Protected Planet National Technical Series: Republic of Korea

국립공원관리공단
KOREA NATIONAL PARK SERVICE
UNEP
protected planet
IUCN
WCPA
WORLD COMMISSION ON PROTECTED AREAS

Protected Planet National Technical Series: Republic of Korea

Protected Planet National Technical Series: Republic of Korea

Authors

Juffe Bignoli, D.[1], Deguignet, M[1]., Park[2], S., Heo[2], H.Y., Kim[2], S.G., Smith R.J[3], MacSharry, B.[1], and Kingston, N.[1].

Citation

UNEP-WCMC and Korea National Park Service (2016). Protected Planet National Technical Series: Republic of Korea. UNEP-WCMC: Cambridge, UK.

[1] UNEP World Conservation Monitoring Centre.
[2] Korea National Park Service.
[3] University of Kent, DICE.

UNEP WCMC

UNEP World Conservation Monitoring Centre (UNEP-WCMC)
219 Huntingdon Road,
Cambridge CB3 0DL, UK
Tel: +44 1223 277314
www.unep-wcmc.org

Acknowledgements

We are grateful for the advice and reviews provided by Neil Burgess and Heather Bingham (UNEP-WCMC), Peter Shadie and Scott Perkin (IUCN). We would also like to thank Bo-Hwan PARK (Korea National Park Service; KNPS), Chong Chun KIM (KNPS), Yong Sang JUNG (KNPS), Myeong Gyu HWANG (KNPS), Jong-Koan CHOI (KNPS), In Young CHOI (KNPS), Han Jin KIM (KNPS), Byeong-Hyeok YU (KNPS), Seon Du KIM (KNPS), Eunjeong KWON (Korea Protected Areas Forum and KNPS), Young-Wook CHO (Ministry of Environment; MoE), Jong-Cheol KIM (MoE), Sang-Kyun MOON (MoE), Tae Cheol JANG (Korea Marine Environment Management Corporation), Jung Hwa CHUN (Korea Forest Research Institute), Tae Joon JUNG (National Institute of Ecology), Won-Ho LEE (National Research Institute of Cultural Heritage), Jang-Bang JEONG (KNPS), Uk-Young KWON (UNESCO MAB National Committee of the Republic of Korea).

Photo credits

All pictures in this report were provided by and are property of the Korea National Park Service (KNPS)

Contents

Executive Summary

The Protected Planet National Technical Series is a new concept under the Protected Planet Report initiative which aims to support decisions on protected area expansion at the national scale by assessing progress towards global biodiversity targets, while also aiming to inform implementation of national targets. Therefore, the use of national biodiversity and land use datasets and the direct involvement of national protected area agencies in the inception, development and writing of the report is a fundamental part of the process.

This first Protected Planet National Technical Series focuses on the Republic of Korea and was completed working closely with the Korea National Park Service (KNPS).

AIM AND SCOPE

The aim of the report is to assess the status of the protected area network of the Republic of Korea and propose priorities for expansion to support the implementation of international and national biodiversity targets.

The geographic scope of this project is the Republic of Korea terrestrial territory, and territorial seas (from the coast to 12 nautical miles from the Korean shoreline).

The Protected Planet National Technical Series is a desktop based analysis that ends with a spatial prioritisation, the results of which can help to inform further decisions on protected area expansion at the national level. These results may be used by the relevant Korean agencies to inform such processes and ultimately to build consensus on actions to improve biodiversity protection in the Republic of Korea. In addition, the approach taken in this report may be replicated by other country agencies.

METHODS

The Systematic Conservation Planning (SCP) framework was followed to design the analysis. Its goal is to develop cost effective networks of protected areas that represent and maintain biodiversity. This project used the decision support tool Marxan and one of its user interfaces, CLUZ, to select additional conservation areas that met (KBAs) conservation targets. These targets were developed in close collaboration with KNPS and methods and results were discussed in a workshop in Seoul, Korea. The project was implemented through three main activities: 1) data collection; 2) assessment of the current coverage of Korea's protected areas network through a gap analyses; and 3) proposal of areas for expansion based on a target based spatial prioritisation analysis.

KEY MESSAGES

- The results of the terrestrial selected scenarios show that, depending on the target scenario, an area between 17.3% and 46.4% of Korea's total terrestrial and inland water areas is needed to meet the set of pre-defined conservation targets while ensuring ecological representation of sites and features important for biodiversity.
- At the time when this report was prepared there was not enough high resolution data to conduct a thorough analysis for the expansion of the protected area network in coastal areas. A preliminary solution that covers 10 % of this area is however proposed with the data available.
- The analyses proposes solutions for expanding the boundaries of Korea's current terrestrial protected area network improving the representation of biodiversity, covering important sites while enhancing connectivity, generally avoiding high levels of agricultural activities and areas of high human population density.
- This report has highlighted areas where the presence of globally threatened species has been confirmed and identified areas of high selection frequency. Some of these areas are not within designated protected areas or existing Key Biodiversity Areas. These areas need further assessment and could be candidates for new Key Biodiversity Areas under the KBA standard approved by IUCN Council in 2016.
- In addition to expanding the protected area network to ensure adequate representation of biodiversity, there are many other attributes that are crucial to achieving a well-functioning network, that were not considered in this analyses for example, effective management, connectivity between protected areas, equity and consideration of the contribution of other effective area based conservation measures to the meeting biodiversity targets.
- While the results presented here can inform future steps and decisions on how to meet national and international conservation targets, a wider stakeholder consultation is needed to prioritise conservation actions and test further alternatives for protected area expansion. Implementation, monitoring and evaluation of actions will be a crucial step in completing a full conservation planning process.

1. Introduction

The Protected Planet Report was originally conceived as an assessment of progress towards global targets for protected areas (Bertzky et al., 2012, Juffe-Bignoli et al., 2014a) and since its inception has focused principally on assessing the status of implementation of the global Aichi Biodiversity Target 11, one of the 20 global biodiversity targets agreed by 193 countries in 2010 as part of the Strategic Plan for Biodiversity 2010-2020 (CBD, 2010). In 2014, following recommendations from the first Asia Parks Congress (IUCN, 2014), the Asia Protected Planet Report was released. The aim was to assess progress towards the achievement of Aichi Biodiversity Target 11 at a regional level by focusing on 24 Asian countries (Juffe-Bignoli et al., 2014b).

In addition to the Aichi Biodiversity Targets, most countries have their own national biodiversity targets which may or may not be aligned with the global Targets. Although the CBD recommends that national and global biodiversity strategies and actions plans are aligned, some countries chose to develop national targets that are stricter than the global ones, and focus on addressing specific national issues, or other international obligations.

The Protected Planet National Technical Series is a new concept under the Protected Planet Report initiative which aims to support decisions on protected area expansion at the national scale by assessing progress towards global biodiversity targets, while also informing implementation of national targets. Thus, the use of national biodiversity and land use datasets and the direct involvement of national protected area agencies in the inception, development and key messages of the report is a fundamental part of the process.

1.1. AIM AND SCOPE

This first Protected Planet National Technical Series focuses on the protected area network of the Republic of Korea and has been developed in close collaboration with the Korea National Park Service (KNPS).

The aim of the report is to assess the status of the protected area network of the Republic of Korea (also referred to as Korea in this report) and propose priorities for expansion to support the implementation of international and national biodiversity targets. This includes, but is not restricted to Aichi Biodiversity Target 11 of the Convention on Biological Diversity and relevant national biodiversity targets.

The geographical scope of this project is the Republic of Korea terrestrial territory, and territorial seas which span from the coast to 12 nautical miles from the Korean shoreline (Figure 1.1). Marine areas beyond 12 nautical miles were not considered because of the lack of appropriate high resolution marine biodiversity data in such areas (see Section 3.1.1 for more information).

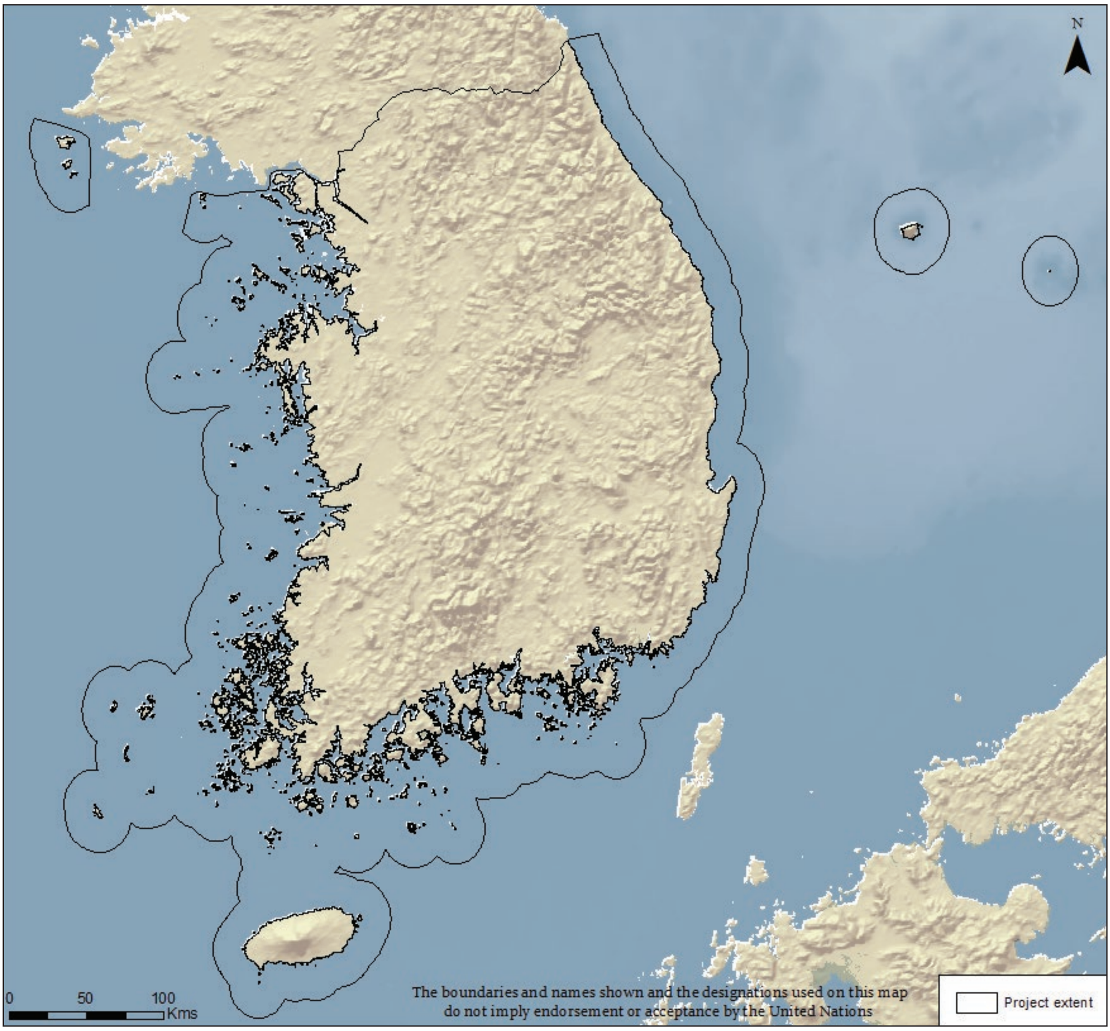

Figure 1.1. *Project extent including terrestrial areas and coastal areas (0-12 nautical miles from the Korean shoreline) of the Republic of Korea.*

The Protected Planet National Technical Series is a desktop based analysis that uses biodiversity information and other relevant available data on the Republic of Korea to inform future decisions on biodiversity. The information used in this report was directly provided by ministries and country agencies and did not involve field work or collection of primary data. In collaboration with KNPS, targets of protection for biodiversity were defined and used to evaluate potential areas for expansion of the current Korean protected area network.

The report ends with a spatial prioritisation analysis, the results of which can help to inform decisions at the national level. However, such decisions are complex, require wide stakeholder consultation, consideration of national policy frameworks and cross-agency cooperation, all of which were outside the scope of this project. Nevertheless, the results presented here may be used by the relevant Korean agencies to inform such processes and ultimately to build consensus on actions to improve biodiversity protection in the Republic of Korea. In addition, the approach taken in this report may be replicated by other country agencies.

1.2. OVERALL APPROACH

This report is structured in five parts. Section one sets the aim and scope of the project as well as the overall approach. The current protected area network of the Republic of Korea is introduced in Section 2. Section 3 describes the methods used to collect spatial data, conduct a protected area gap analyses and propose areas for protected area expansion. Results of applying this methodology are presented in Section 4. Finally, Section 5 provides some conclusions and recommendations.

Systematic Conservation Planning (SCP)

The Systematic Conservation Planning (SCP) framework was followed to design the analysis (Margules and Pressey, 2000). Systematic conservation planning is an operational model for identifying and implementing priority areas for conservation. It is a long-term process that combines a spatial conservation prioritisation with approaches for developing an implementation strategy with relevant stakeholders. SCP is widely regarded as a comprehensive and scientifically sound method to identify gaps in protected area networks and priorities for expansion (Margules and Pressey, 2000; Sarkar et al., 2006; Smith et al., 2007; Moilanen et al., 2009). Its goal is to develop cost effective networks of protected areas that represent and maintain biodiversity. It uses spatially explicit targets, and considers irreplaceability and complementarity as core concepts in its framework (Box 1.1.). Pressey and Bottrill (2009) defined 11 non-sequential key stages in conservation planning (Figure 1.2.).

SCP has been used to assess priorities for protected area expansion in various countries, for example in South Africa (Driver et al., 2011; Smith et al., 2008), Madagascar (Kremen et al., 2008), the Solomon Islands (Game et al., 2011), Indonesia (Syakur et al., 2012), and the English Channel (Delavenne et al., 2011). A recent review of how spatial biodiversity analyses can support the implementation of Aichi Biodiversity Target 11 found that, during the period 2010-2012, a total of 705 scientific articles directly relevant to spatial conservation decision making were published, 207 of which included information potentially relevant for spatial conservation resource allocation (Kullberg and Moilanen, 2014).

Box 1.1 Key concepts of Systematic Conservation Planning

Representation: To be representative a protected area network must contain the range of biodiversity found in the planning region. This can be measured using any appropriate and available spatial distribution data including presence/absence and probability of occurrence maps (Sarkar et al., 2006).

Persistence: Conservation plans must aim to maintain biodiversity through time by accounting for ecological, evolutionary and socio-political processes (Sarkar et al., 2006).

Complementarity: Systematic conservation planning seeks to identify a complementary set of priority areas that best meet the proposed goals, rather than consider the values of each priority area on a one-to-one basis.

Irreplaceability: This is a measure of the likelihood that an area will be required as part of a system that achieves a set of representative targets, or the extent to which the options for achieving the set of targets are reduced if the area is unavailable for conservation (Ferrier et al., 2000).

