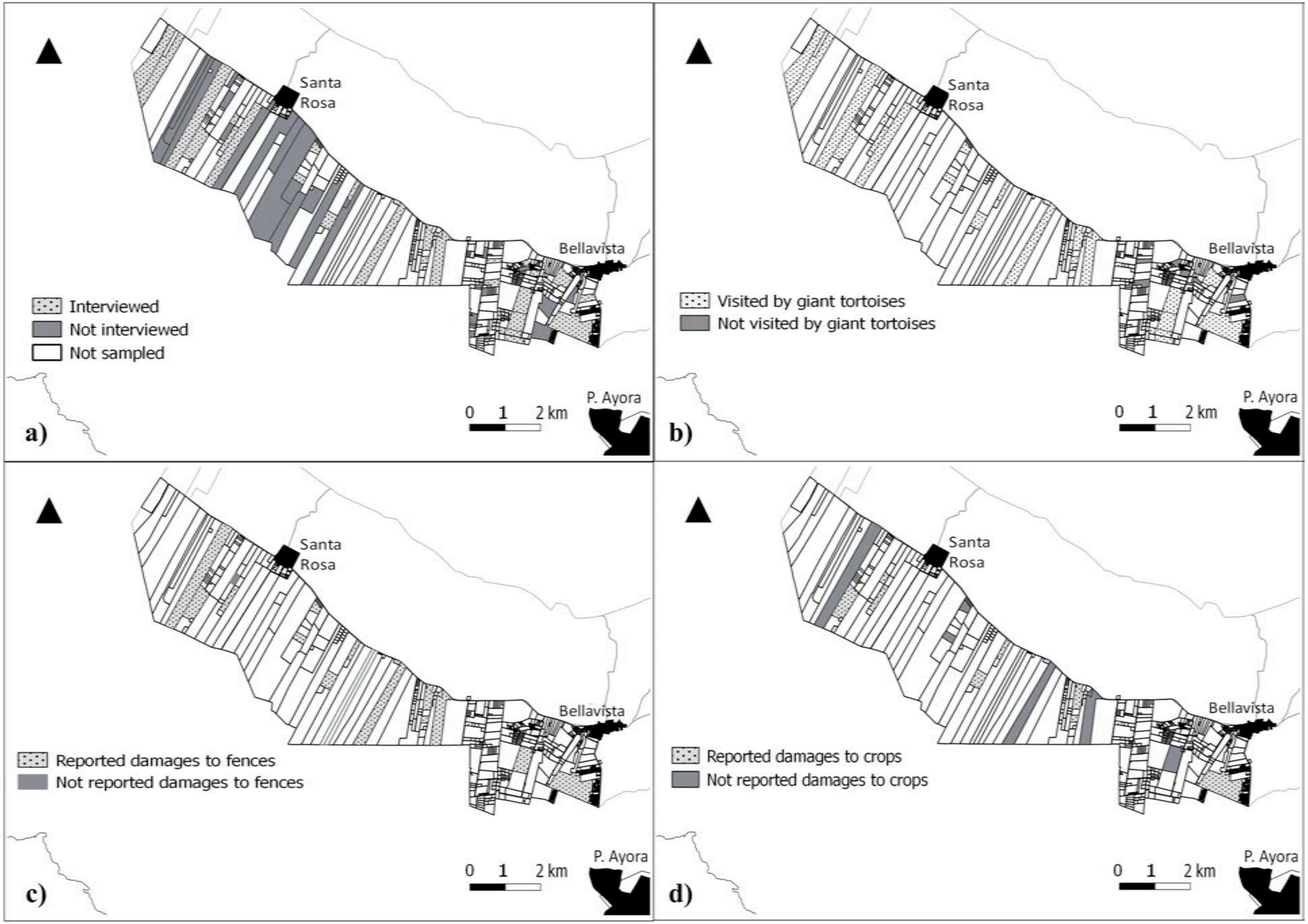

Figure 5.5. Stratified random sample of study area for socio-economic questionnaires.
a) Completed questionnaires (n = 53), **b)** landowners reporting giant tortoises entering farms (n = 41), **c)** landowners reporting damages to fences (n = 16), and **d)** landowners reporting damages to crops (n = 9).

Table 5.3. Sample characteristics of the socio-economic valuation in the rural area of Santa Cruz Island (n=53).

Characteristic	Sub-characteristic		Detail
Crop cultivation as primary economic activity			11
Presence of crop cultivation			30
Not presence crop cultivation			23
Top crops damaged by giant tortoises	**Species**	**Frequency**	**(%)**
	a. Banana cultivars	7	23
	b. Maize	6	20
	c. Pineapple	5	17
	d. Cassava	2	7
	e. Coffee	2	7
	f. Grass	2	7
	h. Watermelon	2	7
	i. Cat's claw	1	3
	j. Vegetables	1	3
	k. Papaya	1	3
	l. Pumpkin	1	3
Total reporting crop economic losses		9	
Crops economic losses	Average: 1194 USD, Maximum 6000 USD		
Economic losses per unit area (USD/m2)	Average: 2.80 USD, Maximum 8 USD		
Total reporting fencing costs		16	
Fencing costs to avoid giant tortoises	Average: 1974 USD, Maximum 9000 USD		
Fencing cost per meter (USD/m)	Average: 13 USD, Maximum 125 USD		
Compensation			Non existent
Alternatives to prevent damages (n=5)			
1) To provide economic incentives for building touristic infrastructure in the land instead of agriculture.			
2) To promote growing crops that will not be damaged by giant tortoises such as: oranges, cocoa and teak trees for timber.			
3) To promote the local agricultural market in particular for those whose subsistence relies solely on agriculture.			
4) To design efficient anti-tortoises fences that do not cause damage to tortoises nor landowners, as well as ecological corridors.			
5) To build and set more (non damaging) fences in the side of the GNP.			

5.2.2.2. Landowners alternatives to prevent damages

The majority of the landowners (75%, *n* =40) reported the use of physical barriers by fencing either with barbed wire, rocks and/or porotillo as the alternative to prevent damages by giant tortoises in their croplands. Other suggestions by the respondents (*n* = 5) included: 1) to provide economic incentives for building touristic infrastructure in the land instead of agriculture; 2) to promote growing crops that will not be damaged by giant tortoises such as: oranges, cocoa and teak trees for timber; 3) to promote the local agricultural market in particular for those whose subsistence relies solely on agriculture, 4) to design efficient anti-tortoises fences that do not cause damage to tortoises nor landowners, as well as ecological corridors; and 5) to build and set more (non damaging) fences in the side of the GNP (Table 5. 3).

5.2.3. Density estimation of giant tortoises in the rural area

For the giant tortoise density estimates in the first transect campaign (April-June 2015) a total of 122 tortoises were encountered along a total of 50.33 km of line transects. To estimate the density we performed a truncation of the outliers set at a distance of 39 m, meaning that we excluded all the tortoises detected farther than 39 m, following the recommendations of Buckland et al. (2012) regarding outliers. Based on the comparison of the AIC values the hazard-rate function with a cosine series extension adjustment was the density function best fitting our data (Appendix C5). The output of the software is shown in Table 5.4. The estimated density resulted in approximately 0.8 tortoises per hectare. For the giant tortoise density estimates in the second transect campaign we encountered a total of 685 tortoises along 79.2 km of line transects. We performed a truncation at 155 m, thus excluding only four observations from the analysis. Following the same procedure as specified above the best fit was obtained with the hazard rate function this time coupled with the hermite polynomial adjustment (Appendix C6). The output of the software is shown in Table 5.4. The estimated density resulted in approximately 1.85 tortoises per hectare, more than the double of the first campaign.

Table 5.4. Estimated tortoises density for both transects campaigns, expressed as number of individuals per km^2.

Transect campaign	No. individuals	No. individuals after truncation	Effective strip width	Density of individuals	95% CI Lower	Upper	CV
1	122	116	13.53	75.70	53.34	107.41	0.18
2	685	681	22.40	184.92	116.50	293.52	0.23

Effective strip width refers to the software estimated width of the transects, 95% lower and upper Confidence Interval (CI) and coefficient of variation are shown

5.3. Discussion

Our results have allowed us to retrieve information about the current status of the conservation conflict between giant tortoises and farmers in the rural area of Santa Cruz Island. The heterogeneity of this farming system makes the identification and categorisation of specific variables key to study the interaction between farmers and giant tortoises. It is important to note that, although the migratory routes of giant tortoises between the national park and the rural area of Santa Cruz Island have been well described and studied by Blake *et al.* (2012); Blake *et al.* (2013); Blake *et al.* (2015), this research is the first to uncover, explain and quantify the main factors associated with this particular conservation conflict. Having used PRA as an overarching systematic approach has proven to be effective, as it has allowed us to identify and characterise conservation conflicts related to agro-ecosystems and wildlife in Santa Cruz Island. In line with Chambers (1994) we also consider that semi-structured interviews (SSI) formed the essential first step of PRA in this research. SSI allowed us to structure our research in three main clusters of information through the use of questionnaires and transects: 1) farmers' perceptions and actions, 2) socio-economic valuation of damages; and 3) population density of giant tortoises in the rural area. In this sense, we agree with Mueller *et al.* (2010) on the advantage of using PRA to combine local knowledge inquiry with scientific study at a low cost. Moreover, as shown in our case, we also see PRA as an adequate tool for a preliminary assessment of conservation conflicts.

5.3.1. Farmers' perceptions and actions

Giant tortoises were present commonly in the study area; in particular in farms with cattle rearing. Although a negative perception towards giant tortoises was not predominant in our sample population; farms with the cultivation of crops and farmers reporting damages were associated with a negative perception. Similarly, those farmers reporting damages to crops were taking more actions, particularly indirect actions (use of fences) to protect their fields. In fact, fencing and direct actions against giant tortoises were taken regardless the negative perception. The large group of farmers without a negative perception could be considered as a 'tolerant' group. Understanding the motivation underlying such attitudes could be fundamental in addressing strategies to avoid conservation conflicts (Kansky *et al.*, 2014). Moreover, the tolerance could be linked to the effectiveness of the prolonged conservation awareness that the iconic giant tortoises have generated in Galapagos society (Benitez-Capistros *et al.*, 2016), this is epitomised in statements like: “they were here before us”, “they are part of the landscape” often reported during the SSI. Moreover, this could also be the result to a habituation process to animal presence (Smith *et al.*, 2005; Zinn *et al.*, 2008), in our case as an acceptance of tortoise presence in the area.

We also found that farmers who had small farms and farmers cultivating crops more often reported giant tortoises as a cause of damage. Naughton-Treves et al. (1998) argues that smaller land plots are more prone to suffer animal incursions (e.g. from elephants) than larger farms. The perception of damage is then associated with the dimension of the land. The larger the land, the more opportunities for diversifying productive activities (i.e. livestock, tourism); consequently generating alternative sources of income and less vulnerability to the wildlife (Naughton-Treves and Treves, 2005). Indeed “being at risk from a threat is not necessarily the same as being vulnerable to it” (Dickman, 2010). For example, we expected that farmers bordering the national park would be more vulnerable and more prone to report damage, as shown by other studies where the distance from the protected areas is a predictor of damage (Hill, 1997; Naughton-Treves *et al.*, 1998; Naughton-Treves and Treves, 2005; Linkie *et al.*, 2007; Mackenzie and Ahabyona, 2012). However our results show that farmers and respondents active on farm for which land bordered the National Park (mostly cattle rearing and touristic farms) although they were reporting a higher number of giant tortoises, also reported less damage. Therefore, the distance to the National Park was not a predictor of damage; but rather the size and type of the primary productive activity that is being developed in the farm.

Most of the actions that were undertaken to prevent damage were fencing plots (indirect actions). Our prediction model allows us to confirm that farmers reporting damage and cultivating crops in their lands had higher odds of taking actions to avoid giant tortoise entrance. Although, from a farmer’s perspective tortoises are generally not perceived negatively, such perceptions are not necessarily constant through time, e.g. a season of failing crops may exacerbate negative perceptions. In effect, despite the fact that they can cause damage, farmers have found strategies to deal with tortoise incursions. These strategies can proof costly and unsustainable both for giant tortoises (disrupting their migratory routes) and for the farmers (economic costs).

5.3.2. Quantification of damages

Losses to important perennial crops (banana cultivars, pineapples, coffee) and short cycle crops (maize, cassava) in Galapagos were reported. Moreover, damage was mostly reported during November and December, which corresponds to the highland migratory phase, which can be considered as the 'high period of interference' between giant tortoises and farmers. The quantification of spatial and temporal aspects of crop losses is essential for managing and mitigating potential conservation conflicts (Nyhus and Sumianto, 2000). Our results allow us to provide an initial measurement of the associated costs of damage to crops and fences. These results will facilitate a further analysis and characterisation of damage costs (direct and indirect) and possible compensation schemes.

It is important to note that landowners were the primary source of information and although this has allowed us to reduce costs and time, it might lack an objective reporting/recording of information due to changes in perceptions and memory that can be influenced by events that may take on a greater significance in retrospect (Osborn, 2002). To minimise this inherent bias we tried to collect information only from the latest event year (2014-2015). However, the low number of landowners reporting economic losses in our sample forced us to consider a larger time frame (since 2007). Thus, the reported costs for damaged crops and fencing have to be interpreted with caution and should ideally be complemented with field-based monitoring in the croplands over time (Karanth *et al.*, 2012).

Additionally, the results of the socio-economic questionnaire allowed us to verify the increasing land abandonment (Benitez-Capistros *et al.*, 2014; Guzman and Poma, 2015). This situation warrants particular attention not only for the future of the intended agricultural development in Galapagos (Benitez-Capistros *et al.*, 2016), but also for the implications for the migratory routes of Santa Cruz giant tortoises. Abandoned lands typically exhibit a proliferation of invasive species such as blackberry (*Rubus* spp.), which become true vegetative barriers for the passage of giant tortoises as observed during the transects, and are at the expense of native flora. Moreover, in combination with the extensive sectors with low fencing (<15cm), which also block giant tortoises passage (Figure 5.6), a reduction of the current suitable foraging and migratory 'rural' area for giant tortoise is to be expected. A continuous monitoring of giant tortoise population density and distribution throughout the rural area will be key for detecting and preventing decreasing population trends as well as to favour an effective conservation (Gaidet *et al.*, 2003).

5.3.3. Density estimation

Our density results allow us to provide an overview of the differences in the relative densities of giant tortoises in the two migratory seasons. As verified, lower and higher densities correspond to the yearly migratory seasonality of giant tortoises from the protected (national park) to the non-protected (rural) area in Santa Cruz (Blake *et al.*, 2012; Blake *et al.*, 2013; Blake *et al.*, 2015). Former studies in Galapagos have focused on determining the density of giant tortoise in the National Park where most conservation efforts have taken place to restore the endangered species of giant tortoises. In Santa Cruz Island the estimated density of *Chelonoidis nigrita* in the National park was of 720 individuals per km^2 (Márquez *et al.*, 2004). Our estimated density in the rural area for the first phase of 'minimum potential interaction' (April-June) is almost 10 times lower (75 individuals per km^2) and; similarly, almost 4 times lower (185 individuals per km^2) for the second phase of 'maximum potential interaction' (October-December).

Considering that giant tortoise habitat was once extending across the rural area (Froyd *et al.*, 2014) the population of giant tortoises could have undergone an "edge effect" just outside the National Park. Fencing as a strategy of protection can threaten tortoise migratory routes impeding animals' movement along the ecosystem (Hansen and Defries, 2007; Jachowski *et al.*, 2014). We consider that the transect lines defined in the study area (Figure 5.1) are well suited for establishing long-term monitoring schemes. This will allow having precise and regular information on giant tortoise abundance and trends, a critical step to ensure adequate and adaptive sustainable management schemes in conservation (Du Toit, 2002; Danielsen *et al.*, 2005; Boissière *et al.*, 2014). Studying and protecting wildlife –in particular migratory species– in non-protected lands is essential, as these areas play a crucial role within an ecological network and are key in maintaining connectivity between the protected areas (Bennett, 1999; LaPoint *et al.*, 2015).

5.3.4. Towards an alternative and adaptive co-management

As we have detailed, this research studied and unveiled different elements of the emergent conservation conflict in the rural area of Santa Cruz Island. Addressing social-ecological dynamics is not an easy task, and needs to include adequate parameters that can explain and transmit the, -sometimes complex- information to policy and decision makers (Rissman and Gillon, 2016). Ideally and as already proposed in an upcoming project in Galapagos (Box 5.1), the results of this work will be used to start a participatory process in the resolution of this emergent conservation conflict. In this way we will try to involve the relevant stakeholders (farmers, scientists, decision makers GNP, MAGAP, GGC) to evaluate the best decisions to manage the conflict regardless of the conflicting views that may exist (i.e. conservation vs. development). For this, we have proposed the use of a participatory multi-criteria decision analysis (MCDA). This decision-support tool allows exploring issues and making decisions that involve multiple criteria (economic, social, ecological), including competing priorities to be systematically evaluated by groups of people. Thus, it is able to address the trade-offs, uncertainties, pluralities of views and incommensurable values and objectives that give rise to conservation conflicts (Davies *et al.*, 2013). A participatory MCDA is an iterative participatory criterion ranking and weighting processes that can allow incorporating and acknowledging the variety of stakeholders' values, views and interests and competing objectives (Moffett and Sarkar, 2006; Mustajoki *et al.*, 2011).

Accordingly, we see that our research has produced already interesting results that are able to couple social and ecological information to understand this emergent conservation conflict. Our analysis raises important points for addressing conservation management implications:

1. Size and type of production in the land were predictors of the perceived damage by giant tortoises. A smaller agricultural (crop-producing) farm will most likely have/report damage by giant tortoises. Yet, we need to stress again that large mono-productive farms are almost inexistent in the rural area of Santa Cruz, and often its labourers set a small plot of land aside, dedicated to crop cultivation for family subsistence (chakra). This situation should be taken into account in any –conflict– management strategy, which would focus only on the part of the population that "seems" to be more affected (i.e. small scale agriculture). Otherwise this could lead to the risk of shifting the problem to the neighbours (Dickman, 2010) and/or shifting the problem to those actors with less (bargaining) power (labourers vs. landowners).

2. Co-generation of knowledge with the people involved in the conflict is essential to meet conservation objectives (Brondizio and Tourneau, 2016). In this research we aimed at including local knowledge with the use of the PRA approach. For example, the suggested alternatives provided in this study for mitigating conflicts (Table 3) are a necessary step towards inclusive sustainable adaptive wildlife management (Du Toit, 2002; Young *et al.*, 2007). However, some of these require further evaluation in order to prevent similar mistakes that have occurred in other non-Galapagos settings with wildlife management. The following conflict mitigation strategies warrant/deserve particular attention:

   - **Fencing with barbed wire**: although it seems to be a non- aggressive or passive protection method, it could represent a serious issue for giant tortoises. Not only because barbed wire fences can represent a pitfall for tortoises as it is for other animals attempting to cross these (Harrington *et al.*, 2006; Rey *et al.*, 2012) but also because it is very likely that an effective ever-widening network of fences following a future (and very likely) land subdivision can have a detrimental effect on wildlife migratory species (e.g. Gates *et al.*, 2012). Indeed, interfering with migratory connectivity through human land use (change) can be one of the major threats to species conservation (Hansen and Defries, 2007).

