Application of GIS for data preparation and modeling for coastal and marine conservation planning in Madagascar

Outline

- Background of coastal and marine conservation
- Species distribution modeling (SDM)
- Reserve selection analysis
- Results & discussion
Background of coastal and marine conservation in Madagascar

Madagascar National Conservation Policy

Millenium Development (Objective n° 7)

Commitment of the parties of the “CBD”: conservation of 10% of the country.

Objectives of the 5th World Parks Congress (Durban 2003) to maintain 20 to 30% of each ecosystem

Target for Madagascar: Select at least 1 million ha of new marine protected area
Protected Areas System in Madagascar

<table>
<thead>
<tr>
<th>Existing PAs</th>
<th>Terrestrial</th>
<th>Marine &amp; Coastal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number</td>
<td>131</td>
<td>14</td>
</tr>
<tr>
<td>Area (ha)</td>
<td>6 375 393</td>
<td>539 316</td>
</tr>
</tbody>
</table>

Goal

Demonstration of GIS application in each step of Conservation Planning

Data preparation for Conservation Planning and Species Distribution Modeling
Conservation Planning

Madagascar’s target: Select at least 1 million ha of new marine protected area

**HOW?**

Identification of priority sites network for conservation

Appropriate technical approach


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**Data sources**
- Publications, Research reports, Data Online, Institutions...
- Website, Experts in Remote sensing

**Decisions**
- Conservation Management

**GIS Data**
- Focal Species Occurrence Data
- Environmental layers data

**Species Distribution Modeling**
- Habitats: Reefs & Mangrove

**Reserve Selection Analysis**
Species Distribution Modeling

Data sources
- Publications, Research reports, Data Online, Institutions...
- Website, Experts in Remote sensing

Focal Species Occurrence Data
GIS Data
Environmental layers data
Species Distribution Modeling

Decisions
Conservation Management
Reserve Selection Analysis

Habitats: Reefs & Mangrove
Species Distribution Modeling

Software « MaxEnt »

Data standardization (ArcView3.2 & Microsoft office)

Environmental layers

Results

“MaxEnt”

(Maximum Entropy modelling) software

Goal: Prediction of species’ geographical distributions under different environmental scenarios
[Niche modeling (SDM), take point occurrence data and turn into species distribution maps]

Input: Species occurrence & Env. Layers

Result: Habitat suitability map of species occurrence

http://www.cs.princeton.edu/~schapire/maxent/
Environmental variables as potential predictors of coastal and marine species habitat distribution:

- Sea surface Temperature (SST)
- Photosynthetically Active Radiation (PAR)
- Chlorophyll Pigment concentration
- Wind Speed
- Bathymetry
- Surface Current velocity
- Ultraviolet radiation
Occurrence data:
Data importation & Conversion
Madagascar projected projection
Madagascar Laborde (m)
Rainbow Butterfly Fish
*Chaetodon trifasciatus*

Probability of occurrence

Species distribution modeling
Reserve Selection Analysis

Data sources
- Publications, Researches reports, Data Online, Institutions...
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Focal Species Occurrence Data

Environmental layers data

GIS Data

Species Distribution Modeling

Decisions
- Conservation Management

Habitats: Reefs & Mangrove

Reserve Selection Analysis
**Conservation Planning**

**Software** « Zonation »

**Data preparation** (use of ArcView3.2 & Microsoft office) *e.g. mask*

**Result**

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**“Zonation”**

Software for Spatial Conservation Prioritization

**Goal**: to identify important areas for retaining high habitat quality and connectivity for multiple biodiversity features (providing a quantitative method for enhancing species.)

**Input**: Species data *(result of SDM)*; mask layers; habitats (mangroves & coral reefs)

**Result**: Quantitative reserve planning

Data preparation for Zonation setup:
Creation of Mask = EEZ (Exclusive Economic Zone) + PA (Protected areas)

Illustration

Data preparation / GIS tools

Data acquisition
Data analysis
Data visualization

Mapping

Warning:
1) Extent and cell size!
2) ascii format: check header!
Structural alteration
Result & discussion
Species Distribution Modeling

Environmental layers data

Focal Species Occurrence Data

GIS Data

Species Distribution Modeling

Reserve Selection Analysis

Decisions
Conservation Management

Data sources

Publications, Researches reports, Data Online, Institutions…

Website, Experts in Remote sensing

Habitats: Reefs & Mangrove

Output

Hierarchical solution of quantitative reserve planning

Coastal and marine potential sites

Reserve planning solution:
- The best 2 %
- The best 2 - 5 %
- The best 5 - 10%
- The best 10 - 25 %
- The best 25 - 50 %
- The best 50 - 80 %
- The best 80 - 100 % (the least valuable 20 %)
Cautions

National scale:
Large grid ≈ 5 km x 5 km

The priority areas are simply proposals
Additional expert opinion
Stakeholder opinion

This map identifies broad regions
Ground-truth
Fine-tune at local scale.

Summary

• Data collection
• Data analysis
• Species Distribution Modeling
• Reserve selection analysis
• Results & discussion
**Next step**

**Additional inputs:**

**Socio-economic data:**
Shipping routes; Fisheries …

**Climate change parameter (coral reef vulnerability index)** ongoing study

**Acknowledgement**

- SCGIS
- ESRI
- Steven Phillips
- Atte Moilanen
- UC Berkeley
- WCS Global Marine Program
- WCS Madagascar Program
- All data providers
- REBIOMA Staffs
- MacArthur Foundation
Misaotra tompoko!
### Focal species for modeling (Occurrence data ≥ 7)

<table>
<thead>
<tr>
<th>Taxons</th>
<th>Focal species</th>
<th>Focal species for modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crustacea</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>Echinodermata</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Fishes</td>
<td>111</td>
<td>63</td>
</tr>
<tr>
<td>Marine mammals</td>
<td>12</td>
<td>4</td>
</tr>
<tr>
<td>Shellfish</td>
<td>59</td>
<td>26</td>
</tr>
<tr>
<td>Seabirds</td>
<td>16</td>
<td>8</td>
</tr>
<tr>
<td>Coastal birds</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Turtles</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>233</strong></td>
<td><strong>110</strong></td>
</tr>
</tbody>
</table>

### Criteria of focal species selection:

- **Biological aspect**: (rarity, endemism, IUCN status, important ecological function, various conventions, ...)

- **Socio-economic aspect**: (threat and vulnerability to fishing, ...)

### Focal Species Identification:

November 2009 – July 2010
"removal mask layer" The goal is to give values:
« 1 » for PA (be removed last);
« 0 » for EEZ (normal)
« 2 » for the remainder (will be removed first)