EASCongress/WP/2015/10

Global Targets
Local Benefits

Setting the Sustainable Development Agenda for the Seas of East Asia beyond 2015

16-21 November 2015

Pre-Congress Event

2nd International Training Program on Marine Ecosystem Services Valuation and Spatial Management Tools

CO-CONVENING AGENCIES:

KMI

PEMSEA

CO-SPONSORS:

MINISTRY OF OCEANS AND FISHERIES

KOEM

East Asian Seas Congress 2015

"Global Targets – Local Benefits: Setting the Sustainable Development Agenda for the Seas of East Asia beyond 2015"

Da Nang City, Viet Nam, 16-21 November 2015

Pre-Congress Event

2nd International Training Program on Marine Ecosystem Services Valuation and Spatial Management Tools

16 November 2015

Organized by:

Korea Maritime Institute
&
Partnership in Environmental Management for Seas of East Asia

Sponsored by:

Ministry of Oceans and Fisheries
and
Korea Marine Environment Management Corporation

1. BACKGROUND AND OBJECTIVES

1.1 In November 2013, a group of experts from Asian countries and Western communities had a meaningful meeting on ecosystem service valuation and its application to marine spatial planning and management. Organized by the Korea Maritime Institute (KMI) and Partnerships in Environmental Management for Seas of East Asia (PEMSEA), the experts shared experiences on ecosystem service valuation and development of spatial management tools, and discussed how to incorporate the valuation process into spatial planning and management mechanism. It was, in the Asian region, the first meeting on ecosystem service valuation and its application to spatial management. Participants recognized the importance of developing management tools, as well as capacity building on the use of these tools.

In line with efforts on capacity building, the 1st training program was organized in 2014 by the Korea Maritime Institute (KMI) in cooperation with PEMSEA, Marine InVEST and PacMARA. Twenty trainees from China, Cambodia, Indonesia Philippines, and RO Korea participated in the said training. Following the training, the 2nd International Workshop on Marine Ecosystem Valuation Spatial Management Tools was also organized. Issues were identified in developing the management tools and institutionalizing them as part of the national policy regime.

At the workshop, enhancement of international networking and cooperation was firmly acknowledged as a common base that would contribute to tackling the issues.

Following the first training, the 2nd training program which was held as one of the pre-EAS Congress events on November 16, 2015 aimed to introduce participants on some of the valuation and spatial management tools applied in Korea and encourage more experts and practitioners to develop, adopt and apply these tools in their respective sites. It was emphasized that a more thorough training will be conducted in 2016 to discuss, in detail, the tools and methodologies.

The Training Program on Marine Ecosystem Valuation and Spatial Management Tools was attended by over 40 participants from various countries including Cambodia, China, DPR Korea, Lao PDR, Malaysia, RO Korea, Thailand, Timor-Leste, United Kingdom, Vietnam, Indonesia and. The special pre-congress event brought together academia, government and practitioners to encourage the wider application of tools and methodologies in other sites and countries in the East Asian region and globally.

1.2 Dr. Jungho Nam of the Korea Maritime Institute (KMI) opened the training by highlighting the importance of the tools, their utilization at a local level, and the significance of this particular pre-congress event.

1.3 Mr. Stephen Adrian Ross, Executive Director of PEMSEA, reiterated Dr. Nam's remarks, encouraging the participants to go beyond the training and facilitate the application of the tools on the ground. He encouraged KMI to develop the training into an annual event to strengthen knowledge and skills among the members of the PEMSEA Network of Learning Centers and other partners for application in new ICM sites.

1.4 A training kit was prepared by the KMI (Annex 1) which contains the updated program, MS PowerPoint presentations made during the training as well as the list of participants.

2. COURSE 1: MARINE ASSESSMENT AND PLANNING SUPPORT SYSTEM-MARINE SUITABILITY ASSESSMENT (MAPS-MSA)

2.1 Dr. Nam (KMI) presented an overview of the purpose of Marine Suitability Assessment and how it can be utilized to support decisionmaking on coastal and marine spatial planning and management. He highlighted how it can be applied to ICM local plans and then provided an overview of the major steps which include the preparation, planning area delineation & grid setting, data collection and pre-processing, score calculation & integration, standardization of scores, and spatial classification. Dr. Nam took the participants through a case study of

Gamak-bay, RO Korea, indicating how each of the major steps were applied to a real-world situation. He concluded the course by discussing the potential applications of MAPS-MSA which included zoning, Environmental Impact Assessments, and designation of Marine Uses.