- **Community-based wildlife tourism (CBWT):** can be traced as one of the main ideas prevailing in the community-based conservation discourse in Galapagos (**Chapter 4**). In the present study CBWT was also frequently reported (directly or indirectly) through the interviews and questionnaires as an appealing alternative for many landowners and farmers to diversify their activities and revenues. Policies to favour CBWT can raise tolerance and prevent retaliations to wildlife by the empowered communities because wildlife is valued as property (Treves *et al.*, 2009). However, valuing a species as a product (e.g. natural capital) in a society with low conservation awareness and that is mainly driven by economical pursuit could have detrimental ecological effects (Benitez-Capistros *et al.*, 2016). Likewise, inequalities in the distribution of CBWT benefits are also an issue, in particular in poor, rural communities (Walpole and Thouless, 2005). Problems arise when governmental or non-governmental market-driven approaches to conservation favour certain consumers and producers, or worse, when local communities are excluded from the main profit of wildlife tourism as well as access to crucial natural resources (Rutten, 2002; Gulbrandsen, 2004). There are several factors for the success of CBWT (see Rutten, 2002; Walpole and Thouless, 2005), but three could be highlighted as most relevant: First, the initiative of CBWT needs to be originating from the local communities and not by external organisations with particular economic interests. Second, local communities need realistic information on the available options to develop touristic infrastructure. This information could be provided be an external organisation or independent sources but with no personal stake or narrow interests. Third, local communities need to build capacities to improve their skills to understand the real access to capital and market in place. This will allow local communities to understand what are the real costs and benefits of CBWT. Therefore, the decisions on venturing in the enterprise of CBWT will not be filled with un-realistic communal expectations such as that the communal benefits of tourism will offset the cost of living with wildlife. Such benefits need to be understood as social (e.g. communal projects for schools, clinics) rather than financial (e.g. net individual economic benefits) (Rutten, 2002; Walpole and Thouless, 2005).

3. Finally, as we have discussed along in this paper, the implications of the intended agricultural development in Galapagos, with particular emphasis in Santa Cruz rural

area, needs to include specific and reliable social-ecological information for an accurate understanding of the dynamics in place. Here we emphasise the human-giant tortoises' interface but other endemic Galapagos species (i.e. Darwin finches) will have to be eventually included because only a good management of giant tortoises may not be sufficient to guarantee the adequate management of other endemic species of the rural area. The temporal information on the population status of giant tortoises; together with the spatial and quantitative information on crop damages and fencing costs, allows us to provide with initial study elements to start addressing this "emergent" conservation conflict in Galapagos. However, it is also important to mention that the quantification of damage to crops and fences is limited by the numbers of participants and by the fact that they are only based on perceived and not verified real damage costs. In the future, it will be necessary to further collect more detailed and verified information regarding the real damage costs of crops and fences.

5.4. Conclusion

The dynamics of linked human and ecological systems requires predictive research that is able to inform interventions to conserve biodiversity while sustaining human livelihood (Milner-Gulland, 2012). Our study provides grounded scientific (ecological) as well as community-based information (social), which we consider essential as a first step for a proper co-management of conservation conflicts. Moreover, we emphasise on two negative issues and three positive actions that need attention before any conservation/development intervention:

Negative issues

- Abandoned lands and the proliferation of invasive plant species such as blackberry (*Rubus* spp.).
- The unregulated physical barriers used to protect crops (in particular with barbed wire) and subdivision of lands.

Positive actions

- Field-based monitoring of croplands and further characterisation of damage costs (direct and indirect) and possible compensation schemes.

- Systematic (at least yearly) monitoring scheme of giant tortoise abundance and trends in the rural area.
- An inclusive participative decision-making process for conservation resolution.

For this last positive action point, as we previously mentioned we will propose the use of a participatory MCDA. We consider that this approach will be useful to evaluate the different decisions and competing interest of the conflicts with the involved stakeholders. For example, in the case we have illustrated in this research, negative perceptions, actions and economic losses could be arranged in set of criteria and defined priorities, where the effects of participants' choices (weighting) on a situation (e.g. fencing costs, crop losses) can make the trade-offs clear and broaden the range of acceptable options on the table (e.g. subsidies for non-damaging fences, designing ecological corridors).

Box 5.1. Upcoming Galapagos project

The close collaboration and participation with many Galapagos stakeholders allowed us to continue with a new project aimed at managing the emergent conflict between giant tortoises and farmers in the rural areas of Santa Cruz Island. This project has been elaborated by a multidisciplinary team, including: two scientists working with Galapagos giant tortoises in Galapagos (ecology and migration), the two leading authors of this manuscript (Chapter 5), a representative of the Ministry of Agriculture (MAGAP) in charge of participatory farming, and the director of the Charles Darwin Foundation. Among the objectives of the projects we will:

1. design and implement agro-ecological farming systems that will conserve biodiversity, particularly dealing with giant tortoises in private lands, and the control of invasive species
2. correct and consolidate existing land use maps
3. complete socio-economic analyses of land management options
4. quantify perceived and actual levels of crop damage by tortoises
5. produce detailed maps of land use and seasonal assessments of tortoise abundance and general health conditions within private lands
6. quantify habitat preferences and how movement patterns are influenced by existing infrastructure and vegetation formations

Chapter 6

GENERAL DISCUSSION

GENERAL DISCUSSION

Overcoming the new conservation and sustainability challenges requires the understanding of the dynamic linkages between the social and ecological systems (Kates *et al.*, 2001; Robert *et al.*, 2005; Ostrom, 2009). These linkages interact at different interconnect levels from social to ecological and governance process which are at the same time interacting at several scales from local to global. Furthermore, this complexity is not only related to the difficulty of understanding the social and ecological dynamics and interactions; but also, at the basis, on how different people perceive and give meaning to different socially constructed realities (e.g. conservation, sustainability) and participate in their definition and implementation of policies. Understanding these linkages and their underlying meanings requires the generation of cohesive and actionable knowledge that can be relevant across scientific disciplines and the society. In particular, knowledge should be exchanged, generated and integrated among different societal actors so that it can contribute in aiding in the transition towards sustainability (Jerneck *et al.*, 2011; Brandt *et al.*, 2013). In this work, I have tried to understand the inherent complexity of a system (Galapagos) by combining and co-creating knowledge from involved actors (scientists, local communities and decision makers). With the co-creation of knowledge I provide co-shared solutions that are aimed at channelling unbiased synthesis of the research findings to policy, managers and decision makers, to favour a transition to biodiversity conservation and sustainability based upon acceptance and a broad societal platform. Such an exchange and co-creation of knowledge and solutions are essential not only to met conservation and sustainability objectives (Lang *et al.*, 2012; Redpath *et al.*, 2013; Cundill *et al.*, 2015; Adams, 2016) but also to promote knowledge transfers between science and decision makers and science and the community (Cvitanovic *et al.*, 2015; van der Molen *et al.*, 2015). To co-create new knowledge and finding co-shared solutions I used a transdisciplinary and participatory approach. This transdisciplinary and participatory approach relied in the selection of three different methodologies that would respond to the goals and objectives of this thesis. Hence, Chapters 3, 4 and 5 systematically respond to all the specific objectives (see Figure 6.1). However, while specific objectives 1-3 directly respond to the methodological approaches, specific objectives 4 and 5 were directed to the transmission of knowledge by all the actors involved in this work: policy and decision-makers, managers, local communities and scientists. Therefore, in the following subsections of this chapter I will: First, outline how knowledge was co-created through the use of each methodological approach as detailed in **Chapters 3-5**, highlight the major finding of each empirical chapter and discuss the limitations of the work and methodological approaches (specific objective 6). Second, I will make cross-comparison between the different results and methodological approaches. Third, I will discuss how knowledge transfer was achieved (specific objective 4); and, fourth I will discuss the relevance of this work in other contexts (specific objective 5).

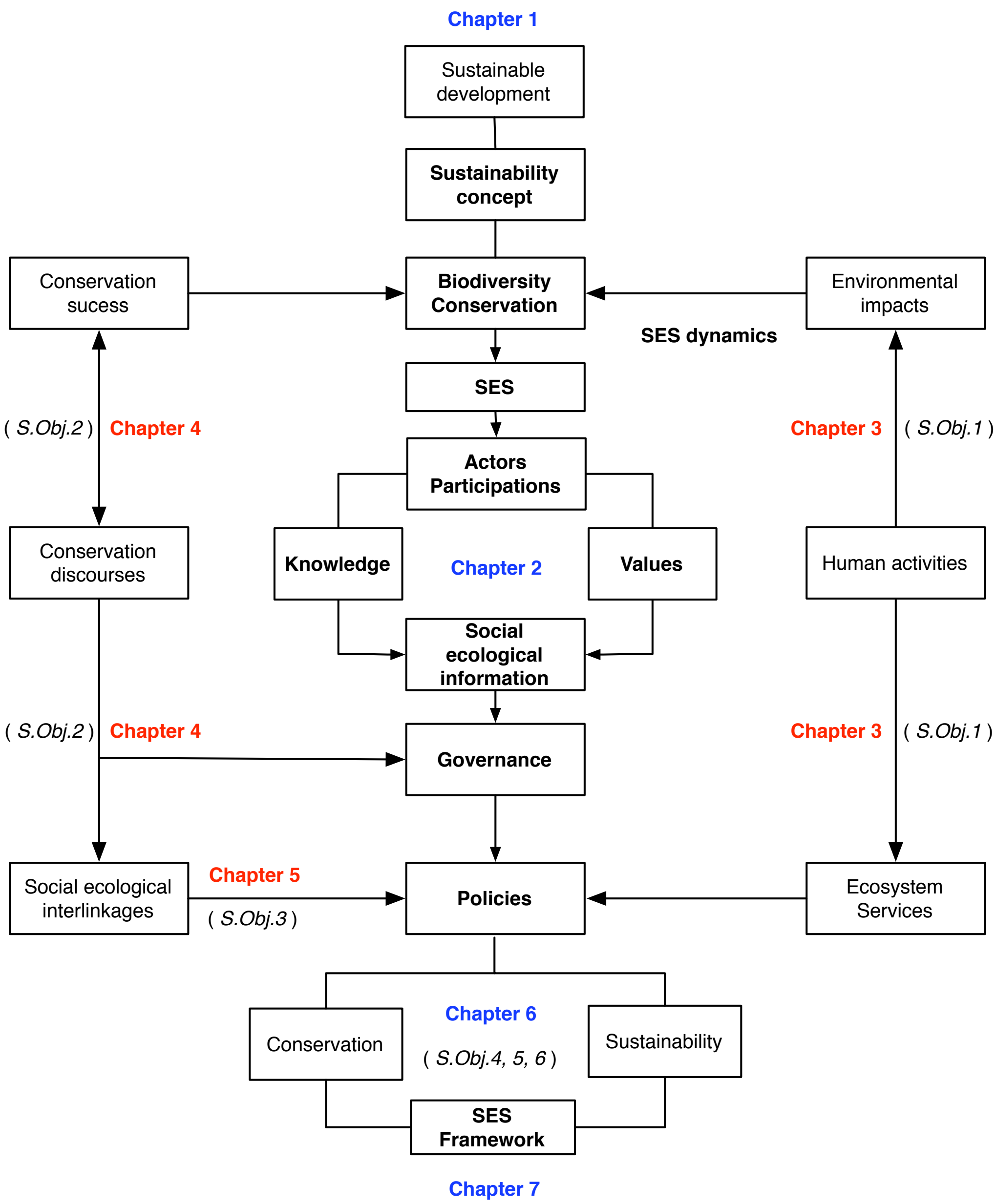

Figure 6.1. ***Reprise*** **of the conceptual scheme of the structure of this doctoral thesis.**

6.1. Co-creation of Knowledge

6.1.1. Delphi method

S.Obj 1. To generate a set of consensus expert-based indicators that can explain the general environmental impacts and the relationship with human activities and ecosystem services on the Galapagos Islands, as well as to provide solutions to facilitate the conservation and management of the archipelago.

An expert-based/informed approach is considered essential to address ecological research questions because ecological system data are complex and characterised by uncertainty, which can lead to uninformative predictions (Kuhnert *et al.*, 2010). The importance of expert knowledge in conservation science is therefore also driven by the need to characterise dynamic complex systems, the limited resources to collect new empirical data and the urgency of decisions (Martin *et al.*, 2012). As explained in Chapter 2, there are several expert elicitation methods (e.g. expert panels, Cooke's method), but more rigorous consensus techniques, such as the Delphi method, have been proposed to deal with these issues as well as to address conflicts and to form better policies for conservation (Sutherland, 2006b; Mukherjee *et al.*, 2015). Indeed, in this work we selected and used the Delphi method, which allowed us to respond to specific objective 1. Although we highlighted several reasons for selecting the Delphi method our experience highlights three important aspects: i) *flexible design*, ii) *anonymity* and iii) *iterative structure to forge consensus*. The *flexible design* of the Delphi allowed us to conduct the process on an online environment and very importantly to combine it with the DPSIR framework. *The anonymity* allowed us to avoid the problems of freely interacting groups such as the dominant personalities or the pressures to conform the majority of opinions. The *iterative nature to forge consensus* allowed us to control the feedback, avoid conflicts and increasing the consensus after each round. It is important to note that although the Delphi is widely used as a consensus building methodology, it can also express dissensus. In fact, in 1970 the Policy-Delphi was specifically designed to open the way for applications aimed more at becoming acquainted with and exploring the different existing positions in relation to a complex problem (dissensus) than at arriving at a consensus or a single opinion (Turoff, 1970). Therefore, the Delphi methodology should better be understood as a group communication process that can facilitate a group's decision-making. Consensus can therefore be reached in the same way dissensus has to be dealt with. In this regard, von der Gracht (2012) argues on the importance of consensus and dissent oriented analyses in Delphi studies to be complementarily applied in order to obtain a deeper understanding of the data. In our work, we have analysed the data in this manner, although consensus building was the main goal, elements of the dissensus were also used to interpret the data. For example, we pointed out that the dissensus found for improving the migratory policies of the Galapagos Special Law (GSL) and its regulation (R_PS7, R_PS8, R_PS9), might suggest opposing views about the benefits that the GSL has given different groups of people in Galapagos (Grenier, 2007).

The combined Delphi-DPSIR approach has been key in this work and allowed us to respond to specific objective 1. Hence, with this combined approach we could explore the complex dynamics of the Galapagos SES, we generated 37 consent indicators and 7 interactions of environmental impacts, which allow us to understand the general complex dynamics of the Galapagos SES (Figure 3.2). As mentioned, the results of this work highlight the effectiveness of the Delphi method to generate group consensus, which in turn allowed us to generate and co-create new knowledge. By new knowledge we refer to the detailed explanation of Galapagos SES dynamics, explained through the DPSIR framework. Consequently, it is not only the Delphi but also the combined Delphi-DPSIR approach that allowed us to co-create new knowledge. Hereafter, our research approach and structure was able to explain a process (SES dynamics), delineate the problems (social and environmental variables); and very importantly, generate solutions (policy actions). These solutions (Responses of the DPSIR framework, strictly not 'indicators') provide a systemic reference for local decision makers to implement conservation and management policies.

Although our results are no panacea, we generated an interpretable SES framework that is potentially suited for opening discussions on policy alternatives between Galapagos' decision makers and different stakeholders. What is interesting to note is that certain important issues that were raised in this work (and the group of experts) had already been taken up at a policy and management decision level in Galapagos. For example, the Galapagos Bio-security Agency (GBA) has been strengthened. The mission of this institution, among others, is to improve the quarantine system for introduced species (R_EI1) and the control of imported animals such as cats and dogs (R_EI4). Likewise, the implementation of a new science-based zoning scheme for the GMR (R_EI6) is today in the process of implementation (MAE, 2016). With these examples I do not want to convey the message that these policy and management changes have been generated solely as a result of this work, but in way this work might have had an influence. In Section 6.3, I will discuss more on the elements that have facilitated the uptake of information during this research process.

6.1.1.1. Limitations of the Delphi-DPSIR approach

It is important to note that in SES research, the DPSIR framework conceptualises social and ecological variables from an anthropocentric perspective. This approach clarifies how human actions and resources affect the ecological system and how the changes in the ecological system potentially affect the social system (Binder *et al.*, 2013). Therefore, the dynamics of the social system are not explicitly conceptualised and are aggregated as socio-economic processes and variables in the drivers and responses (Binder *et al.*, 2013). In our results this is evident (box-I DFED and box-IV responses, Figure 3.2) and might highlight one of the limitations of using the DPSIR framework.

The second limitation is related to the dropouts per round and rates of attrition during the Delphi process, which is a common issue (Landeta, 2006; Sinha *et al.*, 2011). Its possible consequence must however be investigated. In our work this affected the final composition of participants categories. Although we tried to reduce biases when recruiting the experts and tried to cover an ample sample (n=42), we could only recruit 10 participants in the first round. Technically speaking, the reduced number of participants is not an issue in an expert elicitation process (Linstone and Turoff, 1975a; Ziglio, 1996; Clemen and Winkler, 1999), but in our work the reduced number of participants and the dropouts affected the final composition of the experts' categories. So, although in round 1 the experts were evenly distributed (government officials: 2, scientists: 2, local residents: 3, officials of NGOs: 3), in the third and last round the total dropout of 5 experts along round 1 and 2, resulted in an uneven composition of the experts' categories (government officials: 0, scientists: 2, local residents: 2, officials of NGOs: 1). Hence, although large sample of participants in a Delphi process is not required (Powell, 2003), it will be very important to avoid dropouts, which might lead to unbalanced representation of opinions and thus generate bias.

6.1.2. Q methodology

S.Obj 2. To determine and map conservation discourses in the Galapagos Islands to assess the degree to which these are influenced by the successful conservation of the iconic Galapagos giant tortoises; as well as to compare these discourses to global conservation governance and conflicts with other iconic or well-known species elsewhere

Discourse analysis is driven by the concern of understanding the societal (individuals or groups) construction and apprehension of meaning and subjectivity. A discourse then becomes an assembly of linguistic and non-linguistic social practices and ideological assumptions that together construct and profoundly shape our views about certain issues (Hajer, 1995; Schiffrin *et al.*, 2008). In the field of conservation, discourse analysis seeks to understand the meaning of problems (e.g. biodiversity loss), the solutions to solve them (e.g. establishment of PAs), the actors involved (e.g. local communities, NGOs) and the consequences of the whole process at local (e.g. control and access of resources) and global levels (Adams *et al.*, 2003; Adams and Hutton, 2007; Sandbrook *et al.*, 2011; Adams and Sandbrook, 2013). In other words, taking a discourse analysis perspective allows us to interpret conservation as a political and social issue. This can entail power struggles between actors who participate in the definition an implementation of policies, but also for example on the influence of science on conservation policies, and their entanglement with understandings, perceptions and values of the most influential actors and interest groups (Brown, 1998; Pochet, 2014).

In **Chapter 4**, we underline the use of the Q methodology to map conservation discourses as it allowed us to explain a range of conservation issues from conflicts, values, and relations of power. Q methodology proofed to be a rigorous and systematic methodology that is able to generate quantitative and qualitative information, expressed in the form of discourses. The results of our work indicated four prevailing discourses: (1) *Multi-actor governance*; (2) *giant tortoise and ecosystems conservation*; (3) *community governance*, and (4) *market and tourism centred*. Each discourse is adhered to by specific groups of actors whose views and values regarding the relationship between human and nature are clearly expressed. For example, discourses 1 and 4 have a more utilitarian conservation perspective, whereas discourses 2 and 3 express a more intrinsic one. In this regard, it is important to highlight our approach on discourse analyses through the Q methodology and the use of iconic species to identify different views on local conservation discourses. This structure of the research approach (use of iconic species) allowed us to compare our results with similar works on discourse analysis in different conservation context and iconic species (e.g. tigers, black rhinos) (Rastogi *et al.*, 2010; Witter, 2013). In this comparison we found certain parallels between discourses. For example, we found shared discourses that consider that conservation of iconic species (tigers) does not require the involvement of local communities, or other discourses that share to the intrinsic valorisation of species. Furthermore, we could identify how each discourse carried elements of conservation governance and global conservation framings. For instance we determined that the dominant discourse (discourse 1: *multi-actors governance*) has a regulatory conservation governance approach that emphasises the unification of international regulatory regimes, institutions (e.g. CITES, WWF) and local legislation to take control over natural resources. An approach that we argue warrants attention, in particular because its effectiveness requires political and bureaucratic will and public willingness to abide conservation regulations (Jepson and Ladle, 2011), both things which are not apparent in Galapagos.