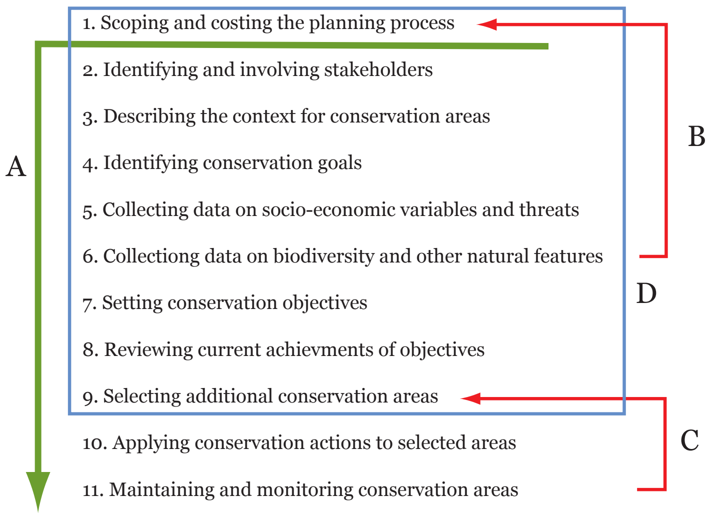

Figure 1.2. *Stages in Conservation Planning. These stages are not necessarily sequential. A: stakeholders can contribute in different stages of the project; B: After data collection revising decisions on previous stages might be necessary; C: Lessons learned from stage 11 can feed into stage 9. D; The scope of this project covered stages 1 to 9 only. Source: Pressey and Bottrill (2009).*

This project covers stages 1 to 9 of the stages defined by Pressey and Bottrill (2009) (Table 1.1.). These two stages - 10. Applying conservation actions to selected areas and 11. Maintaining and monitoring conservation areas - were beyond the scope of this project. However, these stages are fundamental to completing a conservation planning cycle and implementing a conservation planning project efficiently.

Table 1.1. *Stages in Conservation Planning from Pressey and Bottril (2009) included in this project.*

Stage	Description	This project
1	Scoping and costing of the planning process	The scope of the project is clearly defined (see Section 1.1) but the project did not include an assessment of the cost of the planning process.
2	Identifying and involving stakeholders	This project was developed with the Korea National Park Service. A workshop was organised to involve a wider range of stakeholders.
3	Describing the context for conservation areas	Section 2 of this report sets such context and section 4.1. Assesses the current coverage of the national protected area network.
4	Identifying conservation goals	Korea's CBD National Biodiversity Strategy 2014-2018 and CBD 5th National Report were used to inform the definition of conservation goals.
5	Collecting data on socio-economic variables and threats	In this project, such data include spatial information on population density, developed areas and agricultural areas, among others.
6	Collecting data on biodiversity and other national features	Underpinning this project are national and global biodiversity datasets collected from governmental agencies and international NGOs.
7	Setting conservation objectives	This project defined specific conservation targets for all conservation features selected (see section 3.3.1).
8	Reviewing current achievement of objectives	In this project the existing progress towards all targets and overall goals were also assessed in section 4.2.2.
9	Selecting additional conservation areas	In this project spatial prioritisation techniques and decision support tools were used to inform the selection of additional conservation areas. No decision is made in this report on which areas need to be specifically selected as these decisions are out of the scope of the project and part of a more complex nationally driven stakeholder consultation process.

2. The Protected Area network of the Republic of Korea

The Republic of Korea is a peninsula surrounded by around 3,000 islands and is located between lat. 33° - 43° and long. 124° - 132°. The country has 100,284 km^2 of territorial lands and 86,891 km^2 of territorial seas. Sixty-three percent of the terrestrial part of Korea is covered by mountain ranges, including Baekdudaegan, which is the largest terrestrial protected area in the country.

Korea has a long history of conserving nature as part of hunting sites, gardens, and royal tombs of kings and noble families. Sacred sites and religious places have also historically been conserved by local communities, although few of these sites survive following the Korean War in the 1950s that devastated much of the Korean peninsula.

The first World Conference on National Parks in Seattle, the United States, in 1962 was a turning point for protected areas in Korea. The conference lent momentum to the development of a formal protected areas system in the country (MacKinnon and Yan, 2008). The first two protected areas, Hongdo Island and Mount Sorak (now known as Seoraksan National Park) were designated as natural monuments in 1965 and the first national park, Jirisan National Park, was designated in 1967 (Heo, 2008). This was followed by the establishment of the Korea National Park Service (KNPS), in 1987, as a specialised management agency for national parks.

There are now over 1,700 protected areas under 17 types of designation (Ministry of Environment of the Republic of Korea, 2015). Protected areas have been designated under a number of different Acts of Parliament (Table 2.2), and each designation has its own criteria. The marine protected areas' system has been established relatively recently with an enactment of the Conservation and Management of Marine Ecosystems Act in 2006 and the Marine Environment Management Act in 2007. The former act aims to protect marine ecosystem in a comprehensive and systematic manner and establishes the legal framework for marine protected areas. The latter act becomes legal ground for establishing marine protected areas management agency.

Table 2.1. *Protected areas in the Republic of Korea (Source: Ministry of Environment of the Republic of Korea, 2015). Spatial data for the Wildlife Specially Protected Areas, Wildlife Protected Areas and Forest Reserves was not available for the analyses carried out in this report. The area of protected areas in this table shows reported areas and it does not exclude overlaps between different designations that might be covering the same geographical space (see section 3.2 and 4.1.).*

Authority	Designation	Number of sites	Area (km^2)
Ministry of Environment	1. National Parks	21	6,656.25
	2. Provincial Parks	30	1,094.69
	3. County Parks	27	237.68
	4. Wildlife Specially Protected Areas	1	26.14
	5. Wildlife Protected Areas	376	948.60
	6. Special Islands	219	11.86
	7. Ecosystem and Landscape Conservation Areas	32	283.53
	8. Wetland Protected Areas	22	125.36
Ministry of Oceans and Fisheries	9. Wetland Protected Areas-Tidal Flats	12	218.96
	10. Marine Protected Areas-Ecosystem	10	252.55
	11. Marine Environment Conservation Areas	4	1,882.13
Cultural Heritage Administration	12. Natural Monuments	205	1,107.72
	13. Nature Reserves	11	456.32
	14. Scenic Sites	109	796.75
Korea Forest Service	15. Baekdudaegan Mountains Reserve	1	2,750.77
	16. Forest Genetic Resources Reserves	631	1,499.37
	17. Forest Reserves	Not reported	2,947.96

Table 2.2. *Timeline of important legislations relating to protected areas adopted by the Government of the Republic of Korea.*

1961	Enactment of Forest Act, later replaced by Act on the Promotion and Management of Forest Resources (2005) and Forest Protection Act (2009)
1962	Enactment of Protection of Cultural Properties Act Creation of Korea's first Protected Area: Natural Monument
1967	Enactment of Parks Act, later replaced by Natural Parks Act (1980) Environment Conservation Act, later replaced by Nature Environment Conservation Act (1991)
1977	Marine Pollution Prevention Act, later replaced by Marine Environment Management Act (2007)
1982	Designation of Korea's first Biosphere Reserve under the UNESCO *Man and the Biosphere* programme
1988	Ratification of the World Heritage Convention Ratification of the Ramsar Convention
1997	Enactment of Special Act on Ecosystem Conservation in Islands including Dokdo
1999	Enactment of Wetland Conservation Act
2003	Enactment of Law on Protection of Baekdudaegan Mountains Range
2004	Enactment of Wild Animal and Plant Protection Act
2006	*Release of the National Plan for Natural Environment* (2006-2015) Enactment of Conservation and Management of Marine Ecosystems Act
2009	*Release of the National Biodiversity Strategy & Action Plan* (2009-2013)
2012	Enactment of Biodiversity Conservation and Use Act

Within the East Asia region the Republic of Korea is a leader in the establishment of protected areas managed by highly motivated staff. Between 2008 and 2009, the country has completed a management effectiveness evaluation of its protected areas in accordance with the WCPA management effectiveness framework. This was the first in Asia. It then undertook improvements based on the recommendations and findings of this study (IUCN-WCPA, 2011). Some of the key recommendations for further improving management include:

1. Move from species to ecosystems
2. Strengthen system planning
3. Integrate management
4. Improve local community relations
5. Interact with more interest groups
6. Improve regional integration
7. Enhance staff effectiveness and satisfaction
8. Diversify funding base
9. Focus research to cover real management issues
10. Harmonising the management of natural and cultural heritage

At the site level, the Ministry of Environment has finalised its first or second management effectiveness evaluation (MEE) in 39 protected areas (6,898 km^2). In 2009, the Korea Forest Service (KFS) completed the first evaluation in 462 forest genetic resource reserves (1,270 km^2). This was followed in 2012 by the first evaluation in 14 marine protected areas (289 km^2), conducted by the Korea Marine Environment Management Corporation (IUCN, Ministry of Environment, Korea National Park Service, and Jeju Island Special Governing Province, 2009)

Through this assessment, KFS identified the need to improve their management for securing the value of Forest Genetic Resource Reserves. KFS established a legal basis to carry out MEE focusing on forest protected areas in Forest Protection Law in 2012. A number of threats have been identified through these management effectiveness evaluations at both the system level and site level. The main threats and management issues identified at the site level were inappropriate behaviour by visitors, illegal harvests, and conflict with landowners (Heo and Kwon, 2012).

Large-scale infrastructure projects such as dams and highways can cause isolation of, or encroachment on, protected areas. These pressures also act as barriers to further expansion of the protected area system. An associated threat, identified at the system level, is the 'edge effect' suffered by many protected areas without buffer zones. Other major problems include fire and disturbance dynamics, invasive species, climate change, and visitor impacts (IUCN et al., 2009). These are issues that demand cooperation between all stakeholders. Other issues identified include poaching pressure and illegal fishing, which are considered to be minor problems within protected areas in the Republic of Korea.

3. Methodology

The project comprised three main activities which this chapter describes: 1) data collection (section 3.1); 2) assessment of the current coverage of Korea's protected areas' network through a gap analysis (section 3.2.); and 3) proposal of areas for protected area expansion based on a spatial prioritisation analysis (section 3.3.).

3.1. DATA COLLECTION

The aim of this activity was to gather spatial data to conduct a protected area gap analysis and to design and run the spatial prioritisation.

The data compilation focused on obtaining data on conservation features, conservation areas, and threats and constraints to biodiversity protection (Figure 3.1). Conservation features data consisted of spatial data on the location of species, ecosystems, land forms and geological features of conservation importance. Conservation areas included currently designated protected areas, Important Bird and Biodiversity Areas (IBAs, a subset of Key Biodiversity Areas), and other relevant areas identified by the Korean governmental agencies. Data on land use, population density and other factors that might conflict with biodiversity protection were also collected analyses.

Conservation features
- Species
- Habitats and ecosystems
- Geological features

Conservation areas
- Protected Areas
- Key Biodiversity Areas
- Other areas

Threats and constraints
- Population density
- Land cover
- Fisheries

Figure 3.1. *Main types of information collected for the gap analysis and spatial prioritisation analysis.*

During data collection, national datasets were prioritised over global datasets. When no data was available at the national level, the use of global datasets was assessed. The resolution of the data was the primary reason for use or rejection of a global dataset. This ensured that the datasets used were of sufficient spatial resolution to inform decisions at the national level.

The data collection phase ran from February 2015 to July 2015. Tables 3.1, 3.2 and 3.3 summarise the datasets selected to conduct the protected areas gap analysis and the spatial prioritisation exercise.

3.1.1. Conservation features

In this report the word 'conservation features' is used to refer to species, habitats and any other biogeographical features considered in the analyses. Similarly, the word 'amount' is used to refer to quantity of any of these conservation features. This mirrors the terminology used in the softwares Marxan and CLUZ, used to carry out the target based spatial prioritisation analyses (see section 3.3.).

The spatial data on conservation features specifically included species, ecosystems, and geological data. Not all datasets compiled were included in the spatial analyses. For example, national data on the spatial location and conservation value of species and vegetation types were used instead of the global datasets. The global Red List of Threatened Species distribution ranges, which were mapped at a global level, were not used, but the Red List category, assigned through the Red List risk assessment processes (IUCN, 2012), was linked to the national data to identify those biodiversity features that were also of global importance.

In total 1,533 different conservation features were selected (Table 3.1). For example, the species dataset provided information on 543 species of national conservation value including amphibians, birds, fishes, insects, mammals, plants, reptiles, and spiders. It specified whether a species was considered threatened at a national level and whether it was an endemic or rare species. The Vegetation types dataset included 325 vegetation types of five different classes of conservation importance assigned by the Ministry of Environment. Similarly, the dataset Geographic features included information on 360 geological and geographical features identified as in need of conservation by the Ministry of Environment. These features consist of caves, sand beaches, cliffs and water falls, and are categorized under two conservation classes: conservation class I (strict conservation is required) or conservation class II (conservation is required).

Table 3.1. *List of datasets and their categories used in this report including the number of different conservation features considered.*

Dataset	Biome	Categories included in the analysis	Source
Vegetation types (polygons)	Terrestrial	I High conservation value: 141 types II Close to natural vegetation: 184 types **Total conservation features: 325**	Ministry of Environment (MOE) of the Republic of Korea
Forest age (polygons)	Terrestrial	50, 60, 70 and 90 years **Total conservation features: 4**	Korea Forestry Service (KFS)
Tidal flats (polygons)	Terrestrial and coastal	Tidal flats **Total conservation features: 1**	Processed by KEI/KNPS (original data from MOE and Ministry of Oceans and Fisheries (MOF))
Species (points)	Terrestrial and coastal	Endangered 1: 20 species Endangered 2: 115 species Natural Monument (NM): 10 species Endangered 1 and NM: 10 species Endangered 2 and NM: 14 species Endemic/Rare plant/Restricted: 374 species **Total conservation features: 543**	Inside national park data (12,522 points) from KNPS and outside national park data (465 points) from National Institute of Ecology
Geographic features (points)	Terrestrial and coastal	I Strict conservation is required: 159 features II Conservation is required: 201 features **Total conservation features: 360**	MOE
Land cover (polygons)	Terrestrial	Inland wetlands and water bodies including rivers. **Total conservation features: 2**	MOE
Seaweed and seagrass (points)	Coastal	Endemic Seaweed : 3 species Other Seaweed : 291 species Seagrass under legal protection: 1 species Other Seagrass : 2 species **Total conservation features: 297**	Based on data from MOF
Coastal Conservation Class (polygons)	Coastal	I High Conservation Value **Total conservation features: 1**	Based on data from MOF

Data collected to inform the coastal analyses were limited to seaweed and seagrass occurrences, geographic features and tidal flats. In addition, a coastal value dataset developed by the Ministry of Oceans and Fisheries was used. This dataset assesses the ecological value of coastal and offshore areas based on marine ecosystem, biodiversity, endangered species' habitat, and marine protected areas. It classifies Korea's marine areas in 278.2 km^2 cells of 3 classes: Class I- High conservation value; Class II - Potential conservation value or buffer area for class I; and Class III - other areas. In this project category I only was used for the coastal spatial analyses.

3.1.2. Conservation areas

The World Database on Protected Areas (WDPA; IUCN and UNEP-WCMC. 2015) was used to consider all protected areas designated and reported to UNEP-WCMC in the Republic of Korea. Protected areas provided with no boundaries (point records) were excluded from the analyses. Therefore, the analyses did not include all protected areas in the Republic of Korea as described in Table 2.1 as there was no data available for some designated sites at the time of the analysis. In total 504 protected areas from the WDPA were considered. In addition, a total of 599 sites of Forest Genetic Resources Reserves were added to the dataset for analysis. These sites, which were not included in the WDPA, are considered as designated protected areas. The final combined dataset, containing 1,103 protected areas, was used in the spatial analysis (Table 3.2.).

Table 3.2. *List of datasets containing conservation areas used in this report.*

Dataset	Biome	Categories included in the analysis	Source
The World Database on Protected Areas (polygons)	Terrestrial and coastal	504 Designated Protected Areas	UNEP-WCMC
Forest Genetic Resources Reserves (polygons)	Terrestrial	599 Sites	Processed by KEI/KNPS (original data from KFS)
Key Biodiversity Areas (polygons)	Terrestrial and coastal	40 Important Bird Areas	Birdlife International, 2015

Forty Important Bird Areas (IBAs; BirdLife International, 2014), located mostly in coastal areas, were included in the analyses (Table 3.2). IBAs fall into different categories, including A1 (presence of globally threatened birds), A3 (presence of biome restricted birds) and A4 (presence of globally significant congregations of birds). Thirty-nine IBAs were identified under category A1, therefore confirming presence of globally threatened species. The description of each IBA includes a list of species that have met the IBA criteria for each of the categories (trigger species), their global status and information on other criteria met by these sites. All information on trigger species for each IBA is accessible online at http://www.birdlife.org/datazone/site. IBAs were considered in the spatial prioritisation analyses as areas where there could be potential to establish new or expand existing protected areas.