Related to this last point is the relevance of discourses analysis for conservation as it can bring about the close links between policies and discourses (Hajer and Versteeg, 2005; Hajer, 2006). Indeed in conservation, conflicts over resources are not only material but also ideological struggles manifested through discourses (Benjaminsen and Svarstad, 2009). This highlights the role of discourse in representing knowledge and power, actions and practices; and where the struggles and negotiations between actors are specified by their discursive formation linked with various strategies of power (Pochet, 2014). In our research with the Q methodology we also explored these discursive formations and relations to power. Mainly, stakeholders from discourse 1 and 2 with formal institutionalised and decision-making power (influential stakeholders) and stakeholders from discourse 3–4 with none or less influence (non-influential stakeholders). In this regard, I also highlight the importance of having performed a stakeholder analysis (SAN) at the very beginning in the Q process. This allowed us two things: First, it generated a solid concourse that was gathered through literature revision and from the 54 stakeholders' interviews from the four inhabited islands in Galapagos (Annex B2). Second, the SAN allowed us to have a very good idea on who to select as Q-sort participants. In fact, this is a very important aspect in the Q methodology, which unlike R methodologies (e.g questionnaires) does not require random large samples of participants, but relatively small samples that however require including, as much as possible, different points of views (Cuppen *et al.*, 2010). In this sense, Q methodology seeks at finding the existence of numerous "truths" or multiple versions of reality and then to exploring the meanings and implications of each (Previte *et al.*, 2007). In conservation this is very important, because exploring the plurality of views can allow the different involved actors build more honest, adaptable and effective relationships with each other and with the wider public (Sandbrook *et al.*, 2011; Adams, 2016).

6.1.2.1. Limitations of the Q approach

The structure of the Q methodology allows for a systematic reduction of possible biases during the Q-process. For example, it reduces the possible bias that could be imposed by the researcher perspectives and positions on a debate. Indeed, Q methodology allows the analysis to be manipulated by respondents, thus the researcher loses the exclusive power to signify the reality of the researched (Cuppen *et al.*, 2010). However, in the in the reduction of concourse to the creation of the Q-sample and its statements (in our case 420 to 60 statements), there is a degree of information loss and this can generate bias. This reduction of qualitative information is considered a problem in Q methodology, but is inevitable (Watts and Stenner, 2012). Furthermore, in this research although we followed all the necessary steps to produce a quality Q-sample (e.g. structured approach to reduce the concourse, tested piloted the Q-sample), there might be a few statements that perhaps could have been eliminated. This was noted during the Q-sorting process with some statements (e.g. S52, S60) that confused some of the participants. Nevertheless, again one of the strengths of Q-methodology is that even if this could have been avoided, when statements do not allow the positioning of the opinion of participants, (s)he will place this statement in the middle of the distribution (Watts and Stenner, 2012). A final minor issue, which however does not alter our research findings, is that although we tried to recruit 2 farmers for the Q-sorting process, these participants were not available at the moment. Their views however were integrated in Q-sample.

6.1.3. The PRA approach

S.Obj 3. To characterise the emergent conservation conflict between humans and giant tortoises in the rural agricultural area of Santa Cruz island, in order to assess several specific socio-economic and ecological inter-linkages and to provide a range of possible scenarios and actions to effectively inform policy makers and managers to improve the social-ecological fit of conservation strategies.

In conservation, understanding the changing social contexts for conflict between conservation and human welfare is extremely important (Peterson *et al.*, 2008; Peterson *et al.*, 2010). People's socially constructed realities are formed by past experiences, views and values that frame people's perceptions of what is important and how they interpret material realities and consequently behave and act (Peterson *et al.*, 2010). When these actions clash against established social norms; such as conservation rules, then conservation conflicts emerge. Indeed, at the basis of conservation conflicts lie the different and opposed opinions between the interests, views and values of nature that people have (Redpath *et al.*, 2015; Chan *et al.*, 2016). Such disagreements are inevitable, but solutions need to be directed towards the understanding of the underlying causes of the conflict, which among others, include different social and cultural-historical contexts and power relations (Campbell, 2007; Armitage *et al.*, 2009; Andrade and Rhodes, 2012). Thus, managing conservation conflicts requires finding shared solutions between the involved parties in the conflict. As we highlighted in chapter 1 and chapter 2, managing the conflict involves a participatory process that comprises two main phases and several steps. The first phase involves mapping the conflict and the second phase managing the conflict (see Figure 6.2). Thus, in the first mapping phase we need start with the identification of the stakeholders, followed by understanding of their values, attitudes, goals and positions, the collection of socio-economic and ecological information, and only then we can start with the second phase of actually managing the conflict (Redpath *et al.*, 2013).

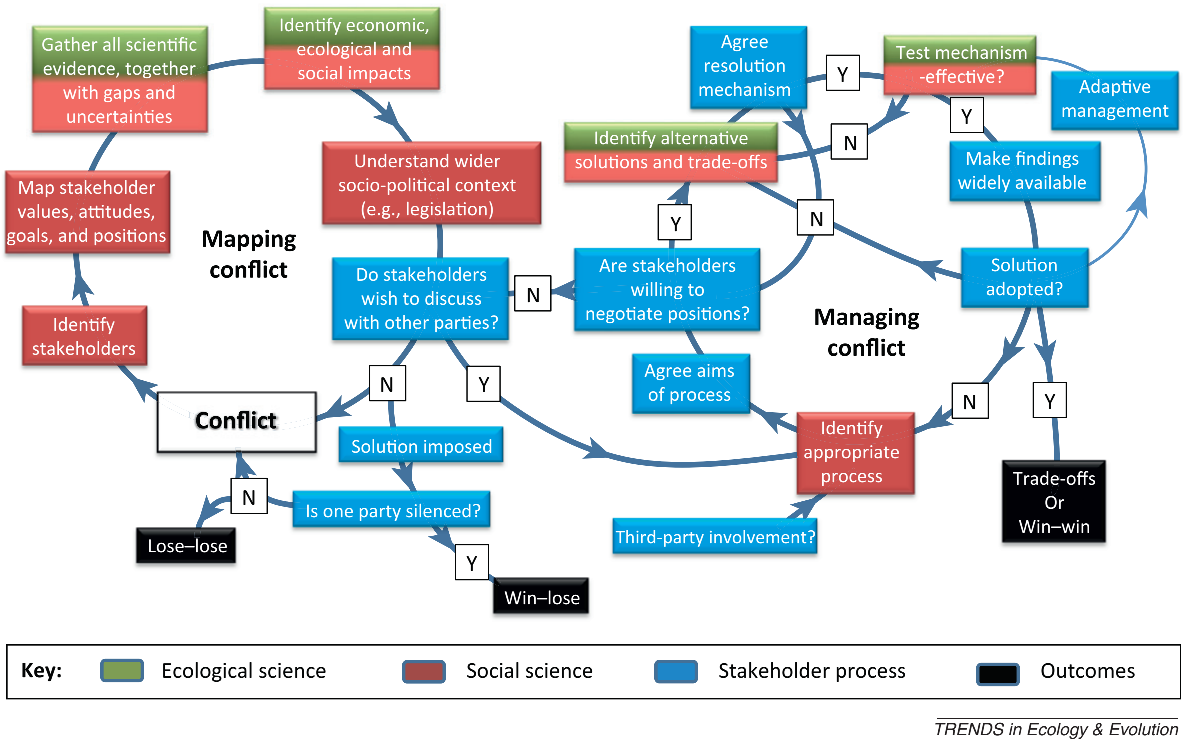

Figure 6.2. ***Reprise*** **of the roadmap to guide effective management of conservation conflicts**
Figure source: Redpath *et al.* (2013)

In line with specific objective 3 we position the work of chapter 5 in the first phase: mapping the conflict. In this work, we used a participatory rural appraisal (PRA) approach to map the emergent conservation conflict between giant tortoises and farmers in the rural area of Santa Cruz. We made this deliberate choice because of two things: First, PRA emphasises empowerment of local people, in particular in farming systems (Friis-Hansen and Sthapit, 2000) and we considered this a very important factor. Second, the choice was made because PRA has been used in conservation conflicts in PA and their surroundings (both rural and urban areas) in many cases involving wildlife and agro-ecosystems that sustain people's livelihoods. Moreover, in these contexts, PRA research has applied a combination of both social and ecological methods (Zhang and Wang, 2003; He *et al.*, 2011; He *et al.*, 2014). Hence, under the PRA approach we selected two methods: semi-structured interviews (SSI) and questionnaires to retrieve socio-economic information. We then coupled this with an ecological method (transect lines) to estimate the density of giant tortoises in the rural areas to confirm (or reject) whether a real problem can exist or is limited to a perception. This combined approach of social and ecological methods allowed us to retrieve the first important socio-economic information about the actors involved in the conflict, mostly the farmers and landowners of the rural area. Notably, in line with the observations by Naughton-Treves and Treves (2005) involving farmers and elephants in Africa, our results confirmed that farmers with small plots of land and producing crops, are likely to have and report damages by the wildlife species, in our case giant tortoises. Furthermore, we were also able to determine that farmers reporting damage took more actions (particularly fencing), regardless of having a negative perception. Interestingly, we found that a negative perception was not the most common in our sample population (37%). Understanding such underlying attitudes is fundamental for managing the conflict (Kansky *et al.*, 2014) and we have already postulated that this is most likely related to an habituation process, but also to the role of iconic species to shape values in favour of conservation (Chapter 4). Similarly, we also provide with quantitative economic information on crop damages and fencing costs, which is also important as a first step to understand the dimension of the conflict, though we acknowledge that this information needs to be furthered consolidated. Conversely, in line with the overall importance of co-generating knowledge and solutions, we also provide a list of suggested alternatives of the actors that are directly involved in the conflict. Some of these alternatives included designing efficient anti-tortoise non-harming fences and ecological corridors and growing crops that will not be damaged by giant tortoises such as: oranges, cocoa and teak trees for timber.

Finally our combined PRA approach allowed us to retrieve ecological information regarding seasonal differences in population densities of giant tortoises in the rural area. We could verify lower and higher densities that correspond to the yearly migratory seasonality of giant tortoises from the protected (national park) to the non-protected (rural) area in Santa Cruz Island (Blake *et al.*, 2012; Blake *et al.*, 2013; Blake *et al.*, 2015). Our results indicated a density of 75 and 185 individuals per km^2 for the low and high migratory seasons, respectively. Our estimated density allows us to provide with information that is relevant to make a first comparison of information with the only available estimates of giant tortoise population density in the National Park which corresponds 720 individuals per km^2.

(Márquez *et al.*, 2004). Thus, our results indicate a difference of 10 and 4 times lower densities of giant tortoises per area if compared to the density of giant tortoises in the National Park. We argue that giant tortoises could have undergone an “edge effect” just outside the National Park and that fencing plots can threaten tortoise migratory routes impeding animals’ movement along the ecosystem (Hansen and Defries, 2007; Jachowski *et al.*, 2014) and/or that the Park’s position and outline has under the current policy and land use structure been well established.

6.1.3.1. Limitation of the PRA approach

In this work we decided to retrieve socio-economic information through the use of two PRA tools: SSI and questionnaires. We made this choice because of logistics (limited time and resources) and although we retrieved important information, we recognise that other PRA tools such as transect maps or focus groups might have retrieved more social information regarding different farming system or differences within the composition of farming groups. However, this would not respond to our objective and goal of the research. In this sense we acknowledge that for example the results of the quantification of damage might be biases. This bias is the result of the limited numbers of participants that could provide us with an economic estimation of crop damage (n=9); and to the fact that the results are only based on perceived and not verified real damage costs. In the future, we suggest that it will be necessary to further collect more detailed and verified information of real damage costs of crops and fences. Another discussable limitation regarding the selection of questionnaires might be the participatory involvement in the research process. However, as already mentioned in **Chapter 2**, this is much arguable since there are several forms of participation (see table 2.1.). In a participatory process there are many elements involved in the assurance and devolution of the information that has been generated. In the following subsections I will explain elaborate on this matter.

A final limitation PRA approach is related to the integration of the ecological data with the socio-economic information. However, it is important to note that although the approaches might be complementary and help in the management of the conflict, interpolating this data is not easy or necessarily correct. As we explain in **Chapter 5**, in our research we randomly sampled 25% of the total 384 registered landowners in the study area, with the idea of having an adequate representative sample to quantify damages to further elaborate risk maps of conflicts (Karanth *et al.*, 2012). However, this was not possible due to the small sample of participants who could provide an estimated cost of damages (for fences=16, and crops=9). Furthermore, I want to put emphasise on the conceptual and philosophical differences in the social and ecological research and information that is generated. In this sense I take the standpoint of Newing (2010) that it is not a matter of which approach is better, but rather that both social and ecological conservation scientists should understand enough about the different approaches to be able to communicate with one another (Newing, 2010).

6.2. Cross comparison of the results and approaches

The three different methodological participatory approaches that were used in this work, allowed us to compare and integrate different and related social and ecological information that we found with the results from the Delphi Q and PRA methodologies. In Table 6.1, I provide an overview of the methodological approaches and main characteristics as found in this research and to respond to specific objective 6. Note that although each methodological approach dealt with different conservation issues, the results are also interrelated. Methodologically speaking, it could be argued that perceptual information from the Delphi and PRA have nothing to do with discourses. However, here I follow the stances of several authors, mainly Barry and Proops (1999) and Brown (1998) reading discourse analysis biodiversity conservation and sustainability. The authors argue that although between individuals with shared experiences and personal attributes it is possible to associate shared discourses, with highly multi-dimensional concepts such as conservation and sustainability, discourse analysis will not be concerned with an individual's discourses, but rather to reveal the entanglement of different understanding, perceptions and values among the involved actors. In other words, the nature of shared perceptions (Brown, 1998; Barry and Proops, 1999). Accordingly, in this section I will compare and analyse the results of the different approaches. I have grouped a set of recurring variables and information in four main clusters: i) social variables, ii) ecological effects, iii) conservation values, and iv) policy intentions (Figure 6.3.).

6.2.1. Social variables

In this cluster, we can note two recurring social variables (Figure 6.1-i) that were brought up from the Delphi and Q methodology results: 1) The weak governance and institutions in Galapagos, indicated by the Delphi with the drivers (DFED10 and DFED11) and the Q with statements (S16 and S40) that were present in all four discourses. 2) The lack of societal environmental awareness indicated by the Delphi results with the driver (DFED5) and with the Q results with the significantly consented statement (S20, $p > 0.01$). These two variables reflect serious (top-down and bottom-up) problems within the structure of the Galapagos society. In areas where conservation is prioritised, weak governance and institutions might limit community participation and or community benefits (Balint, 2006). Agencies and officials are allowed to take a portion of the revenues from local conservation activities or assert their authority at the expense of the community, which can increase the disputes over the use, access and control of the natural resources (Balint and Mashinya, 2006). Not surprisingly in Galapagos such disputes are well documented, in particular within the fisheries sector during the sea cucumber exploitation during the 2000s (Bremner and Perez, 2002). Nielsen (2012) argues that it is of critical importance at all levels of governance structures, especially at local levels, to be transparent, trustworthy, fair and to allow for participation and creation of an environment that enables the productive use of existing capacities (Nielsen, 2012). However the lack of societal environmental awareness in Galapagos (second recurring social variable) might be a direct consequence of the weak governance and management in Galapagos. Local institutions have not been in the capacity to create the necessary tools to address this important societal issue. Accordingly, we see that these two recurring variables 1) The weak governance and institutions and 2) the lack of societal environmental awareness generate a negative feedback loop that will increase conflicts in conservation. Building and maintaining institutional and interpersonal trust between stakeholders is considered essential, in particular in areas where conservation conflicts occur (Young *et al.*, 2016). However, I recognise that this is not an easy task because of the complexity to understand what shapes a pro-environmental behaviour (Kollmuss and Agyeman, 2002). Particularly, considering the mix of communities that form the Galapagos society (the recent sub-generation of colonists and new people from the mainland) who all have different values, behaviours and attitudes towards the environment. However, this is where we can reconnect to the importance of our findings with the Q methodology, as they also allowed us to determine the variety of views and values –ranging from the intrinsic value of species to the use-values of nature to humans– that exist across the wide range of individuals and organisations in Galapagos (Benitez-Capistros *et al.*, 2016). Having identified such diverse conservation views is an important step to recognise shared problems and to develop shared solutions, which can generate interpersonal and institutional trust among stakeholders and which can potentially connect stakeholders with less and more differences in perceived legitimacy (Young *et al.*, 2016).

6.2.2. Ecological effects

In this cluster, we note already four additional recurring variables that already explain the change from social variables cluster (Figure 6.1-i) to the ecological effects cluster (Figure 6.1-ii). The first variable of recurring information in this cluster is land abandonment, characterised in the pressure compartment of the DPSIR (box II- PE2) and verified with the socio-economic questionnaire and transects method in the rural area with the PRA results. It is important to mention that these matching findings emerged from two research approaches that, although interconnected, were designed and applied independently with separate goals. However, in both cases land abandonment appeared as a clear result. This suggests that land abandonment is a serious issue in Galapagos, not only for the intended agricultural development in the archipelago as explained with our Q results (statement S27), but also, as we demonstrated with the PRA research, for the implications for the migratory routes of Santa Cruz giant tortoises. Moreover, here we can reconnect again with the Delphi-DPSIR results and explain the dynamics from the pressures (box-II PE) to the impacts (box-III EI) compartment and the interaction of impacts: Land abandonment - introduction of species (IS) and biodiversity loss (BL) (Figure 3b). Consecutively, we can confirm through our PRA results, that the abandoned lands exhibiting a proliferation of invasive species such as blackberry (e.g. *Rubus* spp.) become true vegetative barriers for giant tortoises' migration routes from and to the rural area and the National Park. Thus, confirming and illustrating the interaction of impacts (IS-BL) from the Delphi-DPSIR approach (see Figure 6.1-ii).

Introduction of species is recognised as perhaps the major short-term threat to the Galapagos biodiversity (Gonzalez *et al.*, 2008; Guézou *et al.*, 2010). However, our results also highlight the threat of introduced species represent for the local communities as we found with our Q (community discourse 3, S17) and PRA results (see Figure 5.3).

6.2.3. Conservation values

The third cluster of related information belongs to the Q and PRA results and refers to conservation values (Figure 6.1-iii). The prolonged conservation of iconic species, such as giant tortoises in Galapagos shows the potential of iconic species to shape values in favour of conservation (**Chapter 4**). However, as we can see from the PRA results, conservation conflicts between giant tortoises and farmers might not simply fit into the intrinsic or instrumental value towards nature conservation. As we showed with our regression logistic model (Table 5.2), farmers cultivating crops and reporting damages have higher odds of taking actions against giant tortoises, regardless of a farmer's perception towards the iconic species. So, though the value of giant tortoises might be intrinsically recognised at global and local scales, farmers who are interacting more closely with the species would better be categorised as having a relational value towards giant tortoises. Chan *et al.* (2016), argues that relational values are articulated by preferences, principles and virtues associated with relationships, both interpersonal and as articulated by policies and social norms (Chan *et al.*, 2016). This suggests that farmers have reconciled with the problem of giant tortoises damaging their crops with their own solutions by taking actions: using barbed wire fences (indirect actions) and by chasing, displacing and turning tortoises upside down (direct actions). Thus, despite the fact that giant tortoises may cause damage to their crops for which farmers then take actions, farmers also realise the importance of the iconic species as a collective good, and its overall importance for Galapagos society and conservation. This underlines the importance of internalising relational values within the conservation community (scientists, practitioners, policy makers) so that environmental decisions can better account for the social-ecological relationships that yield fulfilling lives for the present and future generations (Chan *et al.*, 2016).