3.1.3. Threats and constraints

Data on land cover, population density, and coastal fisheries were compiled to assess potential threats and constraints to the expansion of protected areas (Table 3.3.). The land cover maps provided detailed spatial information on developed areas (e.g. cities and villages), agricultural areas, bare grounds, artificial grasslands, and artificial water bodies. These were used to test different contextual situations also referred as settings in this report.

Table 3.3. *List of datasets containing threats and constraints used in this report.*

Dataset	Biome	Categories included in the analysis	Source
Land cover (polygons)	Terrestrial	Developed areas, agricultural areas, bare grounds, artificial grasslands, artificial water bodies	Ministry of Environment
Population density (2.5 km^2 grid)	Terrestrial	No categories. Number of habitants per square kilometre	Adapted for the analyses by UNEP-WCMC from point data on actual population processed by the Ministry of Land, Infrastructure and Transport. Available at biz-gis.com
Fishery in shallow water (polygons)	Coastal	Aquaculture, coastal fishery, community fishery	Ministry of Oceans and Fisheries

3.2. PROTECTED AREAS GAP ANALYSES

Knowing where protected areas are located, their management objectives, and the diversity and quantity of species and ecosystems they protect, is fundamental to identifying gaps, and to inform options for improvement of the network.

The protected areas gap analysis consisted of measuring the extent of habitats and number of species (conservation features) within the existing protected area network using Geographic Information Systems (GIS) software. The area of protected areas both in the terrestrial and coastal areas of the Republic of Korea was calculated by removing all overlaps between different designations types to avoid double counting. The land cover of protected areas and the overlap with Important Bird and Biodiversity Areas were also assessed.

For all measurements and maps produced for the gap analysis, the Universal Transverse Mercator (UTM WGS84) Zone 52 N projected coordinate system was used.

3.3. EXPANDING KOREA'S PROTECTED AREA NETWORK

Potential areas for expansion of protected areas were identified through a spatial prioritisation analyses. In collaboration with stakeholders, a set of conservation targets were defined and tested through target scenarios using conservation planning decision support tools and software. Stakeholders were consulted on the targets set and the preliminary results. The analyses were re-run incorporating stakeholder input and portfolios of proposed protected areas networks that met the conservation targets were selected. Finally, the achievement of conservation targets under each proposed network was assessed.

3.3.1. Defining conservation targets

Setting targets involves determining the number of species, species' assemblages, ecological communities, and extent of ecosystems that should be included in the network of protected areas. These targets should be set based on local expertise and the best available data and be influenced by key concepts in systematic conservation planning (see Box 1.1.).

In this report the term "amount" is used to refer to how much (i.e. square kilometres of habitat, number of species) of each of these elements of biodiversity targets were set using the datasets compiled in the data collection phase (see Section 3.1.) and by considering the importance, at the national and global level, of biodiversity, while aiming to achieve an adequate representation of biodiversity.

Approach to define targets

The Korea's CBD National Biodiversity Strategy and Action Plan (NBSAP; Ministry of Environment of the Republic of Korea 2014a) and the Fifth National Report to the CBD (Ministry of Environment of the Republic of Korea 2014b) were reviewed to inform target-setting. References to habitats and species identified as national and international priorities in these reports were compiled. In addition, the level of importance assigned by the Government of Korea to the different datasets was used to inform the targets. Targets were assigned to all conservation features considered important and were refined through discussions with KNPS (see Table 3.4.).

To assess the performance of different spatial configurations, and determine the total area needed to meet the conservation targets a series of target scenarios were developed. For each successive scenario, conservation targets were increased, ranging from an improvement in existing representation, to inclusion of all relevant conservation features (see Appendix 2 for more details on these scenarios).

These conservation target scenarios were tested running a spatial prioritisation analyses (see section 3.3.2) and discussed with relevant stakeholder to agree on a final set of selected targets and scenarios (Table 3.4).

Stakeholder consultation

Involving local stakeholders is fundamental for the success of any conservation planning exercise. Two meetings were organised during the project to seek stakeholder input. Although the meetings carried out in this project were fundamental to design the analyses and discuss the results, a broader stakeholder consulation workshop would be needed to define and implement actions on the ground.

The first meeting was held in Cambridge, UK in June 2015 where UNEP-WCMC and KNPS discussed the results of the data collection stage, the gap analysis, and the approach for the spatial prioritisation analyses. To seek further input from local institutions a second meeting was organised in Seoul, Republic of Korea in October 2015, where the methods and preliminary results of the spatial prioritisation analyses were presented and discussed with KNPS staff and a number of local experts (Figure 3.2).

Figure 3.2. *Participants in the stakeholder consultation held in Seoul in October 2015.*

After the meetings, KNPS proposed new terrestrial target scenarios that would inform future decisions on protected area expansion (see Appendix 2 for more details on scenario settings and results). Two terrestrial scenarios (TS) and one coastal scenario (CS) were considered to be the most appropriate to meet the conservation goals and inform future decisions on protected area expansion.

The selected scenarios and their targets are summarised in Table 3.4 (see Appendix 2 for further details). These scenarios have assigned targets to both species and habitats and are considered appropriate for representation of biodiversity features.

Table 3.4. *Targets for the selected terrestrial (TS) and coastal (CS) scenarios. Further details and results for other scenarios are available in Appendix 2. CF = Conservation Feature.*

<table>
<thead>
<tr><th>Dataset</th><th>Category</th><th>Target for TS405</th><th>Target for TS7</th><th>Target for TS9</th><th>Target for CS702</th></tr>
</thead>
<tbody>
<tr><td rowspan="4">Forest age</td><td>50 years (km^2)</td><td rowspan="4">No Target</td><td>20 %</td><td rowspan="4">100%</td><td rowspan="4">Not applicable</td></tr>
<tr><td>60 years (km^2)</td><td>75 %</td></tr>
<tr><td>70 years (km^2)</td><td>100 %</td></tr>
<tr><td>90 years (km^2)</td><td>100 %</td></tr>
<tr><td rowspan="2">Vegetation</td><td>High conservation value</td><td rowspan="2">No Target</td><td>100 %</td><td>100%</td><td rowspan="2">Not applicable</td></tr>
<tr><td>Close to natural vegetation</td><td>No Target</td><td>100 %</td></tr>
<tr><td rowspan="6">Species</td><td>Endangered 1</td><td rowspan="5">At least 2 points of each CF</td><td rowspan="5">At least 3 points of each CF</td><td rowspan="5">At least 4 points of each CF</td><td rowspan="5">At least 3 points of each CF</td></tr>
<tr><td>Endangered 2</td></tr>
<tr><td>Natural Monument (NM)</td></tr>
<tr><td>Endangered 1 and NM</td></tr>
<tr><td>Endangered 2 and NM</td></tr>
<tr><td>Endemic/Rare plant/Restricted</td><td>At least 1 point of each CF</td><td>At least 2 points of each CF</td><td>At least 3 points of each CF</td><td>At least 2 points of each CF</td></tr>
<tr><td rowspan="2">Geographic features</td><td>Strict conservation is required</td><td>At least 2 points of each CF</td><td>At least 3 points of each CF</td><td>At least 34 points of each CF</td><td>At least 3 points of each CF</td></tr>
<tr><td>Conservation is required</td><td>At least 1 point of each CF</td><td>At least 2 points of each CF</td><td>At least 3 points of each CF</td><td>At least 2 points of each CF</td></tr>
<tr><td rowspan="2">Wetlands</td><td>Waterbody_fresh</td><td>17%</td><td>7 %</td><td>30%</td><td>7 %</td></tr>
<tr><td>Wetland_inland</td><td>17%</td><td>4%</td><td>17%</td><td>4%</td></tr>
<tr><td colspan="2">Tidal flat</td><td>100%</td><td>40%</td><td>No Target</td><td>40%</td></tr>
<tr><td rowspan="2">Seaweed</td><td>Endemic</td><td rowspan="5">Not applicable</td><td rowspan="5">Not applicable</td><td rowspan="5">Not applicable</td><td>At least 3 points of each CF</td></tr>
<tr><td>other species</td><td>At least 2 points of each CF</td></tr>
<tr><td rowspan="2">Seagrass</td><td>Marine species protected</td><td>At least 3 points of each CF</td></tr>
<tr><td>other species</td><td>At least 2 points of each CF</td></tr>
<tr><td colspan="2">Coastal conservation class I</td><td>15%</td></tr>
</tbody>
</table>

3.3.2. Setting the spatial prioritisation analyses

Decision support tools

The decision support tool Marxan and one of its user interfaces, CLUZ, were used to select additional conservation areas that met the conservation targets set in each of the scenarios (see Box 3.1).

Spatial planning software and decision support tools usually require input data to be formatted in a specific way to produce the desired outputs. CLUZ and Marxan work by dividing the planning region into a series of planning units, listing the distribution of the conservation features found in each planning unit, setting targets for the amount of each feature to be included in the conservation landscape and using computer software to identify portfolios of units that best meet the targets.

Box 3.1 Marxan and CLUZ

Marxan is a decision support tool for conservation planning, developed by the University of Queensland and extensively used in spatial prioritisation exercises with over 2,600 individuals and 1,500 organisational users in 110 countries (Watts et al., 2009). Marxan is designed to resolve the "minimum set problem" when designing a reserve network or solving a conservation planning issue. This problem arises when there are a great number of potential sites and manual calculation of the best options is highly complex. MARXAN software runs simulated annealing algorithms to identify near-optimal sets of sites for meeting targets for each conservation feature at the lowest possible cost (Possingham et al., 2000; Ball et al., 2009). Cost may refer to area, financial costs, social cost, environmental cost, or level of threat.

CLUZ was developed by the University of Kent with support from UNEP-WCMC (Smith RJ, 2015). It is an open source user interface of the software Marxan that can be integrated into the QGIS software. It can be used for on-screen planning and also acts as a link to the Marxan conservation planning software.

Marxan and CLUZ are not the only software available for conservation planning. Zonation, for example, is another widely used and publically available decision support system for spatial conservation planning (Moilanen et al., 2005; Moilanen, 2007). Zonation differs from other spatial prioritisation software in that it does not require the setting of conservation targets, instead trade-offs are incorporated into the model through the prioritisation or weighting of features. Zonation starts with a full landscape and attempts to solve the maximum representation problem by using an accelerated reverse stepwise heuristic to iteratively remove the cells that cause the smallest marginal loss (i.e. the cells with the least conservation value) (Moilanen et al., 2014). Zonation produces a single hierarchical prioritisation which ranks all cells based on their conservation value. This is accompanied by a performance curve which represents the performance of the reserve network at protecting the defined conservation features at different levels of landscape removal (for more information see http://cbig.it.helsinki.fi/software/zonation).

Steps to run the spatial prioritisation analyses

The terrestrial and coastal analyses were run separately due to the differences in quality and scale of the marine and terrestrial data, and to ensure adequate representation of biodiversity features across the different biomes. The steps followed are described in Figure 3.3.

The terrestrial and coastal areas of Korea were divided in hexagonal planning units (PU) of 2.5 km^2. Each PU was labelled either as terrestrial (including inland waters), coastal or terrestrial/coastal when the hexagon was present in both biomes. Hexagons were chosen instead of squares as they produce more efficient and less fragmented portfolios (Nhancale and Smith, 2011).

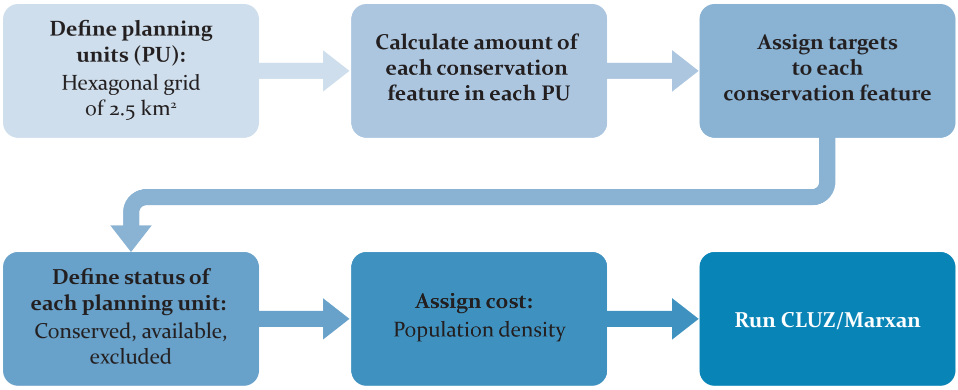

Figure 3.3. *Main steps followed to run the spatial prioritisation analyses in each of the target scenarios using CLUZ/Marxan.*

The amount of each conservation feature in each PU was calculated using GIS software (ArcGIS desktop) and the previously defined targets (see 3.3.1) were assigned through CLUZ.

The data collected for the coastal analyses were not sufficient to conduct a comprehensive spatial prioritisation analysis. Nevertheless, a preliminary analysis was completed to inform further decisions on the key gaps. The results of the coastal assessment are available in Appendix 2.

Focusing on the terrestrial analyses for which there were enough data to conduct comprehensive analyses, nine terrestrial target scenarios (TS) with different increasing targets were developed. The aim was to test different spatial configurations for conservation features found in terrestrial and inland water areas that would inform stakeholder consultations and target refinement (see section 3.3.1). For each of the scenarios four different settings were tested:

Setting 1 – No areas locked in or excluded.

Setting 2 – Current protected areas locked in.

Setting 3 - Current protected areas and Key Biodiversity Areas locked in.

Setting 4 – Current protected areas and Key Biodiversity Areas locked in. Areas where more than 60% of a planning unit is occupied by developed areas, bare grounds, artificial water bodies, artificial grasslands, or agricultural areas are excluded.

Depending on the settings assigned to each target scenario, each planning unit was classified under one of three different status: 1) Conserved (locked in): planning units that needed to be included in the proposed network (e.g. existing protected areas); 2) Available: planning units that might be available for protected area expansion (e.g. undeveloped land); 3) Excluded (locked out): planning units that are or might not be available for protected area expansion (e.g. highly developed areas, croplands).

After assigning the targets and defining the status of planning units, assigning the cost to each of these is one of the most important decisions in an analysis using CLUZ/Marxan (see Box 2.1). Cost may refer to the area of that planning unit, financial costs of the planning unit, or level of threat. Population density was used to assign a cost to each planning unit. To reduce the total cost of the proposed network, the Marxan algorithm, would favour planning units with low population density, therefore avoiding potential conflicts related to densely populated areas.

Another important decision when setting the spatial prioritisation analyses in Marxan is the use of the Boundary Length Modifier (BLM) variable. This variable, is used to determine how much emphasis should be placed on minimising the overall reserve system boundary length. Increasing the BLM value will produce a more compact reserve system, while decreasing it will deliver a more dispersed solution. The method recommended in Game et al. (2008) was used to apply the select the right BLM value for this analyses.

Once all settings were ready, all scenarios proposed were run using CLUZ 1,000 times with 10 million iterations. Marxan/CLUZ delivers a series of output files that can be used to assess the results of the spatial prioritisation exercise. The main outputs presented in this report are:

i) Near to optimal solution or best solution: a proposed network or portfolio of sites for each of the scenarios;

ii) Selection frequency: the number of times each planning unit is selected during all runs. For example, a planning units that is selected 999 times in 1,000 runs should be considered very important for meeting the conservation targets under the pre-defined conditions of the scenario.

3.3.3. Assessing the achievement of targets

The aim of the spatial prioritisation analyses was to identify a portfolio of sites or proposed conservation network that meets the conservation targets at a minimum cost. Due to the exclusion of some areas where land use could potentially conflict with the establishment or expansion of protected areas, some targets will only be partially met or not met. The degree to which targets are not meet depends on 1) the tolerance settings in Marxan; 2) specific spatial constraints defined in the settings.

Tolerance refers to the extent to which Marxan considers a target to be met. In some cases, stakeholders may accept a tolerance lower than 90%. This requires careful assessment of which features have been excluded, to what extent, and whether this is acceptable for the actors involved. For example, if a target for a given conservation feature is to select 100 km^2 of it and the tolerance is 95%, the target will be considered as met if the result captures 95 km^2 or more.

For some conservation features it might not be possible to fully meet the targets even with high tolerances. For, example a conservation target for a specific conservation feature might be to protect 10% of its known range. However, due to specific spatial constraints defined in the settings (e.g. exclude all developed areas and agricultural areas), it may only possible to conserve a limited amount below 10%.

The achievement of the targets for each of the conservation features was assessed by comparing the amount included in the proposed network to the target amount assigned in the settings of the analyses. In addition, those conservation features for which targets were not met were identified and listed (See section 4.2.2 and Appendix 2).

3.4. CAVEATS

Any spatial prioritisation analysis is subject to data limitations that have an impact on the quality and comprehensiveness of the outputs. These limitations include, but are not restricted to, lack of data, issues related to the quality of the data, or outdated data. Other potential issues include low resolution of data, lack of comprehensiveness, or inappropriate scale for the scope of the project.

The analyses presented in this report did not use Species Distribution Models (SDM) to predict the presence of species of conservation concern in areas of suitable habitat (Elith and Leathwick, 2009). SDM reduces the probability of commission (false positives) or omission (false negatives) errors. Instead, confirmed occurrences of species through point data were used. Thus, the analyses might be biased to areas where there has been more data collection. The use of habitats maps such as vegetation types, forests, or tidal flats might in part reduce this bias as they can be considered as proxies of suitable habitats for some species.

The lack of a high quality marine and coastal biodiversity data arose as one of the major issues for the analyses. Due to this constraint the analysis was restricted to Korea's territorial seas (from the coast to 12 nautical miles). In addition, the coastal data used consisted only of seaweed and sea grass occurrence points, tidal flats habitats, some geographic features and the pre-defined coastal value map which was low resolution. Therefore the coastal analyses and results need to be taken with extreme caution as other potentially important biodiversity features have not been considered.

4. Results

4.1. PROTECTED AREAS GAP ANALYSES

According to the data stored in the WDPA in October 2015, the protected area network of the Republic of Korea covers 7.92% of terrestrial and inland water areas (7,876.32 km^2) and 4.5% of the coastal areas (3,366.34 km^2). The Ministry of Environment of The Republic of Korea reported in 2015 a protected area coverage of 12.6% for terrestrial and inland areas and 6.1% for coastal areas (Ministry of Environment of the Republic of Korea, 2015). This difference is because the data used at the time of the analyses presented in this report did not include all protected areas currently designated in the Republic of Korea. Despite this difference, both calculations show protected areas coverage, falling short of meeting the 17% and 10% respective the marks specified in Aichi Biodiversity Target 11.

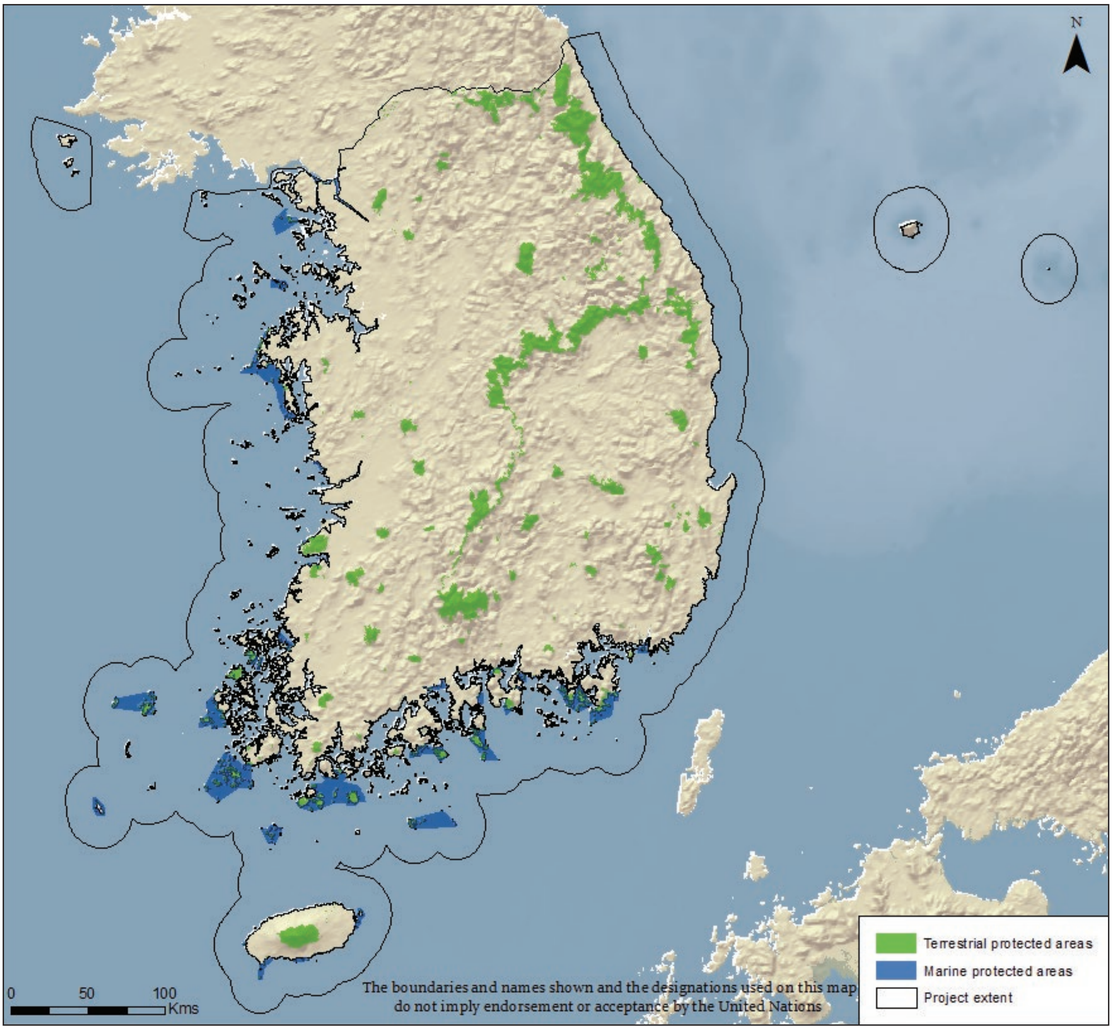

Figure 4.1. *Designated protected Areas in the Republic of Korea used in this report.*

Based on the WDPA analyses and taking Aichi Target 11 as a national target for Korea, an additional 9,034 km² of protected areas would be needed to reach 17% of terrestrial and inland water areas. Similarly, if the aim is to cover 10% of Korea coastal areas an additional 4,122 km² of coastal protected areas would be needed.

The results of the spatial analyses (Table 4.1) show that only 30.9% of vegetation types with conservation value I or II and 23 % of forests with more than 50 years old are within protected areas. This is due to the low coverage in forest between 50 -60 years (9.8%) and 60 - 70 years (37.6%) old and that half of Class I (High Conservation Value) Vegetation Types (49.9%) are in protected areas (see Appendix 1 for full details).

Table 4.1. *Summarised results of Protected Areas (PAs) gap analyses for terrestrial and coastal areas. A comprehensive set of results is available in Appendix 1.*

Dataset	Percentage in terrestrial PAs	Percentage in coastal PAs	Percentage in all PAs (%)
Forest age	23.38%	Not Applicable	23.38%
Vegetation types	30.92%	Not Applicable	30.92%
Species inside and outside Protected Areas	86.22%	51.92%	86.74%
Geographical features	47.18%	44.16%	70.66%
Tidal flats	13.08%	10.14%	10.53%
Key Biodiversity Areas	5.57%	9.56%	8.66%
Wetlands	2.06%	8.55%	3.16%
Seaweed	Not Applicable	55.51%	60.54%
Seagrass	Not Applicable	33.33%	33.33%
Coastal conservation class I	Not Applicable	6.79%	6.79%

Almost half (47.1) of terrestrial geographic features are under terrestrial protected areas (Table 4.1). Taking into account geographic features in coastal areas this increases to 70.7%. Species of conservation concern are well represented in both coastal and terrestrial protected areas (86.7%). Conversely, only 8.7% of Important Bird Areas overlap with Protected Areas and only 6.8% of areas of coastal conservation class I are in protected areas (Figure 4.2).

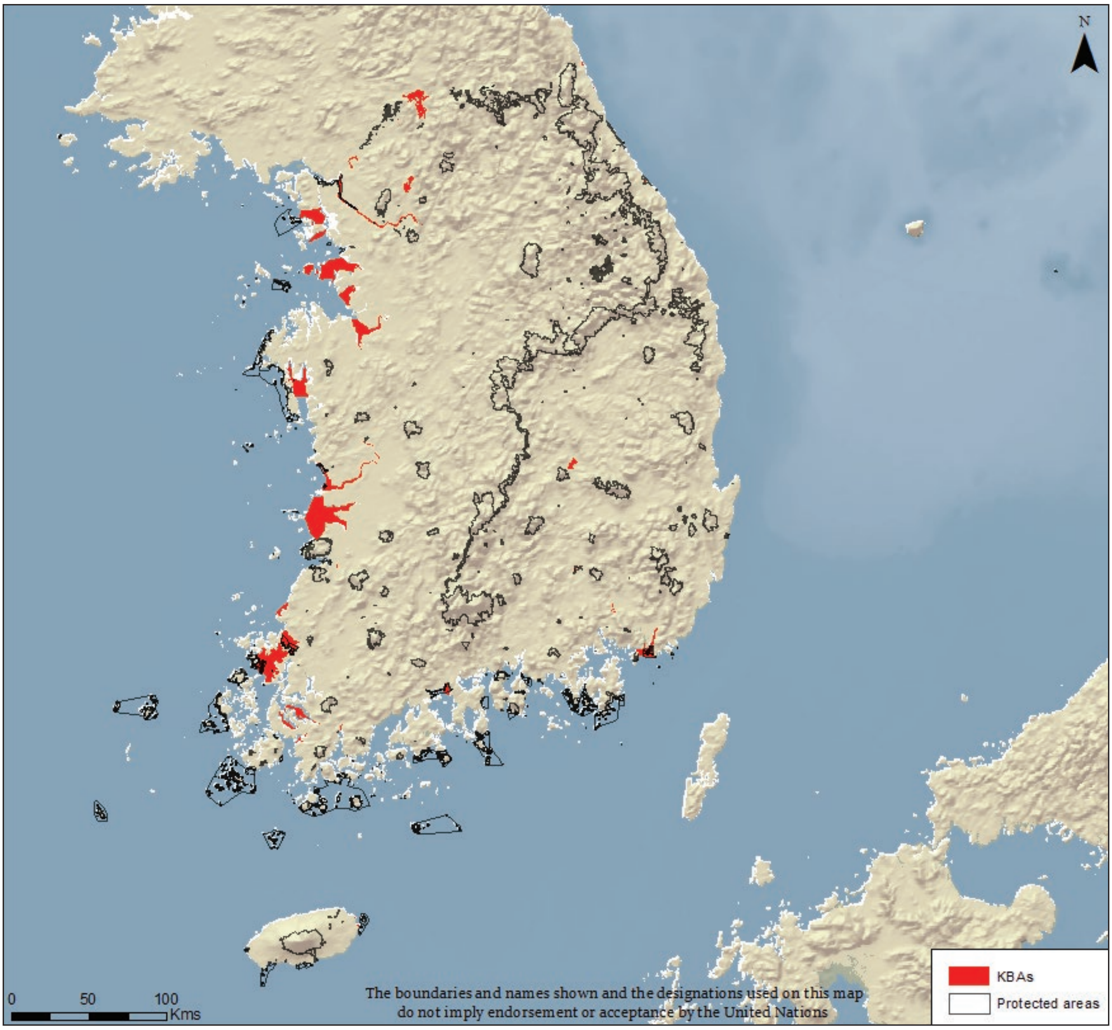

Figure 4.2. *Important Bird and Biodiversity Areas and Protected Areas in the Republic of Korea. Source: Birdlife Data Zone (http://www.birdlife.org/datazone/site).*

An assessment of land cover in protected areas using the land cover map collected in this project reveals that 90% of the protected areas in Korea are covered by different types of forest (Table 4.2). Of these, broadleaf forest is predominant. Only around 6% of the area within protected areas are consists in artificial land uses such as agriculture, artificial grasslands or developed areas.

Table 4.2. Land cover in terrestrial protected areas in the Republic of Korea. Source: Intersection between the protected areas dataset and the Land Cover Map for Korea (see sections 3.1.2 and 3.1.3 for details on the datasets used).

Land cover type	Area in protected areas (km^2)	Proportion in protected areas (%)
Agricultural area	334	4.24%
Bare ground (natural)	3	0.04%
Bare ground (other)	42	0.53%
Developed area	62	0.79%
Forest area (broad leaved)	3,758	47.71%
Forest area (coniferous)	1,760	22.34%
Forest area (mixed)	1592	20.21%
Grassland (artificial)	2	0.02%
Grassland (natural)	26	0.33%
Grassland (other)	48	0.61%
Waterbody (fresh)	44	0.56%
Waterbody (salt)	142	1.81%
Wetland (coastal)	26	0.33%
Wetland (inland)	6	0.08%
Unknown	31	0.39%
Total	**7,876**	**100%**

The IUCN Red List of Threatened Species has assessed the risk of extinction of 995 species whose ranges overlap with the territory of the Republic of Korea. However, the species range maps provided by the IUCN Red List were not used because they were of too coarse scale for a national level analysis. Instead, the species national dataset was used to confirm presence of some of these globally assessed species. In total the presence of 91 species assessed at a global level was confirmed. Of these, 26 were classified as globally threatened (Critically Endangered, Endangered or Vulnerable). Results of the protected areas gap analysis revealed that the current protected area network covers only 54% (14 species) of these 26 globally threatened species (Figure 4.3). The Critically Endangered insect Libellula angelina of which there were 12 confirmed occurrences (points) is not found in any protected areas or Key Biodiversity Areas included in this analysis. Confirmed presence of globally threatened species is a first requirement to identify areas that might be candidates for new Key Biodiversity Areas (see section 4.2).

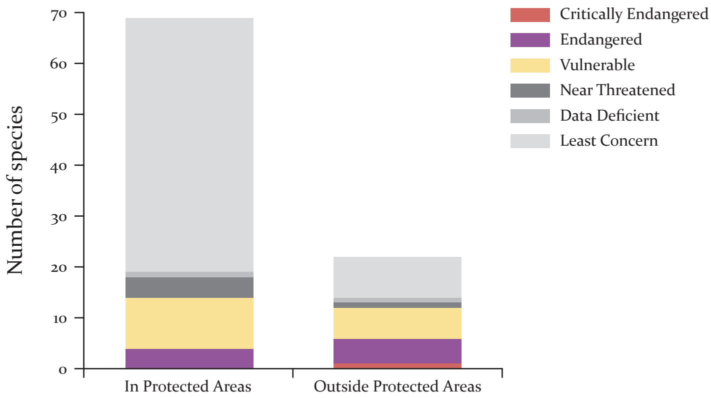

Figure 4.3. *Assigned categories and presence in Korea's Protected Area network for 91 species assessed at a global level by the IUCN Red List of Threatened species inside and outside of protected areas.*

4.2. EXPANDING KOREA'S PROTECTED AREA NETWORK

A number of target scenarios were developed to assess the performance of different spatial configurations and determine the total area needed to meet a set of pre-defined conservation targets. The scenarios that best met national and international obligations related to protected areas and conservation were chosen and presented in a stakeholder consultation workshop.