Table 6.1. Overview of the methodological approaches main characteristics and research uses

Methodology	Delphi	Q	PRA
Complementary framework / analysis / method	DPSIR framework	Stakeholder analysis	Transect method
Use for conservation	Characterise complex SES.	Conservation discourses and governance.	Conservation conflicts in farming systems.
Main advantage	Flexible, anonymous, iterative.	Well structured, semi quantitative and qualitative methodology.	Allows complementary social and ecological data generation by using mixed methods.
Drawbacks	Long iterative process for participant, might increase drop-outs in the Delphi rounds.	Data collection, generation and analysis is time consuming and demanding.	Social and ecological data collection is time consuming and demanding. Requires good logistic support and adequate planning.
Guidelines	Yes, Mukherjee *et al.* (2015) describe it for the use in conservation and ecology.	Yes, many guidelines from various social and ecological domains (Watts and Stenner, 2012). Scientific articles are also easily found.	Only in a few in articles and books (Friis-Hansen and Sthapit, 2000; Newing, 2010).
Consensus building	Yes, consensual indicators generation.	Yes, by statements of discourse groups.	Not the goal.
Online tools to collect data	No, but online tools for creating questionnaires exist (i.e. OSUCRE, Monkey Survey).	Yes, Flash Q software.	No, but online free and pay tools exist (e.g. Monkey survey, Quick tap survey).
Use of ecological variables	Yes, but needs to be specified in the expert elicitation process.	Yes, but it is presented in the form of statements for discourse interpretation.	Yes, by data collection from complementary ecological methods.
Use of social variables	Yes, but needs to be specified in the expert elicitation process.	Yes, retrieved from semi-structured interviews and revision of grey and scientific literature.	Yes, by semi-structured interviews and attitudinal and socio-economic questionnaires.
Qualitative, quantitative data	Both, but quantitative data is based on consensus building (>< 80% consensus after n rounds). Data is not generated empirically.	Both, but quantitative data is used to group and generate factors (discourses). Data is not generated empirically.	Both. Data is generated empirically.
Main statistical analysis and tools	Descriptive statistics, consensus building based on quartile deviation rules.	Factor analysis/Principal component analysis (PCA)/chi square/correlations.	Chi square, binomial logistic regression, and density estimates.
Software for data analysis	No.	PQ-method software, Q method package for R software.	Questionnaire data:. R software, SPPSS. Density ecological data: Distance software.
Sample size	Very small (minimum 5).	Small (minimum 15).	Large (minimum 50).
Type of participants	Experts who can come from several stakeholder groups such as: government and NGOs officials, scientists and local communities.	Deliberately selected participants from varied stakeholder (e.g. decision and policy makers, scientists and local communities) reflecting the widest range of opinions of research topic.	Specific stakeholder groups affected or in the area of conflict: mostly farmers and landowners from the rural areas.
Type of participation	Collaboration.	Dialogue.	Consultation.

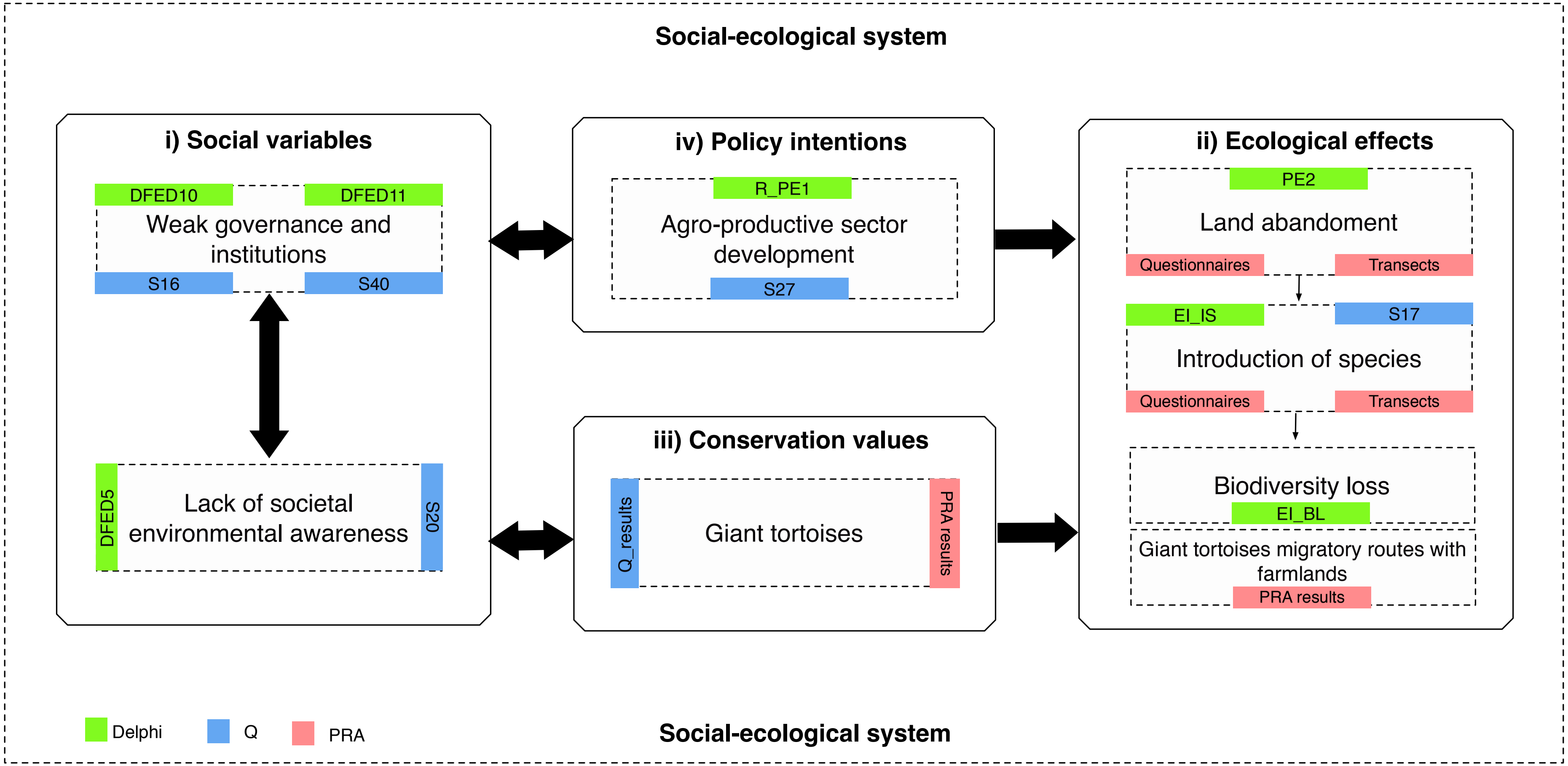

Figure 6.3. Clusters of recurring information as found with the results from the Delphi, Q and PRA methodologies.
The Delphi, Q and PRA results are highlighted in the green, blue and red boxes respectively. Black arrows indicate interconnections between clusters and recurrent variables

6.2.4. Policy intentions

Finally, the fourth cluster of recurring information concerns the policy intentions and recommendations (Figure 6.1-iv). We emphasise the usefulness of the DPSIR framework for studying SES as its social scale is conceptualised for decision makers (Binder *et al.*, 2013), whereby explicit policy strategic decisions, and management alternatives are provided with the responses (R). In our results this was evident in particular with the suggested promotion of an agricultural development in the archipelago (R_PE1 and R_PE2). This same policy and management alternative was also found with the Q results in the multi-actors governance discourse (discourse 1, S27). The promotion of agro-production (S27) was argued to be the solution for avoiding the importation of goods and controlling introduced species. This re-connects with our Delphi-DPSIR results as indicated in the flow from responses (R) box IV, to pressures (PE) box II; and finally to the impacts (EI) box III (Figure 3.2). Moreover, it is important to note that in our Q results, discourse 1, was mostly populated by policy and decision makers (GGC, MAGAP, municipalities and NGOs), which suggests that the promotion of the agro-productive sector is a policy management alternative that is currently on the process of implementation (Guzman and Poma, 2015). However, as we mentioned in our Q results and discussion, this policy still requires being weighted at all social and ecological levels. In particular because we note that although there is a similarity in terms of policy goals (development of agro-productive sector) there is also a difference in the means to achieve the goals. In our Delphi results it was explicitly mentioned that the agricultural development would have to have high ecological standards (PE1), whereas in the Q, only the promotion of the agro-productive sector (S27) is mentioned. The type of participants can explain this difference in emphasis between the perceived means and ends. In the Delphi research the expert participants were mostly associated with conservation whereas in the Q research participants from discourse 1 were mostly decision and policy makers who are not necessarily related to conservation.

Developing ecological and low intensity agriculture and/or wildlife-friendly farming has been proven to contribute to biological diversity (Mander *et al.*, 1999; Green *et al.*, 2005; Gabriel *et al.*, 2013). On the contrary, other forms of agriculture, such as intensive agriculture, have proved to produce negative impacts to humans and the environment. In particular, bio-accumulating pesticides, or the agricultural amendments that pollute aquatic and terrestrial habitats and groundwater (Tilman *et al.*, 2002; Green *et al.*, 2005; Matson and Vitousek, 2006). Thus, we can only expect that the social and ecological effects from an intensive agriculture would be exacerbated in the fragile and space-limited insular ecosystems and affect its endemic wildlife in the rural agricultural areas.

Developing agricultural policies that effectively balance agriculture and biodiversity in the archipelago will be necessary. In this regard, here is where we can reconnect and highlight the importance of our PRA research. As we showed in Chapter 5, our research provides a series of ecological and social data that can well help decision and policy makers to have and to make better and informed decisions for any intended implementation of a new agro-productive sector in the archipelago. Although in our PRA results we emphasise the human-giant tortoises interface, we also highlight that other endemic Galapagos species (i.e. Darwin finches) will have to be included. Our results would ideally complement and contribute to new approaches to farming and conservation such as land sparing, land sharing and wildlife-friendly farming (Green *et al.*, 2005; Fischer *et al.*, 2008; Phalan *et al.*, 2011), which would address the effect of land abandonment, particularly in crucial migratory trajectories.

6.3. Knowledge transfer

S.Obj.4. To provide decision and policy makers with understandable recommendations about the use and application of the different participatory methodologies to address the gaps of knowledge in the complex social-ecological dynamics for conservation science and management.

In conservation science new approaches emphasise the need to include cultural, societal structures and institutions to develop sustainable and resilient interactions between human and nature (Mace, 2014). Similarly, social-ecological system (SES) research aims at integrating the social and ecological aspects of systems to understand their interactions and to design effective sustainability and biodiversity conservation initiatives (Liu *et al.*, 2007; McClanahan *et al.*, 2008). However, as we have argued earlier, understanding such interactions requires the exchange and co-creation of knowledge to promote knowledge transfers between science and decision makers and science and the community. It is in this context that transdisciplinarity and participation allows for the co-production of knowledge, which in turn involves a collaborative process of knowledge co-production that can foster knowledge transfers between science and decision makers and science and the community (Cvitanovic *et al.*, 2015; van der Molen *et al.*, 2015). In this doctoral thesis I have used a transdisciplinary and participatory approach co-produce knowledge by elucidating the links between social and ecological systems through the application of three participatory methodological approaches that are all able to balance social and ecological variables; as well as to provide with sound quantitative and qualitative information. While I acknowledge that participatory approaches to conservation are varied and that the selection of the methods or techniques must rely on the point of departure and on the objective of the research (Friis-Hansen and Sthapit, 2000), the explicit dynamics of the interlinked social and ecological systems require scientifically sound methodologies that are able to provide policy and decision makers with qualitative and quantitative results. In this work, practical solutions have been generated by the co-production of knowledge from a variety of stakeholders and through a participatory process involving the three methodological approaches (Delphi, Q and PRA).

The potential use of these methodologies has not yet been fully explored for conservation science and management. In this thesis I provide a detailed description and use of each methodology and their effectiveness to be applied and to characterise dynamic complex systems, conservation discourses and conservation conflicts (Benitez-Capistros *et al.*, 2014; Benitez-Capistros *et al.*, 2016). The added value of having used these methodologies that are participatory in nature is that they allowed us to engage with different stakeholders, institutions and power structures of the Galapagos society. These involved stakeholders are more likely to be more committed to consider and apply the different results that we found. However, it is important to note that although the degree of involvement and power sharing may vary within each methodological approach, one of the most important elements of an effective transdisciplinary and participatory process is the transparent position and attitude of the researcher to guarantee the correct provision and devolution of the decision making authority to participants (Benham and Daniell, 2016). Therefore, in this section I will present the several elements, which have all allowed us to transfer knowledge during the participatory process. As explained in **Chapter 2,** there are several key elements and typologies (see Table 2.1) that are important to consider while conducting a transdisciplinary and participatory research process. These elements and typologies can clarify the how research process was conducted, the level of participation of each methodological approach and how knowledge transfer was achieved in this doctoral thesis. Inspired the work of Benham and Daniell (2016) I will situate the whole research process and methodologies as depicted Figure 6.4. It is important to clarify that although some research methodologies cannot be classified as highly participative, the following features have allowed us to strengthen the participatory nature of the research process and facilitated knowledge transfer:

1. Addressing real problems and involving stakeholders' concerns and perspectives.

The entire research process and each methodological approach was aligned with key issues of concern by the local community and the reviewed literature:

- Delphi method: lifestyles and education, population and tourism growth, food security, fisheries and introduced species (Hearn *et al.*, 2005; Jiménez-Uzcátegui *et al.*, 2006; Ospina, 2006; Taylor *et al.*, 2006; Zapata, 2006; Guézou *et al.*, 2010).
- Q methodology: giant tortoises, conservation and development, governance, institutions, local communities, contribution of science for the local communities (Tapia *et al.*; Márquez *et al.*, 2004; Blake *et al.*, 2013; Ciccozzi, 2013b; Gibbs *et al.*, 2014).
- PRA approach: giant tortoises and agricultural practices, crop and economic losses and introduced species (Blake *et al.*, 2012; Blake *et al.*, 2013; Blake *et al.*, 2015)

2. Including local knowledge bases on which to construct research questions and validate research findings.

Each methodology facilitated the access to local knowledge to better understand the particularities and realities of the system. For example by collecting information with Q methodology we could identify the knowledge gaps in relation to giant tortoises and farmers. With this information, we formulated research questions and through the information collected by the questionnaires and ecological data under the PRA approach, we could formulate new research questions as well as finding knowledge gaps.

3. Establishing relationships and accessing to key stakeholders.

From the beginning of this doctoral thesis, I established relationships with two important institutions and their involved international and national scientific and administrative staff. First, the Charles Darwin Foundation (CDF), which was the first institution to be contacted and which provided logistic support during the different research stays in the archipelago. Second, the Galapagos National Park which was the institution that reviewed and accepted the project proposal to conduct research in the archipelago. Officially registered under the Project No: PC0-31-4. Besides these two important institutions in the Galapagos context, each methodology also allowed us to establish relationships and access to key stakeholder. Then by the process of the participatory research with each methodology we built more relations:

- The Delphi method though it was conducted on an online environment already allowed us to establish relationships with a few but key actors in Galapagos.
- With the Q methodology we structured the concourse to conduct *viva voce* 54 semi-structured interviews (SSI) with a varied group of key stakeholders (Annex B2). The SSI and later the Q-sorting and post sorting interviews (n=28), allowed us to enrich the relationships of the whole research, as they engendered trust.
- Building on the Q methodological process, with the PRA approach we conducted 18 SSI to several key stakeholders, and then used the two questionnaires to retrieve information from a total of 155 farmers and landowners of the rural area. It might be argued that questionnaires are a too little enriching tool for building relationships (Gross, 2014). However, relationships had already been consolidated. Questionnaires were only conducted at the very end of the research process and always with a 'transparent attitude', with which I mean full information on the purpose of the study, its process and the future use of the information to be obtained.

4. Transmission of results and findings.

While the structure of Delphi method allowed for the most rapid sharing of the results and information (e.g. through the reports after each round), the Q methodology and PRA needed other means to disclose the findings and information. These included the mandatory reports to the GNP and two public seminars (March 2014, June 2015), several presentations of the research findings at the CDF and the Galapagos directorate Ministry of Agriculture (MAGAP). Last but not least, the peer reviewed articles and several presentations at international conferences and congress including: EcoSummit 2012 (USA), SYKE, GTOE, Finnish Environment Institute (SYKE), Flanders Marine Institute (VLIZ), the European conference on Tropical Ecology (GTOE), and International Conference on Island Evolution, Ecology, and Conservation over the past few years. As we can see the whole transdisciplinary and participatory research process in this work counts with many elements to produce and adequate transfer of knowledge so that provision and devolution of the decision-making authority is returned to the involved participants. Although the impact of this work does not guarantee the use and uptake of information by the policy and decision makers, certain elements of this work and its structure might suggest to have a higher potential impact on policy. In a recent study Rose *et al.* (2016) analysed how certain documents in conservation (The Lawton review in the UK) through a series of embedded elements might have a higher impact on policy and integration of results. These element include i) selecting politically salient frames through which to communicate; ii) using clear, accessible language, and; iii) conducting rigorous science using an authoritative team of experts (Rose *et al.*, 2016). The authors however noted that in any case, first a favourable policy window is required, but then that it is necessary to seize on this opportunity to communicate a rigorously argued, persuasive and practical conservation message, or in other words performing an ‘honest advocacy’ or ‘honest brokership’ *sensu* Pielke (2007).

In this doctoral thesis I have not (yet) seized any specific political opportunity to convey the message, but the uptake of information by policy makers might have been guaranteed by several factors and particularities of this work, including: the transdisciplinary and participatory approach, the involvement with varied stakeholders, the several means to transfer knowledge; and finally, certain inherent politically salient themes (Rose *et al.*, 2016) such as: an emblematic conservation figure and conservation success story (giant tortoises), politically salience of economic valuation of nature (Ecosystem Services), localism; and, lastly a clear and accessible language. Certainly, the upcoming collaborative Galapagos project for the managing the conflict with giant tortoises (see Chapter 5, Box 5.1) is a reassuring fact.