4.2.1. Selecting additional conservation areas

Terrestrial areas

The results of the selected terrestrial scenarios (TS) show that, depending on the target scenarios, an area between 17.3% and 46.4% of Korea's total terrestrial extent is needed to meet the set of pre-defined conservation targets (see Table 3.4). The terrestrial scenario TS405 would cover 17.3% of Korea's terrestrial area. However, it does not consider any improvement on coverage of vegetation types or forest age type nor capture all geographic features of importance (see TS405 and Appendix 2 for full results on the 3 selected terrestrial scenarios).

The two terrestrial scenarios TS7 and TS9 are considered to represent two extremes for protected area expansion (Table 4.3 and 4.4). The first one (TS7, Figure 4.4) adequately covers all conservation features while meeting most targets. The second one (TS9, Figure 4.5) was proposed as an aspiration to determine how much area would be needed to cover 100% of the most important conservation features at a national level.

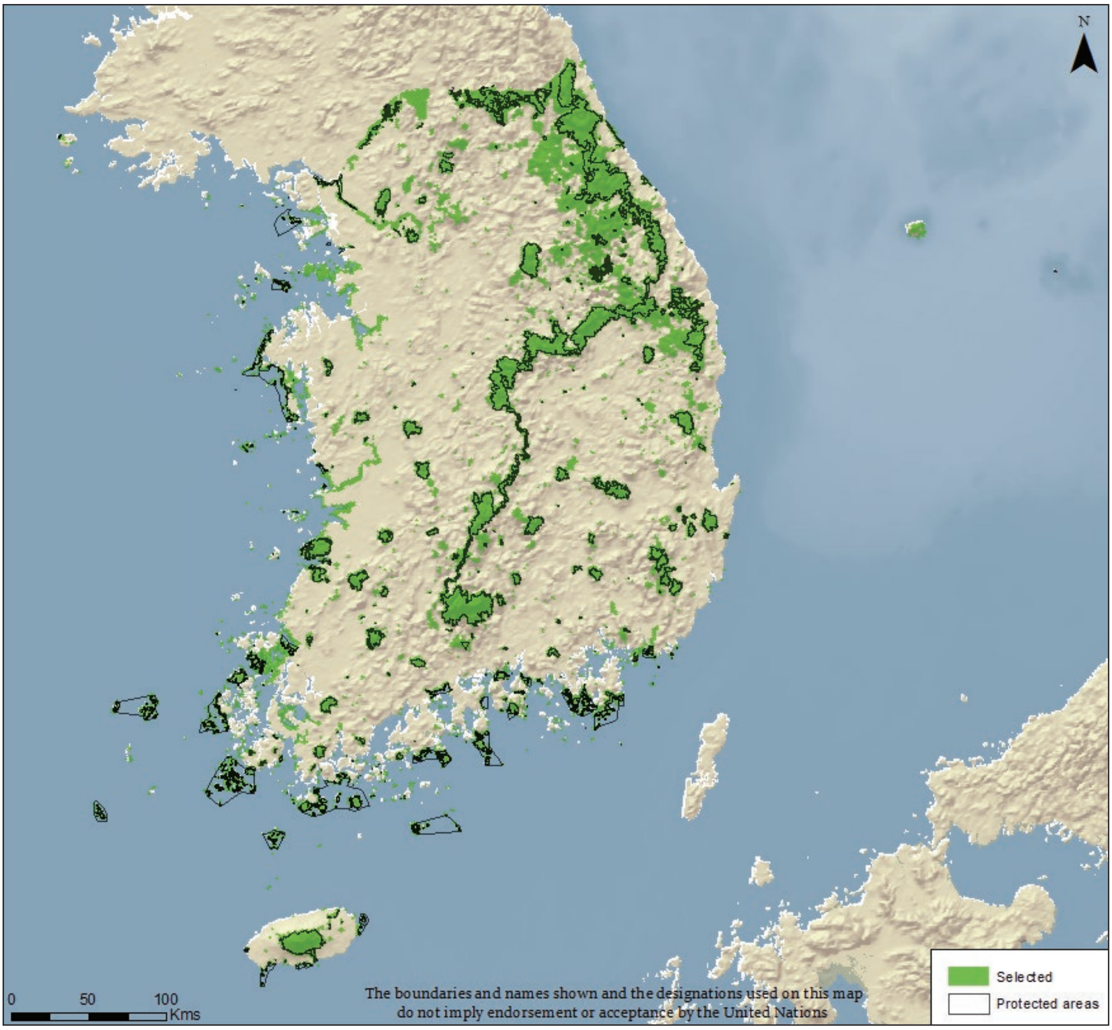

Figure 4.4. *Proposed network for terrestrial scenario (TS) TS7 based on the best solution output from Marxan.*

Table 4.3. *Results of the spatial prioritisation analysis for the selected terrestrial scenario TS7. Settings: Protected areas and Key Biodiversity areas locked in. Excluded areas where more than 60% of a planning unit occupied by developed areas, bare grounds, artificial water bodies, artificial grasslands, and agricultural areas.*

<table>
<tr><th>Number of planning units total</th><th>Final area (km^2)</th><th>% of the country's terrestrial area</th><th>Additional PA area (km^2)</th></tr>
<tr><td>10,431</td><td>21,345</td><td>21.5</td><td>13,469</td></tr>
<tr><th></th><th></th><th colspan="2">Amount held</th></tr>
<tr><th>Conservation feature</th><th>Total</th><th>Currently in PAs</th><th>In proposed network</th></tr>
<tr><td>Forest age types more than 50 years (km^2)</td><td>13,369</td><td>3,125</td><td>6,146</td></tr>
<tr><td rowspan="3">Geographical feature with conservation class I, II (Number of features)</td><td rowspan="3">354</td><td rowspan="3">167</td><td>289</td></tr>
<tr><td>Strict conservation is required: 135</td></tr>
<tr><td>Conservation is required: 154</td></tr>
<tr><td>Wetland (km^2)</td><td>2,440</td><td>50</td><td>322</td></tr>
<tr><td rowspan="7">Species (Number of species)</td><td rowspan="7">537</td><td rowspan="7">463</td><td>526 species</td></tr>
<tr><td>Endangered 1: 19</td></tr>
<tr><td>Endangered 2: 104</td></tr>
<tr><td>Natural Monument (NM): 10</td></tr>
<tr><td>Endangered 1 and NM: 8</td></tr>
<tr><td>Endangered 2 and NM: 14</td></tr>
<tr><td>Endemic/rare plant/ restricted: 371</td></tr>
<tr><td>Tidal flat (km^2)</td><td>397</td><td>52</td><td>166</td></tr>
<tr><td>Vegetation types with class I, II (km^2)</td><td>44,257</td><td>6,214</td><td>13,950</td></tr>
</table>

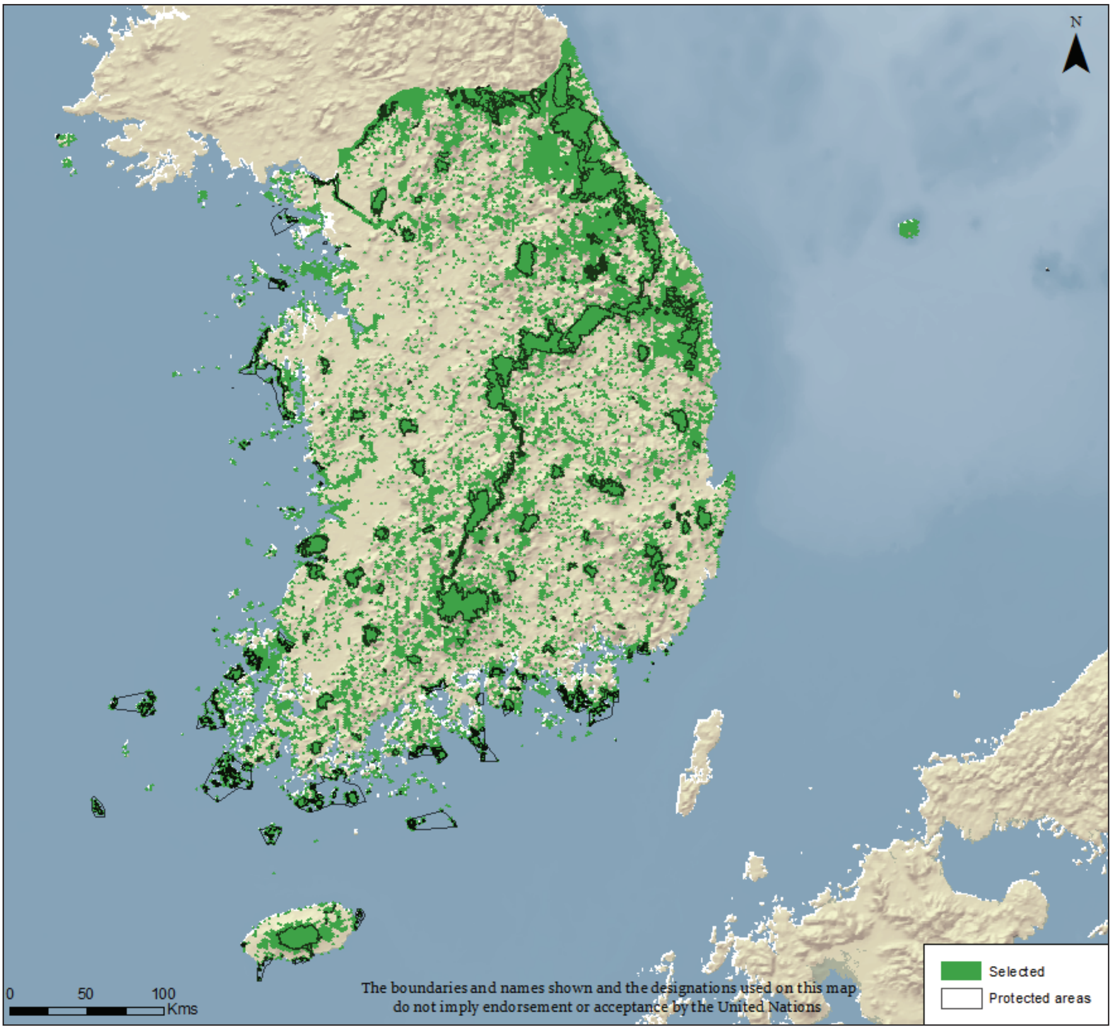

Figure 4.5. *Proposed network for terrestrial scenario TS9 based on the best solution output from Marxan.*

Table 4.4. Results of the spatial prioritisation analysis for the selected terrestrial scenario TS9. Settings: Protected areas and Key Biodiversity Areas locked in. Excluded areas where more than 60% of a planning unit occupied by developed areas and bare grounds.

Number of planning units total	Final area (km²)	% of the country's terrestrial area	Additional PA area (km²)
17,298	37,044	37.2	22,038
		Amount held	
Conservation Feature	**Total**	**Currently in PAs**	**In proposed network**
Forest age (km²)	13,369	3,125	10,630
Geographical feature (Number of features)	354	167	**289**
- I Strict conservation is required	154	94	139
- II Conservation is required	200	73	159
Wetland (km²)	2,440	50	792
Species (Number of species)	537	463	**526**
- Endangered 1	537	463	526
- Endangered 2	20	7	19
- Natural Monument (NM)	110	69	104
- Endangered 1 and NM	10	9	10
- Endangered 2 and NM	10	9	8
- Endemic/rare plant/restricted	14	8	14
Tidal flat (km²)	397	52	236
Vegetation types (km²)	44,257	6,214	21,107

Coastal areas

The data collected to represent biodiversity in coastal areas of Korea (from the shore to 12 nautical miles) was considered insufficient to run a comprehensive spatial prioritisation analysis. However, a preliminary analysis run with the existing data shows a combination of targets assigned could be enough to cover 10% of Korea's coastal areas (Table 4.5, Figure 4.6). These results must be taken with caution as the analysis only included seaweed and seagrasses, some legally protected terrestrial species occurring in coastal areas and geographic features, tidal flat, and large areas considered as of conservation value by the Ministry of Oceans and Fisheries (see section 3.1.1.).

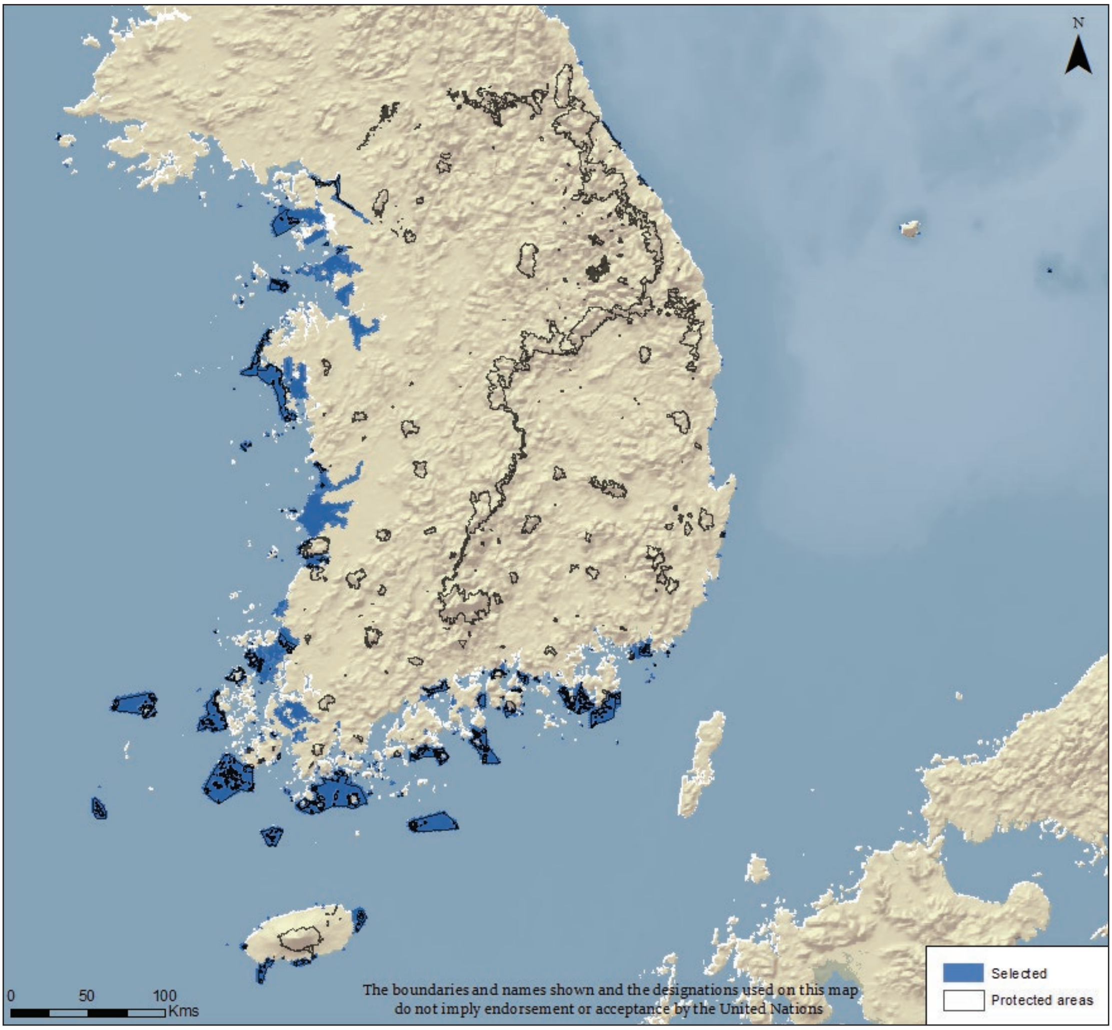

Figure 4.6. *Provisional network for coastal scenario (CS) CS702 based on the best solution output from Marxan.*

Table 4.5. Results *of the spatial prioritisation analysis for the best selected coastal scenario (CS702). Settings: Protected areas and Key Biodiversity Areas locked in. No areas were excluded.*

Number of planning units total	Final area selected (km^2)	% of the country's coastal area	Additional area selected (km^2)
3,999	7,468.81	10.0%	4,105.40
		Amount held	
Conservation feature	**Total**	**Currently in PAs**	**In proposed network**
Coastal conservation class 1 (km^2)	23,288.52	1,581.41	3,500.86
Tidal flat (km^2)	2,619.53	265.73	**1,338.85**
Seaweed (number of species)	294	294	294
Seagrass (number of species)	3	3	3
Species[1] (Number of species)	**52**	**27**	**42**
- Endangered 1	4	2	3
- Endangered 2	30	13	22
- Natural Monument (NM)	2	2	2
- Endangered 1 and NM	3	2	3
- Endangered 2 and NM	8	4	7
- Endemic/rare plant/restricted	5	4	5
Geographical feature (Number of features)	**77**	**34**	**49**
- I Strict conservation is required	36	18	24
- II Conservation is required	41	16	25
Wetland (km^2)	500.35	42.77	264.22

[1]Legally protected terrestrial species occurring in coastal areas

Combined results

The combined results in Figure 4.7, based on terrestrial scenario TS7 and coastal scenario CS702, present a network that would cover 21.5 % of terrestrial areas and 10 % of coastal areas while meeting most of the conservation targets. It includes protected areas and key biodiversity areas and avoids areas that might conflict with setting new protected areas such as developed areas or agricultural lands.