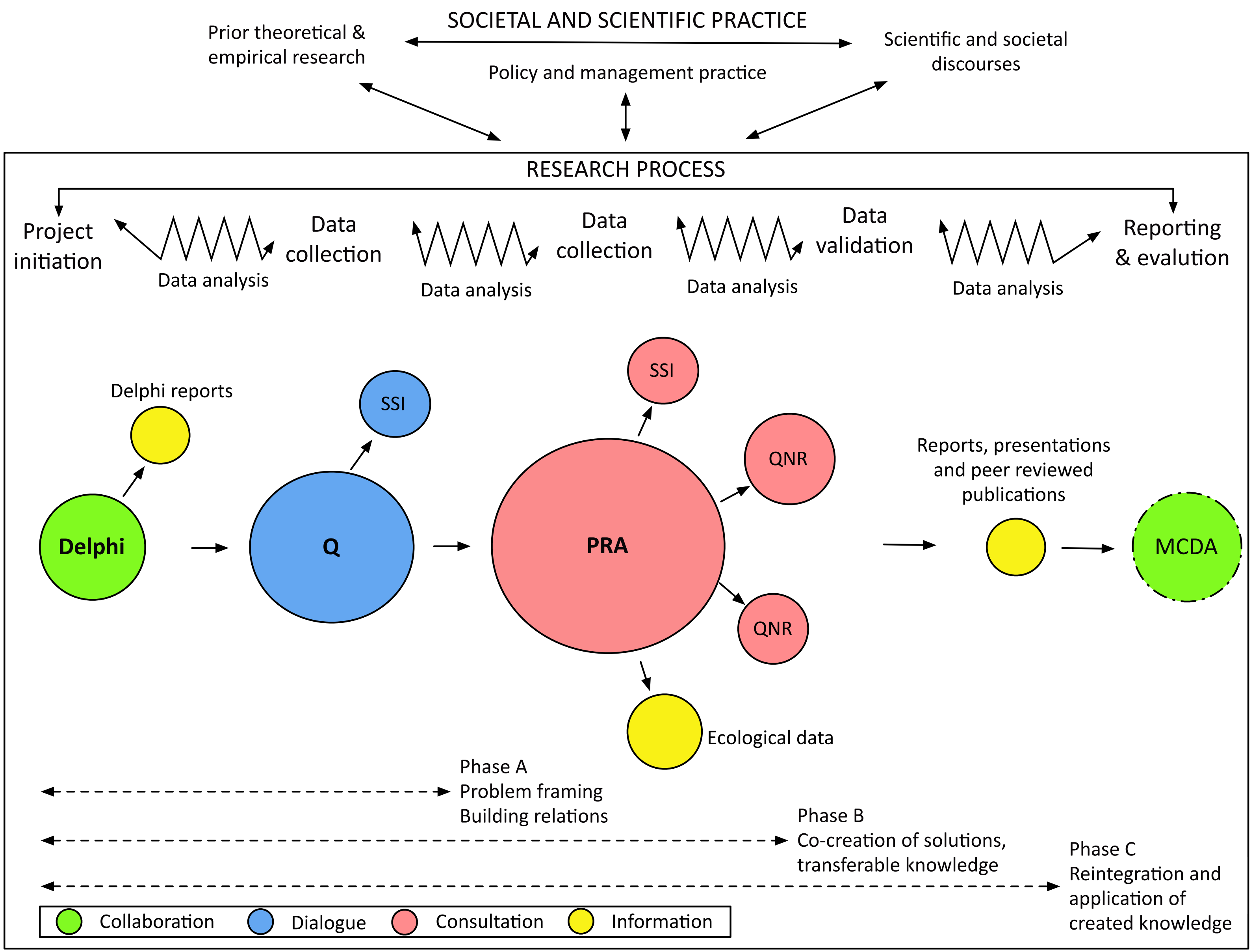

Figure 6.4. Applied transdisciplinary and participatory research process in the Galapagos Islands in this doctoral thesis
The figure illustrates the different phases and methodological methods according to the type of participation (collaborative, dialogue, consultation) and information transmitted. Acronyms are semi-structured interviews (SSI), questionnaires (QNR), and multi-criteria decision analysis (MCDA). MCDA is depicted with cross-lines because it was not applied yet. Figure adapted and modified from: Benham and Daniell (2016)

6.4. Relevance of the research to other conservation SES beyond Galapagos

S.Obj. 5. Understand the Galapagos Islands case in order to provide a system, which can then be used to understand the relevance and applicability of the research to other non-Galapagos social-ecological systems.

Although this thesis is contextually focused on the Galapagos Islands, our research approach and analysis can be applied in other context and settings outside this realm. Certain specific local problems that we identified in this work can relate to other problems outside Galapagos and each methodological approach that we have detailed in this research has the same potential to be used and transferred to other contexts, as we are now demonstrating (Hugé *et al.*, 2016). The characterisation of dynamic complex systems through the combined used of the Delphi-DPSIR allows for detailing and better understanding SES. Here we used the DPSIR framework because of its easy guidance, its ability to find causal relationships between social and ecological compartments, and its implications regarding policy outcomes to mitigate environmental impacts (Svarstad *et al.*, 2008; Binder *et al.*, 2013). However, depending on the purpose and orientation of the research (action or analysis oriented) other SES frameworks could be used. DPSIR is an action oriented framework, but for instance, the Ecosystem Services (ES) (an analysis oriented framework) can be used to assign economic values to the services provided by the natural capital in relation to the services it provides to society (Daily, 1997). At global scale, the ES framework has been used to estimate the economic value of the earth's natural capital (Costanza *et al.*, 1997); and at local scales, it has been used to estimate the annual economic benefit to maintain forests in the watersheds for power services in China (Guo *et al.*, 2000). The Social-Ecological Systems Framework (SESF) that I have detailed in Chapter 1, is also an analysis-oriented framework conceptualised to understand how actors use resources impacting on the ecological system and may cause externalities in the related SES. These externalities feedback on the social system because the productivity of the system changes affecting harvesting rates (Binder *et al.*, 2013). Thus, the SESF has been mostly adapted for local food production systems (Marshall, 2015) and to model fisheries (Biggs *et al.*, 2009; Horan *et al.*, 2011) in which social-ecological interactions between natural resources (e.g. fish, cattle), actors (e.g. fisherman, cattle-owners), and their institutions are strong and intimately coupled (Schlüter *et al.*, 2014). Nevertheless, our joint methodological approach Delphi-DPSIR proves ideal to address general inter-linkages of SES, as well as to group several knowledgeable participants (experts) from different disciplines (social, ecological and transdisciplinary) and reach to consensus, a very difficult but necessary step in conservation conflict resolution (Marshall *et al.*, 2007; Redpath and Thirgood, 2009; White *et al.*, 2009; Young *et al.*, 2010; Kovács *et al.*, 2016) and increasingly needed in SES research (Anderson *et al.*, 2008; Norgaard *et al.*, 2009).

Therefore, the applicability of the Delphi-DPSIR joint approach could be expanded to other systems to find the causal relationships between human activities and environmental impacts. For instance, the approach could be used to help with the mitigation of the known impacts on coral and fish reefs of coastal ecosystems (Hughes *et al.*, 2003; Bellwood *et al.*, 2004; Buchanan *et al.*, 2016; Lewison *et al.*, 2016). Thus, by using the Delphi and selecting a group of expert stakeholders (e.g. scientists, local communities, and decision makers) it would be possible to determine causal SES relationships and find consensual DPSIR indicators. Moreover, it would also be possible to determine how different Driving Forces of Environmental Degradation (DFED) such as tourism and related recreational sub-sectors (e.g. diving, sport fishing) exert numerous Pressures (e.g. harvesting, waste, anchor, gear and boat groundings) on the environment (the coral reefs and the coral reefs communities); and how these in turn generate associated Environmental Impacts (e.g. nutrient cycling, biodiversity loss). Finally, consensus-based policy Responses and management actions would allow for ideal conditions to help in the mitigation process (e.g. regulation sport finishing, law enforcement, ecosystem monitoring).

As I have highlighted along this work, the Delphi is a flexible and rigorous consensus and dissensus methodology suited to address and forming better policies for conservation, which has not yet been fully explored and applied in ecology and conservation science (Mukherjee *et al.*, 2015). In this thesis, I intend to contribute to fill this gap not only with the Delphi but also with the Q and the PRA methodologies. Marshall *et al.* (2007) argue the increasing need in conservation biology and science to use sociological and psychological approaches to understand controversial environmental situations. Successful management actions need to be generated by the co-identification of challenges/issues and by the co-creation of solutions by the involved stakeholders, which means that their views, culture, identity and relationship with the environment need to be acknowledged (Marshall *et al.*, 2007).

Indeed, as indicated earlier, both social sciences and ecological sciences are equally valuable for conservation. The insights of this work however go one-step further. By structuring a transdisciplinary and participatory research process and using strong and structured methodologies to respond to conservation challenges, we were able not only to co-generate knowledge and solutions from the perspectives of different stakeholder groups, but very importantly we have, in a large degree, made sure that the uptake of information by the involved stakeholders (scientists, local communities and policy and decision makers) has been assured. Thus feeling another gap, which corresponds to the integration of research, policy and conservation (Young *et al.*, 2005; Anderson *et al.*, 2008).

6.4.1. Relevance of the research for international policy frameworks and platforms

As indicated in **Chapter 1**, conservation national legislation is influenced by several international agreements and platforms (i.e. CBD, CITES, Paris Climate Agreement, IPCC), and among which I detailed the 2030 Sustainability Agenda and the IPBES Both are closely related to this work and include targets and goals related to the enhancement of human responsibilities and values towards nature, the emphasise in the engagement of a diversity of stakeholders to co-create knowledge and solutions to real world problems (Assembly, 2015a; Díaz *et al.*, 2015). Interestingly, the recently emerged concept of Nature Based Solutions (NBS) is resonating in these international platforms and Agendas such as the IUCN and the European Commission. In fact, the IUCN which has aligned with the 2030 Sustainability Agenda clearly indicates the necessity of adapting of NBS to ensure the effective governance of natural resources of the SDGs (IUCN, 2016). The IUCN has recently proposed to define NBS as "*actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits*." (Cohen-Shacham *et al.*, 2016).

NBS is also re-focusing the conservation and management debate to focus on humans and specifically integrating societal factors such as human well-being and poverty alleviation, socio-economic development, and governance principles (Eggermont *et al.*, 2015). In practice NBS heavily relies on different types of management actions, such as minimal ecosystems interventions, development of sustainable multifunctional ecosystems and intrusive ecosystem managements. Although each of these management actions might potentially led to couple social, economic and environmental challenges, they are all embedded in different societal structures formed by a variety of actors where NBS might not fit into a decision-making structure. This has already been pointed out as one of the barriers of NBS in a recent study (Kabisch *et al.*, 2016). Certainly, this barrier, at the basis is related at the pluralities of views, values and knowledge that different groups of people has about socially constructed realities in particular those involving conservation and sustainability. Thus, as also pointed out by Eggermont *et al.* (2015) NBS will need to ensure stakeholder involvement and participation. In this regard, a transdisciplinary and participatory approach such as the one I used in the doctoral thesis, could well be used to involve stakeholders and co-create knowledge and co-shared solutions to different social-ecological challenges. Furthermore, through the process and by generating relations with key stakeholder, providing means to disclose the resulting information, the impact of a NBS approach could be raised.

Chapter 7

CONCLUSIONS AND PERSPECTIVES

7.1. Conclusions

Research in social-ecological systems proposes a reflection to recognise and integrate these complex challenges throughout inter and transdisciplinary approaches that would allow to guide knowledge generation and knowledge sharing to be accessible across scientific disciplines and the society so that -ideally- practical co-shared solutions aid in the transition to sustainability and biodiversity conservation. However, although it is undisputable that SES research has contributed to bridge the widely detached social and natural sciences into one new ontological approach to science (see Schoon and Van der Leeuw, 2015), there are still several tools and conceptual pathways that are needed to adequately aggregate knowledge. In particular when considering the multidimensional understanding of the sustainability concept (Fischer *et al.*, 2015). I consider it therefore appropriate to present this inter and transdisciplinary doctoral thesis where I have integrated knowledge and three different participatory methodologies (Delphi-Q-PRA) to support the conservation and sustainability of social-ecological systems. In this work I investigated the dynamic inter-linkages and causal relationships of SES that generate environmental impacts and the responses in the form of policy and management actions that are required to mitigate these impacts. I also focused in exploring conservation discourses to explain a range of conservation issues from conflicts, values, and relations of power and how these discourses are related to different conservation governance approaches and conflicts with other species. I finalise by characterising and mapping an emergent conservation conflicts to assess the relationship of several social and ecological inter-linked variables and how these can be used to improve conservation and sustainability strategies.

Since this doctoral thesis is based in the Galapagos Islands as a case to study conservation and sustainability challenges of social-ecological systems, I will mention and specify some particularities of the Galapagos Islands during the following sections.

7.1.1. Dynamic inter-linkages of SES

Dynamics in SES are better understood as the way in which SES change over time. For example how and to what extend social structure change, or how and to what extend social learning plays a role within the ecological system (Binder *et al.*, 2013). I acknowledge that dynamic inter-linkages of SES are not easy to comprehend because of the inherent uncertainties that exist in both social and ecological systems and, as I have mentioned earlier, because it is not possible to oversee all. Nonetheless, as we have demonstrated in **Chapter 3** with the Delphi-DPSIR methodological approach, it is possible to generate an understandable framework that is capable to describe the causal relationships of the interlinked social-ecological systems as well as to relate the findings with the corresponding ecosystem and services of the Galapagos Islands. It is important to reiterate that the Delphi-DPSIR approach could well be applied to other systems such as water bodies (e.g. rivers, lakes), marine (e.g. coral reefs and their communities) and on other insular or terrestrial ecosystems (e.g. rain forest, grassland), as I have exemplified in **Chapter 6**. However, I would suggest two important points to consider before using the Delphi-DPSIR approach:

1. The causal relationships of SES are explained anthropocentrically with the DPSIR framework: Social to ecological (S→E). This means that there needs to be an underlying assumption or evidence that the social system (S) impacts the ecological system (E).
2. The social capital of the system needs to count with recognisable "knowledgeable experts" that can participate in the knowledge exchange and generation process with the Delphi methodology.

In the case that the DPSIR framework is replaced with another SES framework, then other assumptions will have to be generated. For example, if the SESF would be used, then there would be more reciprocity between the social and ecological systems (S↔E). However, it would not be possible to determine the causal relationships of the SES, but rather the feedbacks between the resource conditions (e.g. fish stocks) and the rules determining the harvesting rates of the resource (e.g. fishing quotas). With this I want to emphasise that the combined approach (Delphi-DPSIR) can well be subjected to modification and further uses in other systems, which will depend on the questions and objectives of the research. Therefore, a generic combined approach that involves SES and the use of expert knowledge to retrieve consensus-based indicators would better be outline as Delphi-SES(F). In this regard, regardless of SES framework that could be used in other SES contexts, it is important to note the relevance of the Delphi as a participatory methodology capable of generating views, integrating knowledge of a varied group of stakeholders and to forge consensus and/or explore dissensus in complex, controversial policy conservation settings where conflicts of evidence are common (Marshall *et al.*, 2007; Redpath and Thirgood, 2009; White *et al.*, 2009; Young *et al.*, 2010; Kovács *et al.*, 2016).

7.1.2. Discourse analysis for conservation and sustainability of SES

In **Chapter 4**, we underline the use of the Q methodology to explain a range of conservation issues from conflicts, values, and relations of power in Galapagos. However, although in our research we use iconic species (giant tortoises) as a key element to frame conservation discourses, this does not have to be generalised to other systems where perhaps iconic species are not present. In such cases, it will be best to associate discourse analysis to a known species or ecosystem that is under threat or that is known to provide important societal services (e.g. rivers, mangroves). One of the purposes of discourse analysis for conservation is to understand the different ways in which the relationship between humans and nature is viewed; and how this influences the framing and practice of conservation. In a recent paper that we have just published (Hugé *et al.*, 2016), we used the same methodological approach as in Galapagos, but focusing on the identification of stakeholders discourses regarding the management of the Matang Mangrove Forest Reserve in Malaysia. The results are equally promising and highlight again the use and application of the Q methodology for mapping conservation discourses in other systems where we do not use iconic species.

Furthermore, I want to emphasise the importance of mapping conservation discourses to understand relationships between humans and nature. As detailed in **Chapter 1**, Oelschlaeger (1991) philosophical treatise argues that the current views on nature are a historical reflection of the human character and a significant component of the evolution of human culture. Therefore, only the understanding of the past, at multiple time and space scales will ensure adequate future responses and feedbacks within a defined SES (Hornborg *et al.*, 2007). In Figure 1.4, I illustrate the historical human-nature relationships in the Galapagos Islands and how these have also been shaped/influenced by global historical views on nature and geopolitical events (e.g. resourcist views on nature, industrial revolution, WW II, protectionist conservation). The Galapagos Islands have a leading role in science and conservation, but little is known about its history of human-nature relationships. The common knowledge associates Galapagos with the idea of wilderness and pristine paradise that was spoilt just recently. Reflecting on the current views of the relationships between human and nature through discourse analysis is also a way to reflect on the past and the different historical processes that shape(d) our current/past understanding and connection with nature. This is certainly important to avoid and correct past mistakes so that we can better address future conservation and sustainability challenges.

Besides reflecting the different views and values (expressed in each discourse) that steer conservation, discourse analysis, through Q methodology, also captures the different relations of power which, when exposed, can contribute to bridge those with less and more perceived legitimacy. Therefore, discourses are an instrument and an effect of power, and actors play a role in constituting power through collective actions, which in turn can drive institutional change by framing the way problems are perceived and potential solutions debated (Hajer, 1995). This means that in a SES a particular discourse (e.g. giant tortoise conservation) can influence actors' beliefs and the perceived legitimacy of the rules (e.g. measures to allow migration, acceptance of crop losses). In this regard however, Partelow (2016) explains the beneficial use of the SESF for the assessment of specific system components that are potentially relevant for data collection to analyse SES interactions and sustainability outcomes. The guiding approach of the SESF expands its ability to be a boundary object, and thus allows for methodological pluralism. Therefore, data from multiple sustainability assessment methods, both qualitative and quantitative, can be structured through the SESF (Partelow, 2016). Building on this observation, our results can well be structured and complement the SESF. However, it is important to note that the SESF is based on specific set of rules (e.g. legal rules), and although a certain set of rules might fit a SES, the rule compliance and sustainability of a SES will be highly dependent on whether the rules are perceived as fair and legitimate (Clement, 2013). In this regard the SESF, although it includes a political-economic context and tries to identify the right institutional fit throughout a set of rules, it does not include any variable on discourses and power distribution. Hitherto, few scholars, notably in the field of political ecology, management of common pool resources and SES, have attempted to reconcile the rigour of an institutional analysis framework or the IAD (Figure 1.3) with discourses and power dynamics (Armitage, 2008; Armitage *et al.*, 2010; Clement, 2010; Whaley and Weatherhead, 2014, 2015).

Therefore, I here reconnect with the importance of incorporating sustainability assessment (SA) as an external tier level of analysis connected to the social, economic and political settings (S) of the SESF. Through SA, particular sustainability/conservation discourse(s) will enable and constrain a range of available policy options to solve sustainability and/or conservation challenges. Although, these available policy options might be influenced by a dominant sustainability and/or conservation discourse(s), the actors involved in the SA process can also gradually change the dominant sustainability/conservation discourse due to their involvement, practice and outcomes of the SA (Hugé, 2012). In Figure 7.1, building on the work and suggestions by Clement (2010, 2013), I incorporate SA and discourses analysis as an external analysis tier that is connected to the social, economical and political setting (S) of the SESF, rather than the IAD framework (Clement, 2013). I do however include the IAD framework external variables (‘biophysical conditions’, ‘attributes of the community’ and ‘rules in use’) because these offer a solid theoretical and sufficiently flexible frame to guide and adapt the multiple biophysical, social and cultural contexts (Clement, 2010).

Furthermore, I connected these three variables to ‘discourses’, ‘dominant discourses’ and ‘knowledge’ (Figure 7.1; added variables appear in the grey shaded boxes). These six variables in the (S) tier, will feedback the Focal Action Situations compartment where the Interactions (I) and Outcomes (O) are produced (dotted line in the red coloured box). ‘Actors and collective actions’ interact through ‘power relations’ and determine ‘policy decisions', which are at the same time been influenced by the 'dominant discourse(s)' and discourses of the (S) compartment. This Focal Action Situation synthesises the previously stated idea of the role that actors play in constituting power through collective actions, which in turn produces institutional change by framing the way problems are perceived and potential solutions debated (Figure 7.1; these are indicated with the resulting and reciprocal 'policy decisions', 'evaluation criteria' and 'Outcomes'). By 'Power and Knowledge" as the ultimate 'Outcome' (O), I refer to the process of compliance that this interaction produces and that will allow actors to perceive that specific sustainability/conservation rules are fair and legitimate.

7.1.3. Conservation conflicts

Both the Delphi and Q are participatory methodologies that are able to identify, compile and combine relevant information from various sources, so that the information that is generated is understandable and available for decision and policy makers. However, when baseline information is not available and needs to be empirically generated, a PRA approach is more suited. As I have mentioned in **Chapter 2, 5** and **6** the variety of methods in PRA (i.e. interviews, questionnaires, ranking, paired comparisons) makes it an ideal approach for mapping conservation conflicts because information is co-generated directly with the people who are involved in the conflict.

Moreover, PRA proves ideal to combine local social information and ecological information, which is essential and useful for decision and policy makers to adequately address an manage conservation conflicts. Again, although the conservation conflict case that we illustrate is based on the Galapagos Islands, and the iconic giant tortoises, this does not mean that a similar approach could be used for other context where the 'iconicity' of the species or of the system is inexistent. In fact, PRA is an approach that provides with tools and techniques that are aiming at gaining both general and more in-depth understanding of community knowledge (Friis-Hansen and Sthapit, 2000). Thus, it allows for an increasing process where people are involved in the conservation issue, which in turn increases the interpersonal and inter-institutional trust between stakeholders where conservation conflicts occur (Young *et al.*, 2016). Nevertheless, each methodological approach (Delphi-Q-PRA) has a potential for conservation conflict resolution, although certainly covering different aspects (e.g. consensus building, discourses and power relations, attitudinal studies).