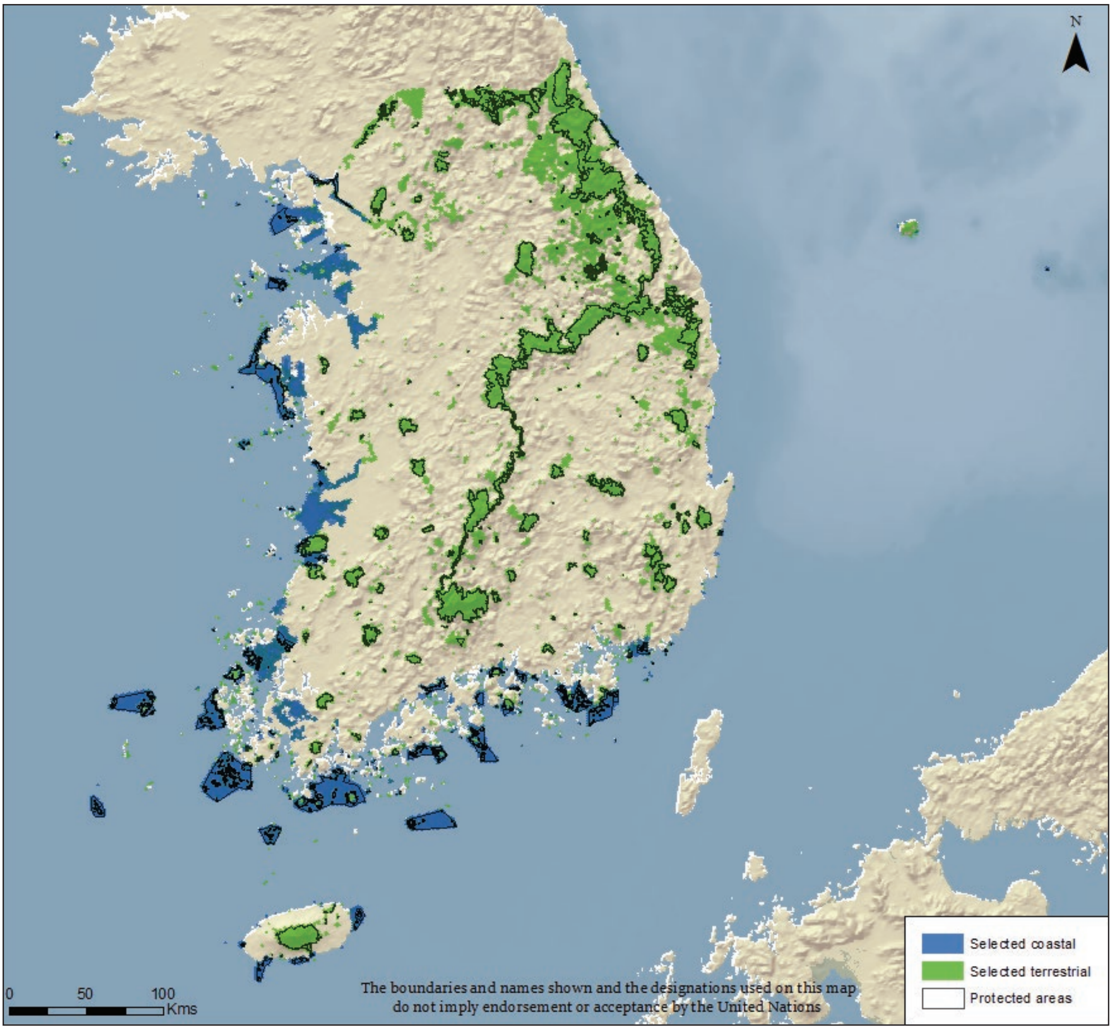

Figure 4.7. *Best solutions for terrestrial scenario (TS) TS7 and coastal scenario (CS) CS702 with location of existing terrestrial and coastal protected areas. Areas locked in: protected areas and Key Biodiversity Areas. Areas excluded: planning units where more than 60% were covered by developed areas, bare grounds, artificial water bodies, artificial grasslands, and agricultural areas.*

The selection frequency for these two scenarios (TS7 and CS702) with no spatial restrictions (Figure 4.8) - this is, not locking protected areas and Important Bird Areas and not excluding areas - gives an indication of how well the current protected area network and Key Biodiversity Areas are covering areas of high selection frequency, hence areas that are important to meet the predefined conservation targets.

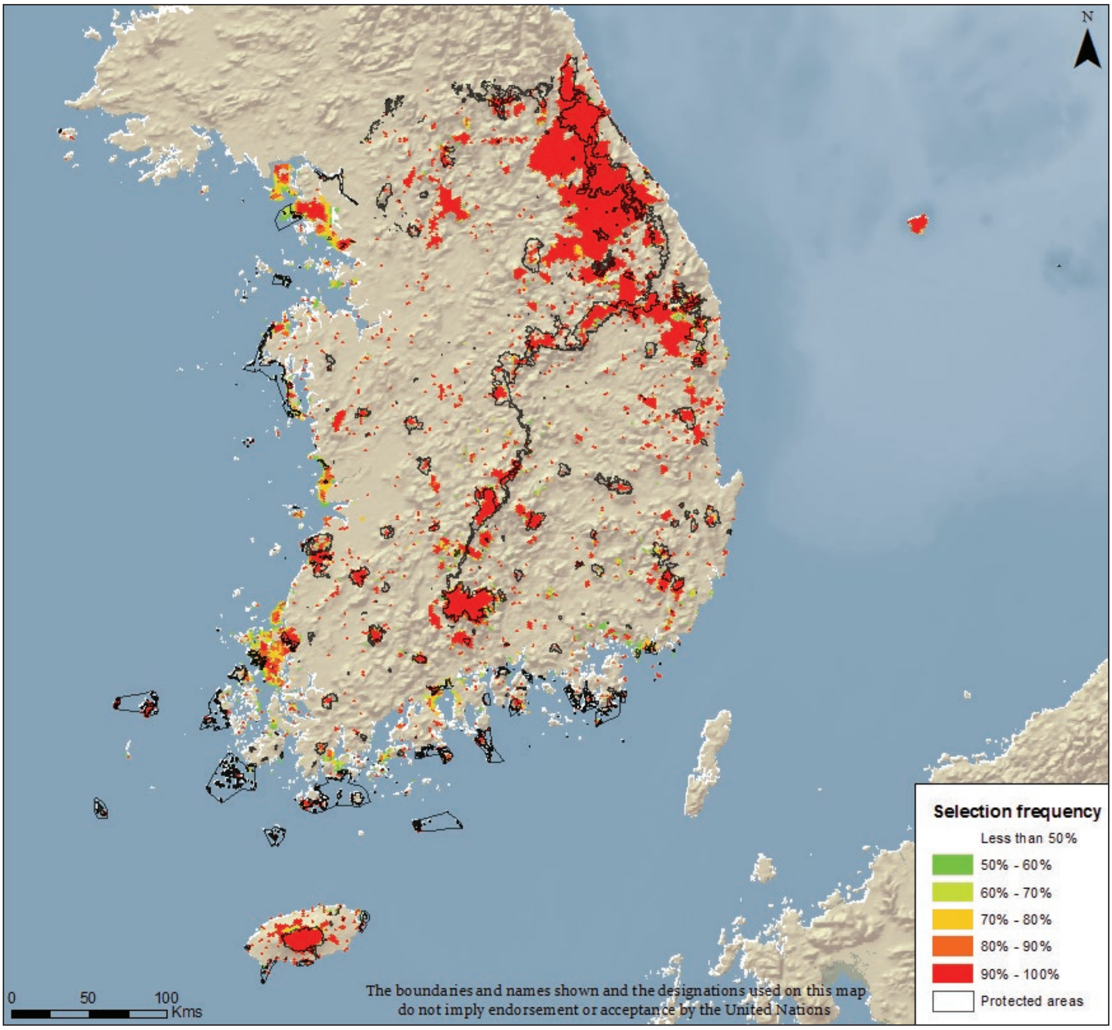

Figure 4.8. *Selection frequency for terrestrial scenario (TS) TS7 and coastal scenario CS702 with location of existing terrestrial and coastal protected areas with. No areas locked in or excluded.*

4.2.2. Assessing achievement of targets

In the terrestrial scenario TS7 the percentage of targets met shifted from 78% to 84% when the tolerance was changed from 99% to 95% (Table 4.6)

Appendix 2 provides an overview of the extent to which some conservation targets have not been met and which conservation features are missing from the proposed network. A final proposed network for protected area expansion should consider these limitations before choosing the priority areas for protected area expansion. However, as explained in section 1.1., the final decision on where to locate new protected areas, or where to expand existing protected areas, is out of the scope of this project and should be informed by a more detailed assessment and a complex stakeholder consultation process.

Table 4.6. *Assessment of target performance for selected scenarios.*

Scenario	All targets	99 % Tolerance		95 % Tolerance	
		Targets met	% Targets met	Targets met	% Targets met
TS7	1048	815	78	884	84
TS9	1232	803	65	935	76
CS702	343	343	100	343	100

4.2. CANDIDATE KEY BIODIVERSITY AREAS

Key Biodiversity Areas are defined as "sites that contribute significantly to the global persistence of biodiversity" (IUCN, 2016). Its identification spans over three decades when BirdLife International started their Important Bird and Biodiversity Areas programme (BirdLife International, 2014). KBA are identified using a globally agreed set of criteria and thresholds that are applied through ideally nationally driven processes. The identification of KBAs requires the assessment of 5 Criteria: A) Threatened Biodiversity, B) Geographically Restricted Biodiversity, C) Ecological Integrity, D) Biological Processes and E) Irreplaceability Through Quantitative Analyses.

Sites identified as KBAs are important for several reasons. They can support the strategic expansion of protected area networks by governments and civil society working toward achievement of the Aichi Biodiversity Target 11 and 12 (Butchart et al., 2012) and the Sustainable Development Goals (Brooks et al., 2015); inform the description or identification of sites under international conventions (such as wetlands of international importance designated under the Ramsar Convention, and natural World Heritage Sites) or inform private sector safeguard policies, environmental standards (Dudley et al., 2014; IUCN, 2016).

Identifying and delineating Key Biodiversity Areas is beyond the scope of this report. However, preliminary candidate areas for Key Biodiversity Areas were identified using KBA criteria A1 Threatened Species only by assessing the location of species that face a risk of extinction globally according to the IUCN Red List of Threatened Species.

Globally threatened species for which there was a known occurrence in the Republic of Korea were identified according to the datasets compiled in this project and its location in relation to protected areas and IBAs assessed (Figure 4.9).

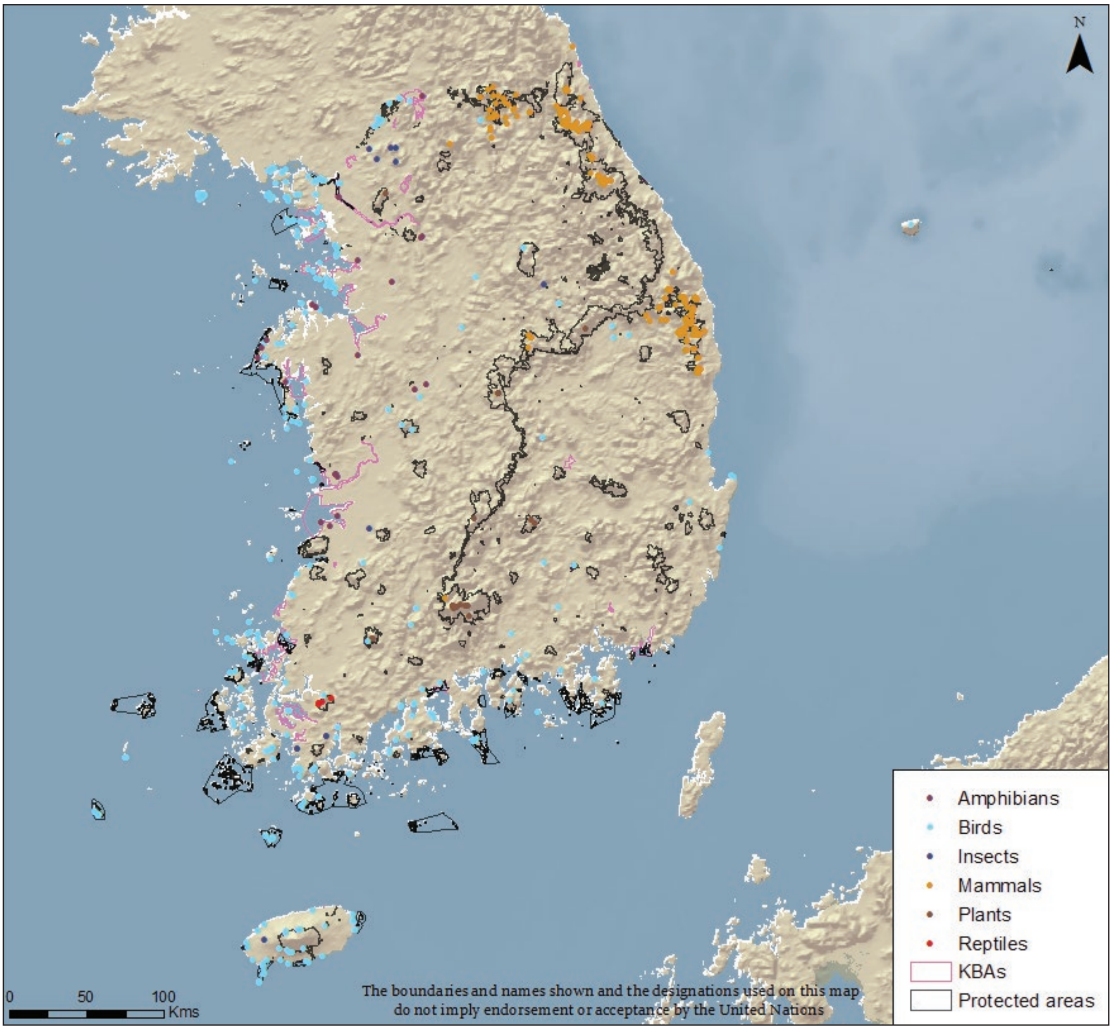

Figure 4.9. *Presence of globally threatened species in the Republic of Korea for different taxonomic groups and location of designated protected areas and currently identified Important Bird and Biodiversity Areas (IBAs).*

The boundaries of protected areas where these species occur can facilitate potential delineation of these globally important sites. Similarly, existing Important Bird and Biodiversity Areas can be documented for other non-bird species. However, identifying the presence of globally threatened species and its priority to KBAs and protected areas is only one step to complete a full KBA identification and delineation process (IUCN, 2016). A comprehensive assessment against the five KBA criteria and a stakeholder consultation is at least needed to identify any additional KBAs to the 40 IBAs already identified in the Republic of Korea.

5. Key Messages

This report carries out a spatial analysis to assess the status of the protected area network of the Republic of Korea and propose priorities for protected area expansion to support the implementation of international and national biodiversity targets. It is a desktop analysis based on biodiversity, conservation area, land cover, threat and constraint data and uses spatial prioritisation software to identify a portfolio of sites that meet pre-defined conservation targets. The results aim to inform decisions on future work on protected area expansion for the Republic of Korea which require wider stakeholder consultation and decisions at a national level that are out the scope of this project.

5.1. CONCLUSIONS

According to the World Database on Protected Area (WDPA), the Protected Area network of the Republic of Korea covers 7.9% of terrestrial and inland areas (7,876.32 km^2) and 4.5% of the coastal areas (3,366.34 km^2). In another recent analyses using a different methodology, the Ministry of Environment of The Republic of Korea reported in 2015 a protected area coverage of 12.6% for terrestrial and inland areas and 6.1% for coastal areas. Both analyses show the Protected Area network falls short of meeting the 17% and 10% marks specified in Aichi Biodiversity Target 11. Although Aichi Target 11 is a global target, in the absence of specific biodiversity targets for protected areas some countries have decided to set this mark as their national target. Based on the WDPA analyses and taking Aichi Target 11 as a national target for Korea, an additional 9,034 km^2 of terrestrial and 4,122 km^2 coastal protected areas would be needed to cover 17% of terrestrial and inland water areas and 10% of coastal areas of Korea.

However, 17% and 10% are politically negotiated values and not scientifically defined end points (Woodley et al., 2012). Research has shown that a considerably larger area will need to be protected to achieve, for example, a global ecologically representative network (Butchart et al., 2015), and there are different strategies to achieve this efficiently (Venter et al., 2014; Montesino-Pouzols et al., 2014). More importantly, an expanded network of protected areas needs to represent adequately all biodiversity, and must take into account the specific biodiversity patterns in each country. To achieve this, some countries might need less than 17% and some countries might need more that 17%. In addition, Aichi Biodiversity Target 11 relates not only to expanding protected areas. There are many other attributes not considered in this project that are crucial to achieving a well-functioning network of protected areas, including, but not restricted to, effective management, connectivity between protected areas, equity and consideration of the contribution of other effective area based conservation measures to the target (Juffe-Bignoli et al., 2014a).

A series of options for protected area expansion are explored in this report by setting conservation targets and testing different spatial configurations. Two of the major outputs from the analyses are a proposed network of sites for each of the scenarios, and the selection frequency (number of times each planning unit is selected in all runs). While the terrestrial results can be considered an adequate representation of biodiversity in the Republic of Korea, the coastal analysis requires more fine-scale data on habitats and species.

The combined solution shown in section 4.2.1 (Figure 4.7) includes protected areas and Key Biodiversity Areas and avoids areas that might conflict with setting new protected areas such as developed areas or agricultural lands. These results show that expanding the boundaries of Korea's current protected areas network will improve representation of biodiversity while enhancing connectivity between protected areas, in a way that generally avoids with high levels of agriculture and human population density. Moreover, the selection frequency for this combined solution (Figure 4.8) with no spatial restrictions - not locking protected areas and Key Biodiversity Areas and not excluding any areas - gives an indication of how well the current protected area network and Key Biodiversity Areas are covering areas of high selection frequency, i.e. areas that are important to meet the predefined conservation targets. While current protected areas are mainly located in areas of high selection frequency some areas of high selection frequency are not within protected areas or Key Biodiversity Areas. These areas need further attention as they may be candidates for expansion or creation of protected areas. They could also be candidates for new Key Biodiversity Areas (see criteria E in IUCN, 2016).

Finally, it is important to stress that solutions and options for protected area expansion are flexible but depend greatly on the conservation targets set and data quality. A different set of targets will provide a different solution. Targets provide a transparent way of defining conservation objectives and a clear end point, but can be subjective or arbitrary if they are not justified and clearly explained. Similarly, more data will improve the quality of the results, thus spatial prioritisation analyses need to be updated and validated periodically to ensure the network adequately conserves and represents biodiversity over time. This is particularly important given the potential future effects of climate change on species ranges.

5.2. RECOMMENDATIONS

The analysis presented here is a starting point for a complex national policy process to determine which areas of the country should be selected for protected area expansion. The methodology and results will prove useful to inform future decisions on how to meet global and national targets for protected areas and biodiversity. The key recommendations from this report are:

- **Consider other elements of Aichi Biodiversity Target 11**: While adequate representation of biodiversity features is important, other elements of Aichi Biodiversity Target 11 need to be considered to achieve a fully functioning protected area system, and to meet Aichi Biodiversity Target 11 such as protected area management effectiveness, connectivity or other effective area based conservation measures.
- **Explore synergies between biodiversity targets**: This report does not evaluate synergies between Aichi Biodiversity Target 11 and other Aichi Targets. Nevertheless, these synergies exist and have been explored (see Di Marco et al., 2015 and Marques et al., 2014). For example, expanding and effectively managing protected areas might help to conserve threatened species (Target 12) and prevent habitat loss (Target 5).
- **Consider other important factors**: Future analyses will need to consider other factors that will impact decisions on where to locate protected areas. These include climate change, long term maintenance of ecological processes to deliver ecosystem services, land use scenarios to assess trade-offs when conflicting uses occur (e.g. designating a new protected area could restrict large-scale development that might have an impact on local economies).
- **Compile better quality data for the marine and coastal ecosystems and species**: A more detailed coastal and marine analysis is needed. Thus, additional species and habitat national data at fine scale needs to become available to fill the gap found in this report and identify potential areas for protected area expansion.
- **Complete a KBA identification process**: this report has highlighted areas where the presence of globally threatened species has been confirmed and identified areas of high selection frequency. Some of these areas are not within designated protected areas or existing Key Biodiversity Areas. These areas need further assessment and could be candidates for new Key Biodiversity Areas under the KBA standard (IUCN, 2016).
- **Consider other approaches**: Target based approaches are not the only option for designating protected area networks under the systematic conservation planning framework. Other approaches, including those based on the decision support tool Zonation for example (Moilanen et al., 2005, Moilanen, 2007), may warrant consideration.
- **Go beyond spatial prioritisation**: The SCP framework was used to identify potential areas for protected area expansion. While the results presented here can inform future steps and decisions on how to meet national and international conservation targets, a wider consultation is needed to prioritise conservation actions and test alternatives for protected areas expansion. Implementation, monitoring and evaluation of actions will be a crucial step in completing a full conservation planning process.

References

Ball, I.R., Possingham H.P., and Watts M. (2009). Marxan and relatives: Software for spatial conservation prioritisation. Chapter 14: Pages 185-195 In Moilanen, A., Wilson, K.A. & Possingham, H.P. editors. 2009. *Spatial Conservation Prioritization: Quantitative Methods and Computational Tools*. Oxford University Press.

Bertzky B., Corrigan C., Kemsey J., Kenney S., Ravilious C., Besançon C. and Burgess B. (2012) *Protected Planet Report 2012: Tracking progress towards global targets for protected areas*. IUCN, Gland, Switzerland and UNEP-WCMC, Cambridge, UK.

BirdLife International (2014). Important Bird and Biodiversity Areas: a global network for conserving nature and benefiting people. BirdLife International, Cambridge, UK.

Birdlife BirdLife International (2015). Important Bird and Biodiversity Area digital boundaries. Retrieved from www.birdlife.org/datazone/info/ibadownload. Accessed on 23/08/2015.

Brooks T.M., Butchart S.H.M., Cox N.A., Heath M., Hilton-Taylor C., Hoffmann M. et al. (2015). Harnessing biodiversity and conservation knowledge products to track the Aichi Targets and Sustainable Development Goals. Biodiversity 16:2-3, 157-174.doi 10.1080/14888386.2015.1075903.

Butchart, S.H.M., Scharlemann, J.P.W., Evans, M.I., Quader, S., Aricò, S., et al. (2012). Protecting important sites for biodiversity contributes to meeting global conservation targets. PLoS One 7: e32529.

Butchart S.H.M, Clarke M., Smith B., Sykes R., Scharlemann J.P.W., Harfoot M. et al. (2015). Shortfalls and solutions for meeting national and global protected area targets. Conservation Letters DOI: 10.1111/conl.12158.

Convention on Biological diversity (CBD) 2010. Convention on Biological Diversity's Strategic Plan for 2020. Montreal: CBD. Available at: www.cbd.int/sp [Accessed 22/07/2015]

Delavenne, J., Metcalfe, K., Smith, R. J., Vaz, S., Martin, C. S., Dupuis, L. et al. (2012). Systematic conservation planning in the eastern English Channel: comparing the Marxan and Zonation decision-support tools. – ICES Journal of Marine Science, 69: 75–83

Di Marco, M., Butchart, S. H. M., Visconti, P., Buchanan, G. M., Ficetola, G. F. and Rondinini, C. (2015), Synergies and trade-offs in achieving global biodiversity targets. Conservation Biology. doi: 10.1111/cobi.12559

Driver A., Sink, K.J., Nel, J.N., Holness, S., Van Niekerk, L., Daniels, et al. (2012). National Biodiversity Assessment 2011: An assessment of South Africa's biodiversity and ecosystems. Synthesis Report. South African National Biodiversity Institute and Department of Environmental Affairs, Pretoria. Available at: http://bgis.sanbi.org/nba/NBA2011_SynthesisReport_medres.pdf

Dudley, N., Boucher, J.L., Cuttelod, A., Brooks, T.M. and Langhammer, P.F. (eds.) (2014). Applications of Key Biodiversity Areas: end-user consultations. Cambridge, UK and Gland, Switzerland: IUCN.

Elith J., and Leathwick J.R. (2009). Species Distribution Models: Ecological Explanation and Prediction Across Space and Time. Annual Review of Ecology, Evolution, and Systematics, Vol. 40: 677 -697

Ferrier, S., R. Pressey, and T. Barrett (2000). A new predictor of the irreplaceability of areas for achieving a conservation goal, its application to real-world planning, and a research agenda for further refinement. Biological Conservation 93:303–325

Game, E. T. and H. S. Grantham. (2008). Marxan User Manual: For Marxan version 1.8.10. University of Queensland, St. Lucia, Queensland, Australia, and Pacific Marine Analysis and Research Association, Vancouver, British Columbia, Canada.

Game, E. T., Lipsett-Moore, G., Hamilton, R., Peterson, N., Kereseka, J., Atu, W. et al. (2011), Informed opportunism for conservation planning in the Solomon Islands. Conservation Letters, 4: 38–46. doi: 10.1111/j.1755-263X.2010.00140.x

Government of Korea (2014). Korea's National Biodiversity Strategy 2014-2018. Available at: https://www.cbd.int/doc/world/kr/kr-nbsap-v3-en.pdf

Heo H.Y. et al. (Ed.) (2007). The Biodiversity and Protected Areas of Korea, Ministry of Environment and Korea National Park Service

Heo H.Y. and Kwon H.G. (2012). Review on the Protected Areas Management Effectiveness Evaluation in Korea-Focus on the Implementation Status and Results. The Journal of Korea Institute of Forest Recreation Welfare, 16(4) (41~57)

IUCN (2012). IUCN Red List categories and criteria: Version 3.1. Second edition. Gland, Switzerland, and Cambridge, UK: IUCN.

IUCN, Ministry of Environment, Korea National Park Service and Jeju Island Special Governing Province (2009). Korea's Protected Areas; Evaluating the effectiveness of South Korea's protected areas system. Available at https://portals.iucn.org/library/sites/library/files/documents/IUCN-2009-035.pdf

IUCN (2014). The First Asia Parks Congress: Report on the Proceedings 13th-17th November 2013, Sendai, Japan. Available at: https://portals.iucn.org/library/sites/library/files/documents/2014-052.pdf.

IUCN and UNEP-WCMC (2015). The World Database on Protected Areas (WDPA) [On-line], October 2015, Cambridge, UK: UNEP-WCMC. Available at: www.protectedplanet.net.

IUCN (2016) A Global Standard for the Identification of Key Biodiversity Areas, Version 1.0. First edition. Gland, Switzerland: IUCN.

IUCN-WCPA (2011). Protected Areas in East Asia: Evaluating and strengthening implementation of the CBD Programme of Work on Protected Areas and the East Asian Regional Action Plan. Gland, Switzerland: IUCN. 48 pp.

Juffe-Bignoli D., Burgess N., Bingham H., Belle EMS., de Lima MG., Deguignet M., et al. (2014a). Protected Planet Report 2014. UNEP-WCMC: Cambridge, UK.

Juffe-Bignoli D., Bhatt S., Park S., Eassom A., Belle EMS, Murti R, et al. (2014). Asia Protected Planet 2014. UNEP-WCMC: Cambridge, UK.

Kremen C., Cameron A., Moilanen A., Phillips S.J., Thomas C.D., Beentje H. et al. (2008). Aligning conservation priorities across Taxa in Madagascar with high-resolution planning tools. Science: 320:222–226.

Kullberg P. and Moilanen A. (2014). How do recent spatial biodiversity analyses support the convention on biological diversity in the expansion of the global conservation area network? (Natureza & Conservacao 2014: 12(1):3-10.

J. MacKinnon and Xie Yan (2008). Regional Action Plan for the Protected Areas of East Asia. Bangkok, Thailand. 82ppMargules, C.R. and Pressey, R.L. 2000. Systematic conservation planning. Nature, 405(6783): 243–53.

Marques, A., Pereira, H. M., Krug, C., Leadley, P. W., Visconti, P., Januchowski-Hartley, et al. (2014). A framework to identify enabling and urgent actions for the 2020 Aichi Targets Basic and Applied Ecology 15(8) 633-638

Ministry of Envrionment of the Republic of Korea (2014a). Korea's National Biodiversity Strategy 2014-2018. Available at: https://www.cbd.int/doc/world/kr/kr-nbsap-v3-en.pdf

Ministry of Environment of the Republic of Korea (2014b). The fifth National Report to the Convention on Biological Diversity. Available at: https://www.cbd.int/doc/world/kr/kr-nr-05-en.pdf

Ministry of Environment of the Republic of Korea (2015). National Road Map on Expanding Protected Area and Improving Its Management for Implementing CBD Recommendations (in Korean).

Moilanen, A., Franco, A.M.A., Early, R., Fox, R., Wintle, B., and Thomas, C.D. (2005). Prioritising multiple use landscapes for conservation: methods for large multi species planning problems. Proc. R. Soc. Lond. B Biol. Sci., 272: 1885-1891.