What all share however is their participatory nature that allowed us to approach and work with different societal groups who form, structure and decide how conservation is viewed, understood and practiced. Still, as we emphasise conservation conflicts are varied and complex and are not only centred in the interaction of wildlife species and humans. As Redpath *et al.* (2015) states: 'most conservation conflicts require the understanding of the ecological interactions, the positions, goals, and values and relations of the humans involved, the politics, the history, the legal framework, the local and indigenous knowledge and the ethical arguments to help guide subsequent conflict management'. Integrating all these variables proves difficult and the efforts to combine them are pointing to the argument to pass from an 'evidence-base' conservation to 'evidence-informed' conservation (Adams and Sandbrook, 2013; Rose, 2015). In this regard, I consider that this doctoral thesis, through the transdisciplinary and participatory process has been able to combine and integrate many variables and to generate understandable and transferable knowledge that is useful for all the actors involved in the conflict (scientists, stakeholders, policy and decision makers).

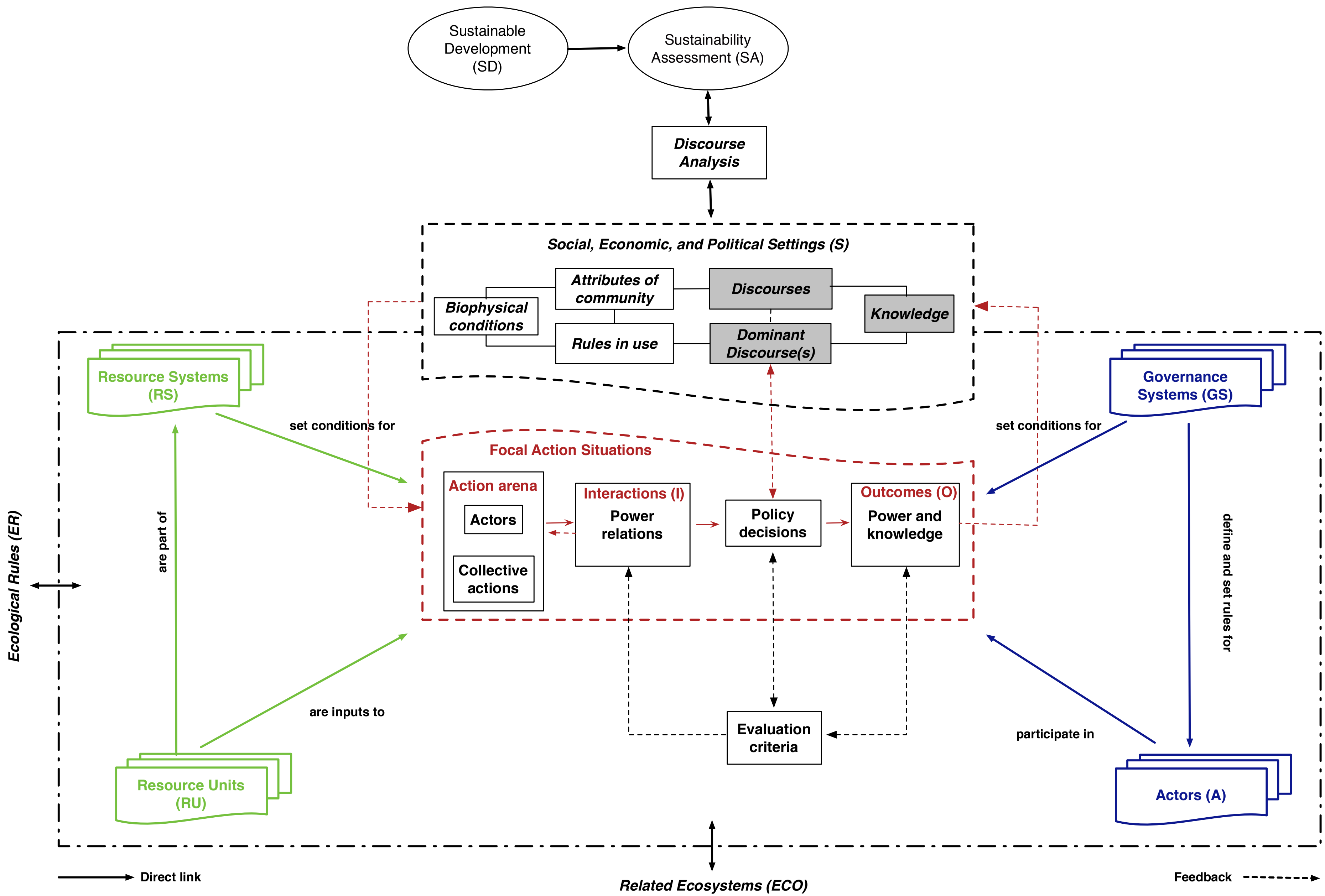

Figure 7.1. Modified social-ecological system framework as an adaption to the Galapagos Islands.
The modified framework adds the missing dimensions of discourses analysis and power.

7.2. Implications and perspectives

Each methodological approach proved adequate to explain and retrieve important SES information, which has particular relevance and use for policy and decision-making processes; thus contributing to reduce the gap between science policy and conservation. While each methodology was used to respond to different research questions, all synthesised or generated up-to-date information concerning biodiversity conservation, ecosystems services and conflicts, whilst always including the varied perspectives from the involved stakeholders (e.g. scientists, decision makers and local communities). Such exchange, co-evolution and joint construction of new knowledge allows to enrich decision-making and/or research because the information that is generated is credible, relevant and legitimate (Sarkki *et al.*, 2013). However, it is important to note that in the realm of a policy and decision-making process there may be a divergence from what is considered as intuitive, trivial or evident information (Sinclair and Ashkanasy, 2005; Sinclair, 2010; Hjørland, 2011). For example, although it is evident that an agricultural development in Galapagos needs to match conservation, this information had to be highlighted and seen together so that the link to scientific evidence was explicit and clear. Making decisions informed by the best available science has become a priority for the management of natural resources and conservation (Segan *et al.*, 2011; Adams and Sandbrook, 2013). It is interesting to note that the potential use of knowledge synthesis methods such as the Delphi and Q methodologies, are being highlighted among the most effective to inform biodiversity policy (Pullin *et al.*, 2016). Yet, hitherto scientific information is not widely incorporated in environmental policy and practice due to the lack of structured frameworks (or scientists) that can channel unbiased synthesis of research findings into decision support systems (Dicks *et al.*, 2014).

This is related to the inherent complexity of understanding a system, for example as we have detailed here with the dynamics of a SES. A single person or stakeholder/decision-maker/scientist cannot behold the entirety of complex systems or let alone its interconnected problems or their solutions. This is not only caused by the complexity of the systems but also because of the bias that each individual has due to background, training. This means that there is a need to combine views and to combine knowledge; but most importantly, as I have presented in this thesis, is also to co-create new knowledge. Combined knowledge should be more than the sum. Through the interaction of views and knowledge, new views/knowledge/solutions should emerge. Therefore, the combined input from different people (e.g. scientists, farmers, and decision-makers) with different backgrounds/disciplines (e.g. farmers, sociologist, and biologists) first helps to delineate problem(s) but in a later stage it is the role of the researcher/scientist to find and provide with novel solutions. I consider that in this trans-disciplinary work, I have analysed the chain of information from the structural bases to the effective implementation (solutions). This has been in part through the process of the research approach (participatory) but also thereafter by the analysis of the SES and the provision of sound solutions that can help in the transition towards sustainability and biodiversity conservation.

Finally, although my research is contextualised for the Galapagos Islands, the leading worldwide image and role in conservation that the archipelago has, allows me to conclude that this research is relevant locally and globally. This has the potential to motivate and generate similar insights for other researchers, practitioners, and decision makers that are facing similar conservation and sustainability challenges. Indeed, the approach, results and insights of this doctoral thesis can well be used to enrich the operationalization of several international conservation policy agendas such as the 2030 Sustainability Agenda, the IPBES and new concepts that deal with similar conservation and sustainability challenges such as Nature Bases Solutions (NBS). Conservation is a multidisciplinary science and practice that needs to embrace several scientific approaches that are able to combine local knowledge, science and policies to produce adequate, persisting and sustainable results. This work is a contribution to bridge this gap as well as to highlight the relevance of the cohesion between different scientific disciplines, scientists and society in general.

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Chapter 8

APPENDICES

APPENDIX A: Delphi methodology

Delphi methodology to study social-ecological dynamics in the Galapagos Islands.

Appendix A1. Characteristics of the Delphi participants per rounds (R1, R2, R3)

		Consecutive Rounds		
		R1	R2	R3
Time lived in the Islands	Less than 1 year	1	1	0
	Between 1 and 4 years	3	1	1
	Between 5 and 9 years	2	2	2
	More than 10 years	4	3	2
Area of Expertise	Conservation/restoration	1	1	1
	Conservation	2	1	1
	Conservation /sustainable development	2	2	1
	Conservation /tourism	1	0	0
	Primary education/ natural sciences	1	1	0
	Resource management/ecology	1	1	1
	Management of research projects Galapagos	1	0	0
	Tourism industry/ diving instructor	1	1	1
Institution	Charles Darwin Foundation (CDF)	2	1	1
	Conservation International (CI)	1	1	1
	Unidad Educativa Tomás de Berlanga	1	1	0
	Autonomous University of Madrid (UAM)	1	1	1
	Scuba Iguana Galapagos	1	1	1
	World Wide Fund (WWF- Galapagos)	1	0	0
	Galapagos National Park (GNP)	2	1	0
	Not affiliated to any institution	1	1	1
Charges	Area coordinators	4	3	2
	Directors and departmental directors	2	1	0
	Educators (professors, teachers & instructors)	3	2	2
	Not mentioned	1	1	1
Total		**10**	**7**	**5**

Appendix A2. Delphi Round 2 (R2) and Round 3 (R3) participant's ratings and descriptives for the DPSIR in the Galapagos Islands.

	Rounds (R2/R3)	Ratings given by each participant							*qi*	*Md*	IQ	(*Q*)
DRIVING FORCES OF ENVIRONMENTAL DEGRADATION (DFED)												
1. Significant increase in tourism and high migration from continental Ecuador to Galapagos.	R2	3	5	4	5	5	4	5	4.43	5	1	0.5
2. Economic growth that increases the consumerism of goods and services, and products for local population and tourists. In particular agricultural products, which bring invasive species that damage natural ecosystems.	R2	4	5	5	4	5	4	5	4.57	5	1	0.5
3. Increase in the number of flights and ships with cargo arriving to the islands	R2	4	4	5	4	5	4	5	4.43	4	1	0.5
4. Increase in the number of cars in the islands.	R2	4	5	5	5	3	4	4	4.29	4	1	0.5
5. Lack of education among locals: Population consciousness of why Galapagos is such a special place a change in life style of insular population is needed since most behave more like in the continent.	R2	5	5	5	5	5	5	5	5.00	5	0	0.0
6. Inappropriate model of development, which makes that some activities to be executed without taking into consideration the ecosystem resilience.	R2	1	1	4	4	3	5	1	2.71	3	3	1.5
	R3	-	-	4	4	1	5	4	3.60	4	0	0.0
7. Erroneous local tourism development (there are more places in ships because there are more ships with bigger capacity and therefore more hotels bring more people).	R2	1	1	2	4	5	4	2	2.71	2	2.5	1.3
	R3	-	-	4	4	1	5	3	3.40	4	1	0.5
8. Tourism monopolisation	R2	1	1	2	4	4	4	2	2.57	2	2.5	1.3
	R3	-	-	3	5	1	5	4	3.60	4	2	1.0
9. Not all tourism activities are well regulated	R2	1	1	2	5	4	4	4	3.00	4	2.5	1.3
	R3	-	-	2	4	1	5	5	3.40	4	3	1.5
10. Limited capacity of institutions to make the present normative or guideline work (weak management caused by lack of political willingness)	R2	4	5	4	4	4	5	5	4.43	4	1	0.5
11. Dysfunctional judicial system.	R2	4	5	4	4	4	5	5	4.43	4	1	0.5
12. (a) and (b) is magnified by local culture of not telling on your neighbour	R2	3	5	3	5	4	5	3	4.00	4	2	1.0
	R3	-	-	3	3	5	5	4	4.00	4	2	1.0
13. Bad government of the population	R2	3	5	4	3	4	3	4	3.71	4	1	0.5
PRESSURES ON THE ENVIRONMENT (PE)												
1. Importation of goods: high risk of introduction of invasive species	R2	5	5	5	4	5	5	5	4.86	5	0	0.0

2. Land clearing for agriculture and land abandonment which brings: Loss of geographic isolation and leads to an increase of introduced species as one of the principal effects	R2	5	5	4	5	5	4	5	4.71	5	0.5	0.3
3. Urban zone extensions bigger pressure towards natural resources due to increase in hotels construction in San Cristobal, Isabela and Santa Cruz and consequent increased energy, drinkable water and stone resources for construction.	R2	5	5	5	5	4	4	5	4.71	5	0.5	0.3
4. Illegal fishing: Sea cucumber fisheries collapse and decline in lobster resources	R2	3	5	4	5	3	4	3	3.86	4	1.5	0.8
	R3	-	-	3	5	4	5	2	3.80	4	2	1.0
RESPONSES												
RESPONSES TO DFED: TOURISM STRATEGIES (R_TS)												
1. To develop an ecological tourism with a lesser impact on the environment.	R2	5	5	5	-	5	2	1	3.83	5	2.2	1.1
	R3	-	5	5	-	2	1	1	2.80	2	4	2.0
2. Define ecotourism products to be commercialised and assure that government entities only promote these products	R2	5	5	5	-	5	5	1	4.33	5	0	0.0
3. Create a regulation plan, which will allow the entrance of	R2	4	5	4	-	5	1	5	4.00	4.	1	0.5
4. Establish a management system of touristic activities in the	R2	4	5	5	-	5	1	5	4.17	5	0.7	0.4
5. To establish maximum annual quotas would be better than the increase of entrance fees.	R2	4	3	5	-	4	1	5	3.67	4	1.5	0.8
	R3	-	5	5	-	1	5	4	4.00	5	1	0.5
6. Stop the tourism growth quotas especially regarding the	R2	4	5	5	-	5	1	5	4.17	5	0.7	0.4
7. Change the touristic packages	R2	2	4	5	-	5	1	3	3.33	3.	2.5	1.3
	R3	-	4	3	-	3	4	4	3.60	4	1	0.5
8. Increase the minimum staying time to 7 days of visit	R2	3	3	5	-	5	1	4	3.50	3.	1.7	0.9
	R3	-	2	5	-	2	4	5	3.60	4	3	1.5
9. Demand the consumption of local products and the usage of biodegradables ones	R2	4	5	5	-	5	1	1	3.50	4.	3.2	1.6
	R3		5	5		1	5	4	4.00	5	1	0.5
10. Certify operations and tourism enterprises which nowadays work in the islands	R2	4	5	5	-	4	1	3	3.67	4	1.5	0.8
	R3		4	5	-	1	3	4	3.40	4	1	0.5
11. Control the material and the process of building of hotels	R2	3	5	5	-	4	1	3	3.50	3.	1.7	0.9
	R3	-	3	5	-	1	5	3	3.40	3	2	1.0
12. Decrease number of planes arrivals and define new visit itineraries	R2	3	4	5	-	5	1	5	3.83	4.	1.7	0.9
	R3	-	3	4	-	1	5	3	3.20	3	1	0.5
RESPONSES TO DFED: POPULATION GROWTH STRATEGIES (R_PS)												
1. Woman sexual education so that they are not dependent	R2	4	4	4	5	4	5	1	3.86	4	0.5	0.3
2. Sexual education: Birth control, family planning	R2	4	5	5	5	5	3	4	4.43	5	1	0.5
3. One child per couple policies	R2	2	5	3	5	3	1	1	2.86	3	2.5	1.3
	R3	-	-	2	3	1	5	2	2.60	2	1	0.5
4. Abortion approval	R2	2	5	3	5	2	1	1	2.71	2	2.5	1.3

	R3	-	-	2	3	1	5	2	2.60	2	1	0.5
5. Demographic integral studies of Galapagos population,	R2	5	5	5	5	5	1	3	4.14	5	1	0.5
6. The strengthening, in capacity building and organisation of local population to improve their chances of being integrated in economical activities.	R2	4	5	4	5	5	5	1	4.14	5	1	0.5
7. Reinforce and be stricter with the migratory restrictions of the present law	R2	1	1	1	4	3	4	5	2.71	3	3	1.5
	R3	-	-	4	1	4	3	2	2.80	3	2	1.0
8. To fasten the approval processes for temporary residents	R2	1	1	1	3	5	5	1	2.43	1	3	1.5
	R3	-	-	4	1	4	5	2	3.20	4	2	1.0
9. Change in laws and regulations to include penalties for those who hire illegal people	R2	1	1	1	3	1	4	3	2.00	1	2	1.0
	R3	-	-	4	1	4	1	2	2.40	2	3	1.5
RESPONSES TO ECONOMIC ALTERNATIVES (R_Ec)	P											
1. Change the development model having tourism as the economic motor of the archipelago but without overcrowding it	R2	4	5	4	4	5	1	5	4.00	4	1	0.5
2. Improve the redistribution of incomes derived from tourism	R2	4	5	4	4	5	1	1	3.43	4	2	1.0
	R3	-	-	4	5	1	3	2	3.00	3	2	1.0
3. Stop foreign investment	R2	5	5	4	3	4	1	3	3.57	4	1.5	0.8
	R3	-	-	4	3	1	3	2	2.60	3	1	0.5
4. Managing the archipelago using the figure of Biosphere Reserve and not as Protected Areas which surround four small populated centres	R2	5	5	4	5	5	1	4	4.14	5	1	0.5
RESPONSES TO SOCIAL ALTERNATIVES (R_So)												
1. Learning to live in a natural environment (e.g. with plants and invertebrates species), embrace concept of novel ecosystems instead of trying to return to pristine state	R2	1	5	5	4	5	5	4	4.14	5	1	0.5
2. Restoration vision: should be one of functional ecosystem maintaining all biodiversity	R2	1	5	5	5	5	5	3	4.14	5	1	0.5
3. Create a new cultural identity on the islands according to the limits the Islands have	R2	1	5	5	5	4	5	5	4.29	5	0.5	0.3
4. A Development based in a growth which values natural resources	R2	4	5	5	5	5	1	3	4.00	5	1.5	0.8
	R3	-	-	5	5	1	5	4	4.00	5	1	0.5
RESPONSES TO PRESSURES ON THE ENVIRONMENT (R_PE)												
1. Develop local agricultural production with high ecological standards to decrease good importation	R2	5	5	5	5	5	1	3	4.14	5	1	0.5
2. To improve the management and control regarding products which need to be imported	R2	3	5	5	4	5	1	4	3.86	4	1.5	0.8
	R3	-	-	5	5	1	4	4	3.80	4	1	0.5
3. Control material used for construction and penalise if laws are breached	R2	4	5	5	5	3	3	3	4.00	4	2	1.0
	R3	-	-	3	5	3	4	1	3.20	3	1	0.5

RESPONSES TO ENVIRONMENTAL IMPACTS (EI)												
1. Strengthen quarantine system to prevent further invasions	R2	5	5	4	3	5	5	5	4.57	5	0.5	0.3
2. Prioritise areas of high biodiversity and concentrate on	R2	4	4	4	3	3	5	5	4.00	4	1	0.5
3. Eradicate large vertebrates when feasible	R2	4	5	5	4	5	4	4	4.43	4	1	0.5
4. Completely forbid dogs and cats in the islands	R2	4	4	4	5	3	4	3	3.86	4	0.5	0.3
5. Economically penalise people who imports animals to the	R2	4	4	4	5	5	5	5	4.57	5	1	0.5
6. Checking and implementing a GMR zoning in accordance to the latest scientific knowledge of itself	R2	3	5	4	5	4	5	4	4.29	4	1	0.5

Appendix A3. Matrix of interaction of environmental impacts in Galapagos from Delphi round 2 and round 3.

Delphi round 2. Matrix of interaction of environmental impacts. Percentage of selected paired impact. Total participants (n=7)									
	Acronym	IS	LBR	LUC	HF	WBO	DWQ	BL	LA
Introduction of species	IS	-							
Loss of biological resources	LBR	0.43	-						
Land use change	LUC	0.43	0.14	-					
Habitat fragmentation	HF	0.29	0.43	0.86	-				
Water basin overexploitation	WBO	0.00	0.00	0.29	0.00	-			
Decrease of water quality	DWQ	0.00	0.00	0.14	0.57	0.57	-		
Biodiversity loss	BL	0.71	0.57	0.29	0.43	0.14	0.14	-	
Landscape alterations	LA	0.57	0.71	0.57	0.00	0.00	0.00	0.29	-

Delphi round 3. Matrix of interaction of impacts of the. Percentage of selected paired impacts. Total participants (n=5)									
	Acronym	IS	LBR	LUC	HF	WBO	DWQ	BL	LA
Introduction of species	IS	-							
Loss of biological resources	LBR	0.40	-						
Land use change	LUC	0.60	0.40	-					
Habitat fragmentation	HF	0.00	0.80	0.60	-				
Water basin overexploitation	WBO	0.00	0.20	0.00	0.00	-			
Decrease of water quality	DWQ	0.00	0.00	0.20	0.00	0.60	-		
Biodiversity loss	BL	0.60	0.20	0.60	0.60	0.00	0.00	-	
Landscape alterations	LA	0.40	0.20	0.40	0,4	0.20	0.00	0.40	-

APPENDIX B: Q methodology

Q methodology to study conservation discourses in the Galapagos Island

Appendix B1. Q methodology data collection process (step by step)

Step and definition	Data collection in the Galapagos Islands, Ecuador

Concourse
The body of information about a research topic
	• Collected throughout:
	  ○ 54 interviews (Table S2) conducted in Spanish (the mother tongue of the researcher and the official langue Galapagos, Ecuador) in the four inhabited Islands;
	  ○ Grey and scientific literature revision (Append B3)
	• After transcribing the interviews and analysing the reviewed literature, a total of 420 statements were gathered.

Q-sample The final and reduced concourse capturing specific issues that could be viewed differently among stakeholders	• A structured approach to reduce the concourse (SARC) from 420 to 60 statements was used. • Six separate dimensions within which opinions about the role of the Galapagos giant tortoise for the conservation and development of the archipelago had been brought up: (i) science-conservation, (ii) conservation-tourism, (iii) tourism-economy, (iv) community involvement, (v) policy and management, (vi) giant tortoise typology/representation • The final 'Q-sample' contained 60 statements selected and were test-piloted with Charles Darwin Foundation staff (academic and linguistic staff, and doctoral students from Galapagos). The wording of some statements was modified to improve clarity (Watts and Stenner,2012).
Q-participants A deliberative selection of participants to reflect the widest range of opinions in order to identify all factors that exist in relation to the topic of research	• Q participants were selected based on the relevance of their viewpoints regarding our research questions (role of giant tortoises in conservation and development in the archipelago) and based on their availability while in the Galapagos Islands. • Having conducted the stakeholder analysis (SAN) and interviews for collecting the concourse made the identification of Q-participants straightforward. • The total number of Q-participants that took part in the research was 28 (n=28). Of these, 20 were selected from the group of 54 interviewees and 8 new participants were selected. These 8 new participants were formerly contacted for the first interviews, but for diverse reasons (e.g. work schedules, outside Galapagos/islands) could not be reached. However, they all accepted the invitation to participate in the Q sort process.
Q- sort Ranked statements of the *Q-sample* according to specific instructions	• Each of the 28 participants was asked to rank each Q-statement in accordance with her/his preferences (agreement or disagreement) over a quasi-normal distribution (-6 to +6) over a pyramidal shape.
Post-sorting interviews Facilitates the interpretation of the identified factors by adding the comments of those individuals whose Q-sorts correlated significantly with the discourse being described	• Upon completion of the Q-sorts, each participant was asked to explain her/his reaction to the statements that they most agree or disagree on, and to particular statement(s) that they wished to discuss. • We audio-recorded the responses and finished by asking demographic information.

Appendix B2. Identified stakeholders in Galapagos and number of interviewees by institution and inhabited island. A stakeholder analysis (SAN) approach was used to identify relevant groups of participants that could capture the spectrum of ideas occurring the four inhabited islands, we. Each interview lasted between 45 to 90 minutes. Interviews were transcribed and used to generate the concourse statements. This approach also allowed identifying relevant Q-participants for the Q-sorting phase of the methodology.

Institution	**Number of interviewees per island**				
	Santa Cruz	San Cristobal	Isabela	Floreana	Total
Ministries					
• *Urban development and livelihood (MIDUVI)*	1				1
• *Agriculture, farming and fisheries (MAGAP)*	1				1
• *Social inclusion (MIES)*	1		1		2
• *Tourism*			1		1
GNP officers		1	2	1	4
Tourism chamber	1				1
Galapagos biosecurity agency (ABG)	1	1	1	1	4
Port captaincy	1	1	1	1	4
Parrish board	1			1	2
NGOs					
• *Conservation International (CI)*	1				1
• *World Wild Fund for Nature (WWF)*	1				1
• *FUNDAR*	1				1
• *Isabela Oceanographic Institute (IOI)*			1		1
Education centres					
• *High school Nacional Galapagos*	1				1
• *High school Amazonas*			1		1
• *High school Ignacio Hernandez*		1			1
• *School Santa Maria*				1	1
• *University San Francisco de Quito (USFQ)*		1			1
Galapagos Governing Council (GGC)		1	1		2
Municipalities	1	1	1		3
Locals					
• *Educator/artist*	1				1
• *Farmers*			4	1	5
• *Independent*	1				1
• *Giant tortoise touristic ranches*	2		1		3
• *Foreign scientist giant tortoise*	1				1
• *Local scientist*	1				1
• *Retired scientist giant tortoise*	1				1
• *Fishermen*			1	1	2
• *Fishermen association*		1			1
• *Tourism guide*			1		1
• *Former park ranger*	1				1
• *Park ranger/Artisan*				1	1
• *Mayor candidate*			1		1
Total of interviewees	**20**	**8**	**18**	**8**	**54**

Appendix B3. Literature revision of grey and scientific literature

Reference	Document type	Journal name or publisher
Kenchington 1989	PRP	Environmental Conservation
Milinkovitch et al. 2004	PRP	Proceedings of the Royal Society of London
Chambers 2006	BK	Oxford University Press
Marquez et al. 2007	PRP	Oryx
Rusello et al. 2007	PRP	Current Biology
Gibbs et al. 2008	PRP	Restoration Ecology
Gibbs et al. 2010	PRP	Biotropica
Blake et al. 2012	PRP	Journal of Biogeography
Blake et al. 2013	PRP	Journal of Animal Ecology
Edwards et al. 2013	PRP	Biological Conservation
Froyd et al. 2014	PRP	Ecology Letters
Hennessy 2013	PRP	Geoforum
Nicholls 2012	PN	Nature news
Cayot 2008	LJ	Galapagos Research
Jiménez-Uzcátegui et al. 2007	LR	Galapagos Report
Atkinson et al. 2008	LR	Galapagos Report
Galapagos Conservancy 2008	LR	Annual Report
Grenier 2010	LR	Galapagos Report
MAE, 2012	WP	Ministry of Environment of Ecuador
Wang 2012	PN	Yalle daily news
Welsh 2012	PN	Life science
Nava 2010	WP	James Nava
El Comercio 2012	WP	El Comercio Peru
El informador 2013	WP	El Informador

Document type: peer reviewed publications (PRP), book (BK) local journals (LJ), local reports (LR), press news (PN), web pages (WP)

Appendix B4. Un-rotated factors with Eigen values (EV) >1

Q-sort	F1	F2	F3	F4	F5	F6	F7	F8	F9
1	0.27	0.50*	0.10	-0.14	0.11	-0.04	-0.37	0.19	-0.05
2	0.39	0.30	-0.09	0.51*	0.01	0.15	-0.08	-0.08	-0.25
3	0.28	0.49	0.16	-0.19	-0.07	0.15	-0.50	-0.08	0.32
4	0.28	-0.05	0.15	0.50	-0.40	-0.12	0.06	-0.41	0.22
5	0.53	-0.14	0.30	-0.39	0.04	-0.19	-0.08	0.13	-0.28
6	0.42	-0.52*	0.14	-0.39	0.18	-0.19	-0.18	-0.16	0.03
7	0.21	0.44	0.48	-0.05	-0.02	-0.11	0.38	0.23	0.09
8	0.49	-0.06	0.13	0.30	0.14	0.45	-0.15	0.16	0.26
9	0.35	-0.05	0.52*	-0.06	0.14	0.29	0.32	0.25	0.21
10	0.51	0.16	0.23	-0.36	0.05	-0.29	-0.03	-0.10	-0.08
11	0.29	0.08	0.62*	0.11	-0.39	0.04	-0.09	0.01	0.14
12	0.57	-0.31	-0.32	-0.03	-0.31	-0.05	0.06	0.29	0.27
13	0.59	-0.35	-0.30	0.23	-0.12	0.34	-0.13	0.07	-0.24
14	0.60	-0.30	0.02	0.01	0.13	-0.32	0.32	-0.01	0.16
15	0.59	-0.23	0.08	-0.12	0.42	0.18	-0.01	-0.28	-0.07
16	0.55	0.27	-0.28	-0.19	-0.30	-0.13	0.21	-0.02	-0.18
17	0.63	0.06	-0.26	0.01	-0.08	0.03	0.19	-0.21	0.08
18	0.13	0.31	0.25	0.36	0.51	0.15	0.24	-0.12	-0.29
19	0.71*	0.13	0.02	0.02	-0.03	-0.10	-0.27	-0.03	-0.24
20	0.40	0.05	0.00	-0.43	-0.22	0.49	0.15	-0.26	0.03

Appendix B4. Un-rotated factors with Eigen values (EV) >1

21	0.34	-0.03	0.27	0.56*	0.01	-0.38	-0.12	-0.06	0.01
22	0.37	0.26	-0.37	-0.14	0.22	0.06	0.03	0.33	0.15
23	0.53	-0.47	0.02	0.24	0.07	0.04	0.07	0.30	-0.12
24	0.60	-0.36	0.09	0.13	-0.20	-0.08	-0.19	0.27	-0.14
25	0.65*	-0.27	-0.06	-0.14	0.22	0.04	0.00	-0.34	0.20
26	0.59	0.41	0.03	-0.13	-0.35	0.14	0.19	-0.04	-0.31
27	0.55	0.33	-0.22	0.18	0.33	-0.15	-0.11	0.01	0.17
28	0.53	0.48	-0.45	0.08	0.08	-0.21	0.13	0.02	0.20
EV	6.60	2.65	2.01	2.01	1.49	1.30	1.19	1.10	1.04
% Var	23.56	9.4	7.18	7.2	5.3	4.7	4.3	3.9	3.7
HRE	**0.46**	**0.26**	**0.32**	**0.29**	0.17	0.22	-0.19	-0.14	0.09

Appendix B5. Parallel analysis takes into account that the first, second and third factors usually are the biggest and calculates EVs that would result from our data set even if all the participants had configured their Q-sorts in an entirely random way (Horn 1965). If the observed EVs exceed the 95th percentile (in this case the forth factor), EVs have less than 5% chance to occur in circumstances where there are, in reality, no factors in our data set (Watts and Stenner 2012). Hereafter, we extracted the first four factors considered that they would best represent an emerging pattern of responses for a particular point of view.

Factor	Actual EV observed	Mean EV for 1000 ramdom data sets	95th percentile EV for 1000 random sets
1	6,60	2,56	2,32
2	2,65	2,29	2,11
3	2,01	2,08	1,92
4	**2,01**	**1,92**	**1,78**
5	1,49	1,19	1,65
6	1,30	1,77	1,54
7	1,19	1,64	1,43
8	1,10	1,52	1,32
9	1,04	1,41	1,23
10	0,98	1,31	1,14

Appendix B6. Varimax rotated factor matrix. * indicates Q-sorts loading with a factor at > ±0.33, significant at a level of *p <0.01*

	Loadings			
Q-sort	F1	F2	F3	F4
1	-0.1243	0.3956	0.4291	0.0245
2	-0.0006	0.4101	-0.0012	0.5840
3	-0.0997	0.3566	0.4877	-0.0076
4	0.1698	-0.0001	0.0054	0.5724*
5	0.5362	0.0587	0.4750	-0.1508
6	0.7121*	-0.1308	0.1596	-0.2558
7	-0.1308	0.0961	0.6377*	0.1859
8	0.3521	0.1340	0.1184	0.4339
9	0.3055	-0.1395	0.5078*	0.1740
10	0.3159	0.2636	0.5357*	-0.1067
11	0.1521	-0.1632	0.5587	0.3505
12	0.6201*	0.3268	-0.1872	0.0138
13	0.6179*	0.2804	-0.2795	0.2651
14	0.6330*	0.1462	0.0731	0.1563
15	0.5988*	0.1490	0.1908	0.0470
16	0.2372	0.6420*	0.1412	-0.0659

17	0.4074	0.5389	0.0229	0.1281
18	-0.1701	0.0862	0.2369	0.4588*
19	0.4212	0.4591	0.2846	0.2319
20	0.3203	0.2751	0.3027	-0.2724
21	0.1844	-0.0268	0.0927	0.6785*
22	0.1078	0.5823*	-0.0091	-0.0982
23	0.6650*	-0.0103	-0.1037	0.3243
24	0.6586*	0.0561	0.0518	0.2704
25	0.6690*	0.2486	0.0916	0.0090
26	0.1695	0.5621	0.4319	0.0913
27	0.1437	0.6106*	0.0814	0.2973
28	0.0384	0.8325*	-0.0002	0.1559
%Variance	17	13	9	8

Appendix B7. Factors Z-scores correlation, % variance explained, number of Q-sorts loading on each factor at *p* <0.01 level.

Z-scores	**F1**	**F2**	**F3**	**F4**	**Variance explained (%)**	**Number of Q-sorts loading**
F1	1. 00	0.30	0.23	0.23	17	8
F2		1.00	0.25	0.18	13	4
F3			1.00	0.21	9	3
F4				1. 00	8	3

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APPENDIX C: PRA approach

APPLICATION OF THE PRA APPROACH TO STUDY CONSERVATION CONFLICTS IN THE GALAPAGOS ISLANDS

Appendix C1. Demographic elements of the interviewees in the SSI and contacted means

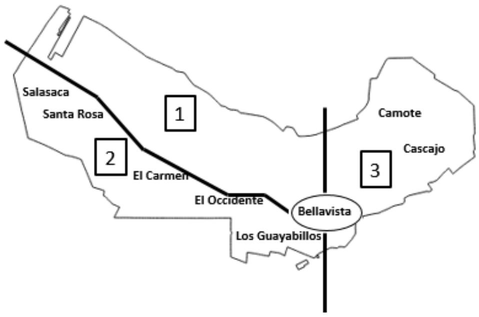
No. Interviewee	Activity	Farm visited	Sex	Contacted through:
1.	Crop cultivation	yes	M	MAGAP
2.	Crop cultivation	yes	M	Market
3.	Coffee plantation and crop cultivation	No	M	Snowball
4.	Small agriculture and cattle rearing	Yes	F	Snowball
5.	Crop cultivation and cattle rearing	No	M	Casual encounter
6.	Coffee plantation	Yes	F	MAGAP
7.	Cattle rearing	Yes	F	Casual encounter
8.	Cattle rearing	Yes	M	Casual encounter
9.	Cattle rearing	No	M	CGG
10.	Cattle rearing	Yes	M	Casual encounter
11.	Tourism	Yes	F	Previous research
12.	Tourism and cattle rearing	Yes	M	Previous research
13.	Tourism	Yes	M	Casual encounter
14.	Tourism, crop cultivation and cattle rearing	Yes	M	MAGAP
15.	Crop cultivation and cattle rearing	No		MAGAP
16.	Ministry of Agriculture	-	F	MAGAP
17.	Ministry of Agriculture	-	F	MAGAP
18.	Galapagos National Park	-	M	-GNP

Appendix C2. First phase questionnaire conducted from May to June 2015

Questionnaire number___________________ **Date: / /201**

Sex: M ☐ F☐

1. **¿En qué área se encuentra el terreno?** *(In which area of the map is your farm located?)*



☐ 1
☐ 2
☐ 3
☐ Otro________________________________

2. **¿El terreno limita con el Parque Nacional?** *(Does the farm border the National Park?)*
☐ SI ☐ NO

3. **Usted es:** *(What is your role in the farm? Worker, owner, other)*
☐ Trabajador
☐ Propietario (pariente de propietario____)
☐ Otro________________________________

4. **¿Usted vive en el terreno?** *(Do you live in the farm?)*
☐ SI ☐ NO

5. **En qué año llego a Santa Cruz?** *(When did you arrive in Santa Cruz?)*
☐ Menos de un ano
☐ Entre 1 y 10 anos
☐ Más de 10 anos
☐ Vivo acá desde siempre

6. **¿Cuántas hectáreas tiene el terreno?** *(Which is the extension of the farm (ha)?)*
☐ Entre 0.1 y 5
☐ Entre 5 y 20
☐ Más de 20
☐ No se

7. **¿Hace cuanto tiene o trabaja en el terreno?** *(Since when you work/own the land of the farm?)*
☐ Menos de un ano
☐ 1-10
☐ Más de 10 anos

8. **¿A qué grupo de edad pertenece? En que año nació?** *(To which age class do you belong? Year of birth?)*
☐ 18-25
☐ 26-50
☐ más de 50

9. **¿A qué se dedica primariamente en su terreno?** *(Which is the main activity conducted in the farm? Sign more than one if necessary)*
☐Ganadería
(Ha____)
☐Agricultura
(Ha____)
☐Café
(Ha____)
☐Madera
(Ha____)
☐Turismo
(Ha____)
☐Nada
☐ Otro______________________________

10. **¿Qué tipo de cerca utiliza para limitar el terreno?** *(Which of the following types of fence do you use to limit your farm?)*
☐ Una, algunas o todas estas técnicas: Porotillo sembrado a menos de 30 cm uno del otro, por lo menos 5 filas de alambre de púa a menos de 5 cm de la tierra, tablas de madera, tablas de madera más alambre púa, rejas, cercos de peregrina.
(Porque?____________________________________)
☐Alambre de púa a una altura de mínimo 50 cm del suelo
☐Nada
☐ Otro______________________________

11. **Se dedica a la agricultura en una parte del terreno?** *(Do you have agriculture in a portion of the farm?)*
☐ SI
(Ha____________________Que:____)
☐ No

12. **¿Qué tipo de cerca utiliza para limitar esta parte de terreno?** *(Which type of fence do you use to limit agriculture, (if you use one)?)*
☐ No tengo agricultura
☐ Una, algunas o todas estas técnicas: Porotillo sembrado a menos de 30 cm uno del otro, por lo menos 5 filas de alambre de púa a menos de 5 cm de la tierra, tablas de madera, tablas de madera más alambre púa, rejas, cercos de peregrina.
(Porque?____________________________________)
☐Alambre de púa a una altura de mínimo 50 cm del suelo
☐Nada
☐ Otro______________________________

13. ¿Tiene cafetal? *(Do you have coffee plantations)*

☐ SI (Ha____________________)
☐ NO

14. ¿Qué tipo de cerca utiliza para limitar esta parte de terreno? *(Which type of fence do you use to limit coffee plantations, (if you use one)?)*