Moilanen, A. (2007). Landscape Zonation, benefit functions and target-based planning. Unifying reserve selection strategies. Biological Conservation, 134: 571-579.

Moilanen, A., Wilson, K.A. & Possingham, H.P. editors. (2009). Spatial Conservation Prioritization: Quantitative Methods and Computational Tools. Oxford University Press.

Moilanen, A., Meller, L., Leppänen, J., Montesino Pouzols, F., Arponen, A. & H. Kujala. (2014). Zonation – Spatial conservation planning methods and software. Version 4. User Manual.

Montesino- Pouzols FM, Toivonen T, Di Minin E, Kukkala A, Kullberg P, Kuusterä et al (2014). Global protected area expansion is compromised by projected land-use and parochialism. Nature 516:383–386.

Nhancale B. and Smith R., (2011). The influence of planning unit characteristics on the efficiency and spatial pattern of systematic conservation planning assessments. Biodivers Conserv (2011) 20:1821-1835.

Possingham, H.P., Ball, I.R. and Andelman, S. (2000). Mathematical methods for identifying representative reserve networks. In: Quantitative Methods for Conservation Biology. (Eds S. Ferson & M. Burgman), pp. 291–305. Springer, New York.

Pressey, R.L. and Bottrill, M.C. 2009. Approaches to landscape- and seascape-scale conservation planning: convergence, contrasts and challenges. Oryx, 43(04): 464.

Sarkar, S., Pressey, R.L., Faith, D.P., Margules, C.R., Fuller, T., Stoms, D.M et al. (2006). Biodiversity conservation planning tools: Present status and challenges for the future. Annual Review of Environment and Resources, 31: 123–159.

Smith, R.J. (2015). CLUZ for QGIS guide. Unpublished report. < https://anotherbobsmith.wordpress.com/software/cluz/>

Smith, R.J., Goodman, P.S. and Matthews, W.S. 2007. Systematic conservation planning: a review of perceived limitations and an illustration of the benefits, using a case study from Maputaland, South Africa. Oryx, 40(04): 400.

Smith, R.J., Easton, J., Nhancale, B.A., Armstrong, A.J, Culverwell, J., Dlamini, S. et al. (2008). Designing a transfrontier conservation landscape for the Maputaland centre of endemism using biodiversity, economic and threat data. Biological Conservation, 141, 2127-2138.

Syakur, A. et al. (2012) 'Ensuring local stakeholder support for marine conservation: establishing a locally-managed marine area network in Aceh', Oryx 46(4): 516-24.

Venter O., Fuller R.A., Segan D.B., Carwardine J,. Brooks T., Butchart S.H.M., et al. (2014). Targeting Global Protected Area Expansion for Imperiled Biodiversity. PLoS Biology 12:e1001891.

Watts, M.E., Ball, I.R., Stewart, R.S., Klein, C.J., Wilson, K., Steinback, C. et al. 2009. Marxan with Zones: Software for optimal conservation based land- and sea-use zoning. Environmental Modelling & Software, 24(12): 1513–1521.

Woodley S., Bertzky B., Crawhall N., Dudley N., Londono J.M., MacKinnon K., et al. (2012).'Meeting Aichi 11: What Does Success Look Like For Protected Area Systems?' PARKS 18(1): 23-36.

Appendix 1: Results of protected areas gap analyses

Table 1. *Amount of the different conservation categories in protected areas in the terrestrial realm.*

Dataset	Category	Terrestrial amount	Amount in terrestrial PAs	Proportion in terrestrial PAs (%)
Forest age (km²)	50 years	7,800.22	767.22	9.84%
	60 years	4,426.81	1,665.96	37.63%
	70 years	1,142.00	692.25	60.62%
	90 years	0.04	0	0.00%
	Total	**13,369.07**	**3,125.43**	**23.38%**
Vegetation types (km²)	I High conservation value	2,180.02	1,087.16	49.87%
	II Close to natural vegetation	10,558.94	2,852.22	27.01%
	Total	**12,738.96**	**3,939.38**	**30.92%**
Species inside/outside protected areas (number of species)	Endangered 1	20	7	35.00%
	Endangered 2	110	69	62.73%
	Natural Monument	10	9	90.00%
	Endangered 1 and NM	10	9	90.00%
	Endangered 2 and NM	14	8	57.14%
	Endemic/Rare plant/Restricted	373	361	96.78%
	Total	**537**	**463**	**86.22%**
Geographic features (features)	Strict conservation is required	154	94	61.04%
	Conservation is required	200	73	36.50%
	Total	**354**	**167**	**47.18%**
Tidal flats (km²)	Tidal flats	396.93	51.93	13.08%
Key Biodiversity Areas (km²)	Important Bird Areas	458.97	25.58	5.57%
Land cover (km²)	Wetland (km²)	2,440.45	50.29	2.06%
Seaweed (species)	Seaweed	172	94	54.65%
Seagrass (species)	Seagrass	1	1	100%

Table 2. *Amount of the different conservation categories in protected areas in the coastal realm.*

Dataset	Category	Coastal amount	Amount in coastal PAs	Proportion in coastal PAs (%)
Coastal Conservation Class (km^2)	Coastal class I	23,288.52	1,581.41	6.79%
	Coastal class II	15,839.63	507.83	3.21%
	Coastal class III	765.58	50.62	6.61%
	Total	**39,893.73**	**2,139.86**	**5.36%**
Fishery in shallow water (km^2)	Aquaculture	1,161.87	118.77	10.22%
	Community fishery	439.16	49.3	11.23%
	Coastal fishery	50.34	0.69	1.37%
	Total	**1,651.37**	**168.76**	**10.22%**
Seaweed (species)	Seaweed	254	141	55.51%
Seagrass (species)	Seagrass	3	1	33.33%
Species inside/outside protected areas (number of species)	Endangered 1	4	2	50.00%
	Endangered 2	30	13	43.33%
	Endangered 1 and NM	3	2	66.67%
	Endangered 2 and NM	8	4	50.00%
	Natural Monument NM	2	2	100.00%
	Endemic/Rare plant/Restricted	5	4	80.00%
	Total	**52**	**27**	**51.92%**
Geographic features (features)	Strict conservation is required	36	18	50.00%
	Conservation is required	41	16	39.02%
	Total	**77**	**34**	**44.16%**
Tidal flats (km^2)	Tidal flats	2,619.53	265.73	10.14%
Key Biodiversity Areas (km^2)	Important Bird Areas	1,564.55	149.63	9.56%
Land cover (km^2)	Wetland (km^2)	500.35	42.77	8.55%

Appendix 2: Spatial prioritisation results

This appendix is divided in two sections. Section 2.1. presents the results for the terrestrial and inland water areas and analyses while section 2.2. does the same for the coastal areas analyses. Each section is structured in 3 subsections: i) Developing scenarios (which scenarios were tested), ii) Selecting additional conservation areas (settings for the spatial prioritisation analyses and results for the selected scenarios), and iii) Assessing the achievement of targets (to what extent targets were met in the selected scenarios)

2.1. TERRESTRIAL AND INLAND WATER AREAS

2.1.1. Developing scenarios

Nine terrestrial target scenarios (TS) with different increasing targets were developed for conservation features found in terrestrial and inland water areas (See Table 1 in Appendix 2).

Table 1. *Criteria used in the different runs to test options for terrestrial scenarios (TS).*

	Terrestrial Scenarios (TS)								
Criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Increase current representation in protected areas of conservation features important by law									
Increase representation from previous scenario									
Increase representation from previous scenario of species and geographic features identified as important in NBSAPs and/or National Reporting to CBD									
Increase representation from previous scenario									
Increase representation from previous scenario of habitats: forest age, vegetation types, tidal flats, and wetlands.									
Increase representation from previous scenario									
Increase representation from previous scenario of wetlands									
Increase representation from previous scenario									
Increase representation from previous scenario									

2.1.2. Selecting additional conservation areas

Table 2 shows the settings for running the Marxan software through the CLUZ interface. The results of the analyses are presented in Table 3. For each of the scenarios four different settings were tested:

Setting 1 – No areas locked in or excluded.
Setting 2 - Protected areas locked in.
Setting 3 - Protected areas and Key Biodiversity Areas locked in.
Setting 4 – Protected areas and Key Biodiversity Areas locked in. Areas where more than 60% of a planning unit occupied by developed areas, bare grounds, artificial water bodies, artificial grasslands, and agricultural areas excluded.

Table 2. *Marxan settings for the terrestrial scenarios (TS) TS405, TS7, TS9: (spf: Species penalty factor; blm: boundary length modifier).*

Number iterations	Number runs	Cost	spf	blm	Description
10 millions	1,000	Population density	10	0.001	Protected areas and Key Biodiversity areas locked in. Areas where more than 60% of a planning unit occupied by developed areas, agricultural areas, bare grounds, artificial grasslands and artificial water bodies excluded

Table 3. *Results of spatial prioritization analysis for three selected terrestrial scenarios (TS) for the settings described in Table 2 of this appendix.*

Terrestrial scenario	Number of PU total	Final area (km²)	Targets met (%)	% of the country's terrestrial area	Additional PA area (km²)
TS405	8,550	17,242	90%	17.3	9,366
TS7	10,431	21,345	78%	21.5	13,469
TS9	20,889	46,133	65%	46.4	38,258
			Amount held		
			In proposed network after analyses		
Conservation feature	**Terrestrial amount**	**Currently in PAs**	**TS405**	**TS7**	**TS9**
Forest age (km²)	13,369	3,125	4,638	6,146	10,630
Number geographic features	354	167	301	289	298
- Strict conservation is required	154	94	139	135	139
- Conservation is required	200	73	162	154	159
Wetland (km²)	2,440	50.29	356	322	792
Number of species	537	463	528	7,526	526
- Endangered 1	20	7	19	19	19
- Endangered 2	110	69	104	104	104
- Natural Monument (NM)	10	9	10	10	10
- Endangered 1 and NM	10	9	10	8	8
- Endangered 2 and NM	14	8	14	14	14
- Endemic/rare plant/restricted	373	361	371	371	371
Tidal flat (km²)	397	52	169	166	236
Vegetation (km²)	44,257	6,214	10,812	13,950	29,253

2.1.3. Assessing the achievement of targets

Table 4 presents an assessment of the achievement of conservation targets under different levels of tolerance and identifies the conservation features missing from the proposed network for each terrestrial scenario (TS).

Table 4. *Assessment of achievement of targets under different tolerance and conservation features missing from the proposed terrestrial networks (TS): TS4, TS7 and TS 9 for the settings described in Table 2 of this appendix.*

		99 % Tolerance		95 % Tolerance	
Scenario	**Targets**	**Targets met**	**% Targets met**	**Targets met**	**% Targets met**
TS4	1,766	1,594	90%	1,595	90%
- 13 species, including one species of bird listed on the global IUCN Red List as Vulnerable *Aquila heliaca* - 57 geographic features: 19 categorized as conservation class I and 38 as conservation class II					
		99 % Tolerance		**95 % Tolerance**	
Scenario	**Targets**	**Targets met**	**% Targets met**	**Targets met**	**% Targets met**
T7	1,048	815	78%	884	84
What is missing: - 13 species, including one species of bird listed on the global IUCN Red List as Vulnerable *Aquila heliaca* - 59 geographic features: 20 categorized as conservation class I and 39 as conservation class II					
		99 % Tolerance		**95 % Tolerance**	
Scenario	**Targets**	**Targets met**	**% Targets met**	**Targets met**	**% Targets met**
TS9	1,232	803	65	935	76
What is missing: - 13 species, including one species of bird listed on the global IUCN Red List as Vulnerable *Aquila heliacal* - 17 geographic features: 5 categorized as conservation class I and 12 as conservation class II					

2.2. COASTAL AREAS

2.2.1. Developing scenarios

Ten coastal target scenarios (CS) were developed for coastal areas assigning targets to conservation features identified as coastal (Table 5).

Table 5. *Criteria used in the different runs to test options for coastal scenarios (CS).*

	Coastal Scenarios (CS)									
Criteria	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Legally protected coastal species with less than ten points										
Legally protected species between 10-50 points										
Legally protected coastal species between 50-100 points, specific species, geographic features I, coastal area CV I.										
Legally protected coastal species with more than 100 points, geographic feature II										
Tidal flats										
Increase representation from previous scenario										
Inland wetland and fresh waterbodies										
Increase representation from previous scenario										
Increase representation from previous scenario										
All conservation features										

2.2.2. Selecting additional conservation areas

Table 6 shows the settings for running the Marxan software through the CLUZ interface. The result of the analyses are presented in Table 7. As with the terrestrial analyses, for each coastal scenario, the conservation target or amount of protection assigned to each conservation feature increased. Each of the scenarios were run under four different settings:

Setting 1 - No areas locked in or excluded.
Setting 2 - Protected areas locked in.
Setting 3 - Protected areas and Key Biodiversity areas locked in.
Setting 4 – Protected areas and Key Biodiversity areas locked in. Fisheries areas excluded.

Table 6. *Marxan settings for the coastal scenarios (CS) CS501, CS702 and CS1001: (spf: Species penalty factor; blm: boundary length modifier).*

Number iterations	Number runs	Cost	spf	blm	Description
10 million	1,000	Area (km²)	10	0.001	Protected areas and Key Biodiversity areas locked in. Fisheries areas excluded.

Table 7. *Results of spatial prioritization analysis for three selected coastal scenarios (CS) for the settings described in Table 6 of this appendix.*

Coastal scenario	Number of PU total	Final area (km²)	Targets met (%)	% of the country's coastal area	Additional PA area (km²)
CS501	4,529	8,641.74	100%	11.5%	5,278.33
CS702	3,999	7,468.81	100%	10.0%	4,105.40
CS1001	6.557	11,597.04	99.7%	15.5%	8,223.63
			Amount held		
			In proposed network after analyses		
Conservation feature	**Total**	**Currently in PAs**	**CS501**	**CS702**	**CS1001**
Coastal conservation value 1 (km²)	**23,288.52**	**1,581.41**	**4,666.60**	**3,500.86**	**5,160.41**
Tidal flat (km²)	2,619.53	265.73	1,424.77	1,338.85	2,607.87
Seaweed species	**294**	**294**	**294**	**294**	**294**
Seagrass species	**3**	**3**	**3**	**3**	**3**
Number of species	**52**	**27**	**43**	**42**	**45**
- Endangered 1	4	2	3	3	4
- Endangered 2	30	13	23	22	23
- Natural Monument (NM)	2	2	2	2	2
- Endangered 1 and NM	3	2	3	3	3
- Endangered 2 and NM	8	4	7	7	8
- Endemic/rare plant/restricted	5	4	5	5	5
Number of Geographic features	**77**	**34**	**51**	**49**	**69**
- Strict conservation is required	36	18	24	24	32
- Conservation is required	41	16	25	25	37
Wetland (km²)	**500.35**	**42.77**	**272.97**	**264.22**	**398.42**

2.2.3. Assessing the achievement of targets

Table 8 presents an assessment of the achievement of conservation targets under different levels of tolerance for each of the costal scenarios (CS).

Table 8. *Assessment of achievement of targets under different tolerance and conservation features missing for the proposed coastal networks: CS501, CS 702, CS1001 for the settings described in Table 6 of this appendix.*

		99 % Tolerance		95 % Tolerance	
Scenario	**Targets**	**Targets met**	**% Targets met**	**Targets met**	**% Targets met**
CS501	341	341	100%	341	100
CS702	343	343	100%	343	100
CS1001	343	342	99%	343	100

NOTES

www.unep.org

United Nations Environment Programme
P.O. Box 30552 - 00100 Nairobi, Kenya
Tel.: +254 20 762 1234
Fax: +254 20 762 3927
e-mail: publications@unep.org
www.unep.org

UNEP WCMC