☐ No tengo cafetal
☐ Una, algunas o todas estas técnicas: Porotillo sembrado a menos de 30 cm uno del otro, por lo menos 5 filas de alambre de púa a menos de 5 cm de la tierra, tablas de madera, tablas de madera más alambre púa, rejas, cercos de peregrina.
(Porque?____________________________________)
☐Alambre de púa a una altura de mínimo 50 cm del suelo
☐Nada
☐ Otro______________________________

15. ¿Tiene invernaderos? *(Do you have greenhouses)*

☐ SI (Cuantos?____________________________De que?_________________________)
☐ NO

16. ¿Tiene pozas? *(Do you have water ponds?)*

☐Artificial permanente (Cuantas?_________________________)
☐Natural permanente (Cuantas?__________________________)
☐ Natural efímera (Cuantas?______________________________)
☐No tengo pozas

17. ¿Cuál considera ser la plaga que afecta su producción y como la elimina? *(Which one you consider as a pestilence in your farm? How do you get rid of them?)*

☐Hormigas____
☐Guayaba____
☐Rata____
☐Mora____
☐Tortuga____
☐Sauco____
☐Pinzón____
☐Pasto elefante____
☐Otro____

18. ¿Qué planea hacer con la finca en los próximos 10 años? *(Which are your plans for the far in the next 10 years?)*

☐Seguir en lo mismo
☐Turismo
☐Cultivo
☐Ganadería
☐Vender

☐Comprar más tierra
☐Parcelar/lotizar (con lotes menos de 10 ha)
☐Edificar
☐Patrimonio familiar
☐No se
☐ Otro______________________________

19. **¿Alguna vez vio tortugas en el terreno?** *(Have you ever seen tortoises in the farm?)*
☐SI
☐NO

20. **¿Cuando fue la última vez que vio tortuga en el terreno?** *(When was the last time you saw a tortoise in the farm?)*
☐ Nunca he visto tortugas

21. **¿Cuál es el número máximo de tortugas que entraron en su terreno en un día?** *(Which is the maximum number of tortoises that entered in the farm in one day?)*
☐0
☐Menos de 10
☐Entre 10 y 50
☐Más de 50

22. **¿Cuál es el número mínimo de tortugas que entraron en su terreno en un día?** *(Which is the minimum number of tortoises that entered in the farm in one day?)*
☐0
☐Menos de 10
☐Entre 10 y 50
☐Más de 50

23. **Usted en el terreno ha notado**: *(Did you notice any change in the number of tortoises in the farm?)*
☐Un aumento de las tortugas____
☐Una disminución____
☐Ningún cambio____
☐Nunca he visto tortugas en el terreno____
☐No se

24. **¿Qué hacen las tortugas cuando entran en el terreno?** *(What do tortoises do when they get in the farm?)*
☐Pasan, comen y destruyen (Que?________________________________
Cuál es el número máximo de tortugas que puede/podría soportar en su terreno?____)
☐Pasan, comen pero no destruyen
☐No entran (Porque____)
☐No se
☐Otro___________________________

25. **Usted, cuando las tortugas entran en el terreno:** *(Which actions towards tortoises do you*

undertake when they are in the farm?)
☐Les viran
☐Las echan
☐Las desplazan
☐Las dejan
☐Llaman al Parque Nacional/otra institución(_____________________________________)
☐Les dan comida/agua
☐La admiran
☐No entran tortugas
☐ No se
☐Otro____________________________

26. **Que usted sepa cuando las tortugas entran en los terrenos, que hacen las otras personas?** *(Do you know which actions towards tortoises are undertaken by other farmers when tortoises get in their farm?)*
☐Les viran
☐Las echan
☐Les dan comida/agua
☐Las desplazan
☐Las comen
☐Las matan
☐Llaman al Parque Nacional/ otra
institución(____)
☐ Las dejan
☐La admiran
☐No se
☐Otro____________________________

27. **Las tortugas en el área rural son***: (Tortoises in the rural area are:)*
☐Una plaga
☐Una molestia
☐Unas mascotas
☐Parte del paisaje
☐Un recurso económico
☐Las representantes de nuestra identidad
☐Las dueñas de la isla
☐No se
☐Otro____________________________

28. **Usted considera las tortugas en el área rural un problema?** *(Do you consider tortoises as an issue when in the rural area?*
☐ Si
☐ No
☐ No se

29. **Quiere tener tortugas en su terreno?** *(Would you like to have tortoises visiting your farm?)*
☐SI
(Cuantas?__________________________Porque___________________________________)

☐NO
☐No se

30. Las tortugas tendrían que estar: *(Where do you think tortoises are supposed to stay?)*
☐En el parque nacional
☐En corrales
☐En el área rural
☐En las fincas turística
☐Por toda la isla
☐No se
☐Otro____________________________

31. Alguna vez se fue a ver tortugas de visita o turismo? *(Have you ever been to see tortoises in a touristic farm or in a park pen? If yes, where and when?)*
☐ SI (Cuando la ultima vez?_____________________En donde?________________)
☐ NO

32. A quien acude si necesita suporte con la presencia de tortugas en su terreno? *(Who do you ask for support if you find tortoises in your farm?)*
☐Nunca tuve tortugas en el terreno
☐Instituciones públicas locales (☐PNG ☐juntas parroquiales ☐municipios ☐Otro_________________)
☐Instituciones gubernamentales (☐MAGAP ☐Ministerio de turismo ☐Ministerio del Ambiente ☐Otro________________)
☐Organizaciones no-gubernamentales (☐FCD ☐WWF ☐Conservation Internacional ☐Otro_______)
☐Personas de la comunidad/amigos
☐No acudo a nadie
☐No necesito soporte
☐Otros____

33. Quien se tiene que encargar del manejo de las tortugas en el área rural? *(Who should be in charge of tortoises' management in the rural area?)*
☐El parque
☐Los propietarios
☐La junta parroquial
☐Las comunidades locales. Cuales?____
☐No se
☐Otro____________________________

34. Alguna vez vio tortugas en dificultad (patas arriba, enredada en alambre, heridas)? *(Have you ever seen tortoises in trouble (*upside down*, trapped in the barbed wire, wounded)?)*
☐Patas arriba
☐Enredada en alambre
☐Herida (Como?____)
☐Nunca he visto tortuga en dificultad
☐Otro____________________________

35. **Si ve/o si viera tortugas en dificultad (patas arriba, enredada en alambre, heridas) que hizo/que haría?** *(what did you do/what would you do when you saw/see a tortoise in trouble?)*
☐La ayudo
☐La dejo y no la toco
☐Llamo al PNG
☐Llamo a un veterinario
☐Otro___________________________

36. **Según usted las tortugas de Santa Cruz están en peligro de extinción?** *(Do you think that Santa Cruz giant tortoises are facing a risk of extinction?)*
☐ SI (Porque/cuáles son las amenazas para la conservación de las tortugas gigantes? Como invertiría usted?____)
☐ No
☐ No se

37. **Si fuera necesario por la conservación de las tortugas seria usted dispuesto a dejar corredores para el paso de las tortugas?** *(If it will be necessary for tortoises' conservation, would you allow giant tortoises to pass through your farm?)*
☐Ya lo hago
☐No
☐Si
☐No se
☐Otro____

38. **La isla de Santa Cruz necesita inversión en temas de conservación de la naturaleza?** *(Do Santa Cruz Island needs more investment in conservation?)*
☐ SI (Según usted cuales son las prioridades?___________Porque?__________________)
☐ No
☐ No se

Comentarios *(Comments)*

Table C3. *Second phase: Socio-economic questionnaire* (adapted and modified from Osborn, 2002; Niyrenda et al., 2013)

Sector:	Forma No.
Nombre y apellido:	Numero de Teléfono
Sexo:	
Edad:	
Nombre de la UPA:	
Cargo en la UPA:	
Coordinadas de GPS:	
Altura del cercado por tipo de producción:	

	Preguntas en español	Questions in english
	I. Pérdidas percibidas, incluyendo las valuaciones contingentes de disposición a pagar (DAP) y la disposición a aceptar (DAA)	***I. Perceived losses, including willingness to pay (WTP) and willingness to act (WTA) contingent valuation***
1	¿Cuál es su actividad económica primaria?	*What is your main economic activity?*
2	La UPA es primariamente:	*The land is primary for?*
	Ganadera, turismo, agrícola, mixta	*Cattle rearing, tourism, crop cultivation, mixed*
	¿Para qué usa los productos de la upa?	*What do you use the products for?*
3	¿La UPA bordea con el Parque?	*Does the land borders with the park?*
4	¿Cuántas hectáreas tiene la UPA?	*How many ha does it have?*
5	¿Entran tortugas en su UPA?	*Do tortoises enter the land?*
6	¿Causan algún daño?	*Do tortoises cause damage?*
7	¿Cuándo (en qué mes(es), temporada) fue la última vez que tuvo daños y a qué?	*When (months, season) was the last time you had damage and to what?*
8	¿Para qué hubiese usado el “producto” dañado? (venta, consumo, vacas, protección)	*What would the damaged product have been used for??*
	II. Para cercas	***II. To fences***
1	¿Estime los metros de cercas que necesita en sus campos para evitar daños por las tortugas?	*Estimate the meters of fences you need in your fields to avoid damage by tortoises?*

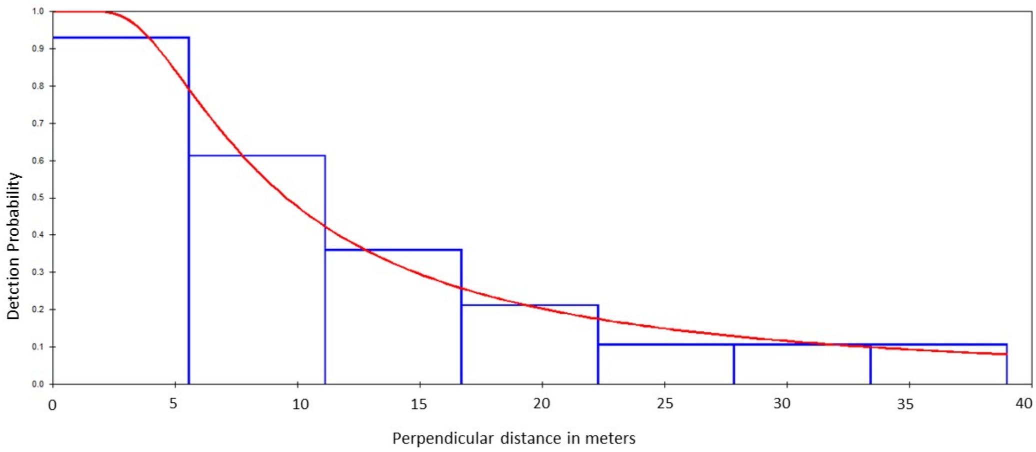
2	Sí previamente sufrió de danos a sus cercas, cuanto fue el daño en (metros) y términos monetarios (dólares-USD) por campo?	*If you previously suffered from damage to fences, how much was damage in (mts) and monetary terms (USD) per field?*
	III. Para las tierras con cultivos	***III. For lands with crops***
1	Estime el tamaño de sus terrenos/campos dañados:	*Estimate the average size (in m²) of your fields:*
2	De estas últimas perdidas en sus terrenos dañados por las tortugas, ¿Cuánto perdió por la invasión de las tortugas en área (m²) y términos monetarias (dólares-USD)?	*If you previously suffered loss from crop damage, how much did you lose to crop raiding in area (m²) and monetary terms (USD) per crop type?*
3	Daños a los cultivos ¿Cuál fue el cultivo, daño, calidad del cultivo y edad/etapa de crecimiento del cultivo?	*Crop damages* *What was the crop, damage, quality of the crop and age/growth stage of the crop?*
	Categoría del daño 1=<5% 2=6-10% 3=11-20% 4=21-50% 5=51-80% 6=>80%	*Damage category*

Español	Daño	Calidad antes del daño				Edad del cultivo		
Cultivo	Tipo	BUENO	MEDIO	MALO		Plántula	Intermedio	Maduro
Cultivo 1	..							
Cultivo 2	..							
Cultivo 3	..							
Cultivo 4……	..							

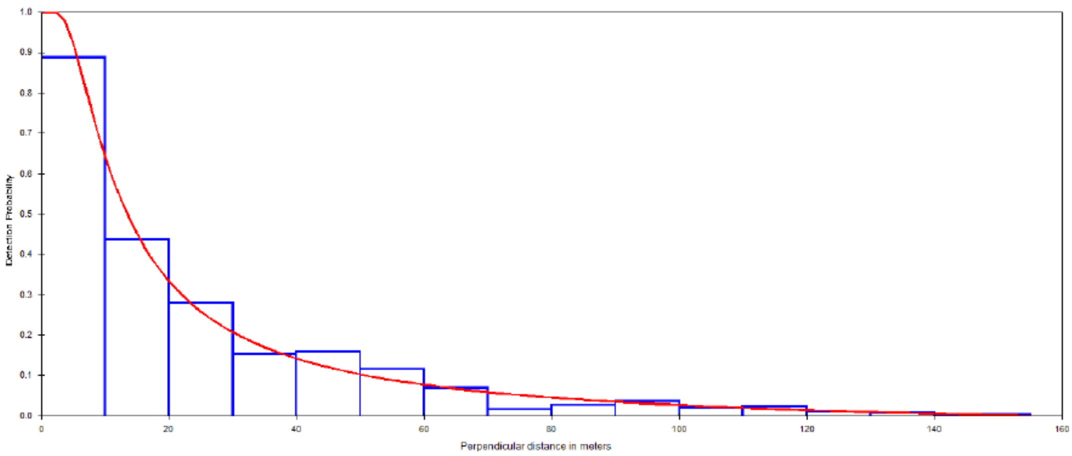
English	*Damage*	*Quality before damage*				*Crop age*		
Crop	*Type*	*GOOD*	*MEDIUM*	*POOR*		*Seedling*	*Intermediate*	*Mature*
Crop1	..							
Crop2	..							
Crop3	..							
Crop4	..							
Crop…..	..							

4	¿Cómo compensó las pérdidas?	*How did you make up for the loss?*
5	¿Cuál es la mejor precio al cual hubiese podido vender sus cultivos?	*Which is the greatest opportunity cost for your growing crops?*
6	¿Cuánto hubiese ganado en la última temporada si hubiese cultivado algo diferente y menos vulnerable a la invasión de las tortugas? (Existe esto?)	*How much would you have gained in the last farming season if you cultivated a different and less vulnerable crop type to invading by tortoises (does it exist?)*
7	¿Qué medidas utiliza para que las tortugas no entren en su terreno? ¿Éstas medidas son sólo para tortugas?	*What meassures do you use to avoid tortoises entering your land? Are these measures only for tortoises?*
8	¿Cuánto invierte para estas medidas en tiempo y dinero?	*How much do you invest in these measure both in time and money?*
9	¿Cuánto estaría dispuesto a pagar para que las tortugas no entren en su terreno?	*How much would you be willing to pay to improve protection against crop raiding?*
IV.	**Cercas dañadas en el ultimo año**	***IV. Damaged fences in the last year***
1	En que mes(es) durante el último año tuvo de daños en sus cercas por las tortugas? (inferida en P7)	*Which month(s) during the last year, did you suffer from fence damage by tortoises?*
2	¿Estime los metros de cercas que necesita en sus campos para evitar daños por las tortugas?	*Estimate the meters of fences you need in your fields to avoid damage by tortoises?*
3	Sí previamente sufrió de danos a sus cercas, cuanto fue el daño en (metros) y términos monetarios (dólares-USD) por campo?	*If you previously suffered from damage to fences, how much was damaged in(m) and monetary terms (USD) per field?*
V.	**Alternativas y perspectivas locales**	***V. Local alternatives and perspectives***
	¿Qué sugiere debería hacerse para evitar que las tortugas le causen daños?	*What do you suggest that must be done to alleviate or reduce crop raiding?*

Appendix C4. Documented damaged crops. **a)** Farmer 1 reporting possible entrance of giant tortoises to his farmland; **b)** giant tortoise in corn crop field; **c)** damaged corn at an intermediate stage; **d)** farmer 2 showing damages by giant tortoises to pineapple crops; **e)** mature pineapple crop eaten by giant tortoises. Photographs by F. Benitez-Capistros, November, 2015.



Appendix C5. First transect campaign. Distance detection function truncated at 39 meter, fitted with the hazard-rate function with a cosine series extension adjustment (model chosen based on the comparison of the AIC values).



Appendix C6. Second transect campaign. Distance detection function truncated at 155 meter, fitted with the hazard-rate function coupled with the hermite polynomial adjustment (model chosen based on the comparison of the AIC values).

- Chapters' illustrations -

Chapter 1 illustration: Marine iguana *Amblyrhynchus cristatus hassi* walking in the main street of Puerto Ayora, Santa Cruz Island, Galapagos. **Photography from:** Francisco Benitez-Capistros ©

Chapter 2 illustration: Sunset landscape in Las Tintoreas, Isabela Island, Galapagos. Photography from**:** Francisco Benitez-Capistros ©

Chapter 3 illustration: Abandoned ship and people bathing on the shore of Puerto Baquerizo Moreno, San Cristobal Island, Galapagos. **Photography from:** Francisco Benitez-Capistros ©

Chapter 4 illustration: *Chelonoidis nigrita* refreshing in a pond from a touristic farm in Santa Cruz Island, Galapagos. **Photography from:** Francisco Benitez-Capistros ©

Chapter 5 illustration: Face to face *Chelonoidis nigrita* and cow in a cattle farm in Santa Cruz Island, Galapagos. **Photography from:** Francisco Benitez-Capistros ©

Chapter 6 illustration: Marine iguana *Amblyrhynchus cristatus hassi* swimming in Las Grietas, Santa Cruz Island, Galapagos. **Photography from:** Francisco Benitez-Capistros ©

Chapter 7 illustration: Marine iguana *Amblyrhynchus cristatus alnemarlensis* resting in the sun in Crossman, Isabela Island, Galapagos. **Photography from:** Francisco Benitez-Capistros ©

Chapter 8 illustration: Cactus finch *Geospiza scandens* foraging on the flowers and seeds of an prickly pear cactus *Opuntia* spp. Santa Cruz Island, Galapagos. **Photography from:** Francisco Benitez-Capistros ©

- Back cover illustration from: Francisco Benitez-Capistros ©
Chelonoidis nigrita eating and walking along one of the roads of the rural area of Santa Cruz Island, Galapagos.

Sustainability and biodiversity conservation are inherently related concepts but there are practical differences in their conceptualisation, interpretation and implementation. The premise of this doctoral thesis is based on the idea that to achieve sustainability, biodiversity conservation needs to be integrated with development considerations to ensure that the best practices to conserve biodiversity can benefit both nature and humans.

Conservation and sustainability challenges are studied and contextualised in the Galapagos Islands, where the links between social and ecological systems are identified through the application of three participatory methodological approaches: The Delphi methodology, Q methodology and the Participatory Rural Appraisal (PRA). Relevant and legitimate knowledge was exchanged and jointly constructed based on the interacting perspectives of a variety of stakeholders (e.g. scientists, decision-makers and local communities). Different key components of conservation science emerged, including the dynamic inter-linkages of social ecological systems, consensus building, conservation discourses, power relations and conservation conflicts. The generated scientific knowledge adequately integrates social and ecological variables, and is of particular relevance and use for policy and decision-making processes.

New scientific approaches that combine local knowledge, science and policies to produce adequate, persisting and sustainable results are urgent to achieve an adequate transition towards sustainability and biodiversity conservation. This work is a contribution to bridge the gap between different natural and social sciences, methods, science and policies, and scientists and the society in general.

Back cover illustration from: Francisco Benitez-Capistros ©
Chelonoidis nigrita eating and walking along one of the roads of the rural area of Santa Cruz Island, Galapagos.