3. COURSE 2: MARINE ASSESSMENT AND PLANNING SUPPORT SYSTEM-SPATIAL ECOSYSTEM VALUATION (MAPS-SEV)

3.1 Professor. Daesok Kang of Pukyong National University, focused on Ecosystem Service Valuation and how the concept of Emergy can be utilized as a biophysical approach to The Economics of Ecosystems and Biodiversity (TEEB) – a global initiative focused on “making nature's values visible”. Prof. Kang explained how energy could be used as a common currency to compare different resources.

In using a biophysical approach to value the contributions of ecosystem services to the wealth of the economy, it attempts to include both human and nature’s contributions in producing these services. He explained that emergy evaluates the work previously done to make a product or service and that it measures energy used in the past making reference to solar emergy, wind emergy and gold emergy.

Examples of emergy indices such as population carrying capacity and the Emergy sustainability index (ESI) were also explained. Prof. Kang went on to elaborate how Emergy valuation using spatial information on natural capital and ecosystem services of marine and coastal ecosystems could be useful in decisionmaking in marine spatial planning. He discussed the tools (GIS and MS Excel) needed for MAPS-SEV implementation and who should be involved in the MAPS-SEV process.

Prof. Kang took participants through the process using a case study of Gyeonggi Bay, RO Korea, which was chosen as a demonstration site for MAPS-SEV as there were multiple uses and conservation needs in the area, as well as heavy development pressure. In conclusion, he presented the potential uses of ecosystem value maps produced by MAPS-SEV which included spatial decision making on priority conservation areas, trade-off analysis, reference data for potential compensation and environmental taxes, integration of natural capital and ecosystem services into EIA’s, cost-benefit analysis of development proposals, raising awareness and education on the importance of marine and coastal ecosystems.

4. COURSE 3: MARINE INTEGRATED VALUATION OF ENVIRONMENTAL SERVICES AND TRADEOFFS (INVEST)

4.1. Dr. Choong-Ki Kim of the Korean Environment Institute (KEI) gave an introduction to Natural Capital Approach and described ecosystem service assessment tools such as ARIES, ESValue, EcoMetrix and InVest. Dr. Kim focused on InVest as a tool to quantify, map and value the benefits provided by terrestrial, freshwater and marine systems. He provided examples of

InVEST Models which are useful for examining how actions taken today play out into the future through the use of scenarios. Dr. Kim demonstrated how InVEST was utilized for marine spatial planning using two examples. The first made reference to MSP in Vancouver Island, Canada using recreation and tourism data. The second demonstrated how InVEST was used to develop an integrated coastal zone management plan in Belize and to use the tool for future EIA assessments for the coastal zone. Finally, Dr. Kim presented a case study on the issue of natural capital management in Jeju and how an ecosystem service model could be applied for decisionmaking.

5. CLOSING OF THE TRAINING PROGRAM

5.1 In closing, Dr. Nam of KMI stated that this one-day training program only provided an introduction to the tools presented. He announced the call for applications to the 3rd Training Program on Marine Ecosystem Services and Spatial Planning Tools to be held in the second quarter of 2016 in Busan, RO Korea, which aims to strengthen the understanding of implementers and professionals on the various decision-support tools for marine valuation and marine spatial planning. As part of the training, hands-on exercises will be conducted by trainers to familiarize the participants on the tools and how these can be used in marine spatial planning. Further, participants were encouraged to submit abstracts to the 4th International Workshop on Marine Ecosystem Services and Spatial Planning which will focus on the challenges and perspectives in mainstreaming marine ecosystem services into marine spatial policy of coastal states. Full papers from the event are expected to be published in a special edition of international journals.

6. SUGGESTIONS MADE TO IMPROVE THE NEXT FULL TRAINING PROGRAM

6.1 Dr. Nam encouraged participants to provide suggestions on how the next training program can be more effectively conducted. The following were provided during the training. CCRES also provided some input after the training, for consideration of the KMI:

- Longer period for training to cover the topics more thoroughly. KMI should also consider two levels of training for technical staff (longer) and for decisionmakers/policymakers (1 day)
- Proper targeting of participants for technical training to ensure that participants will have basic knowledge, for instance on GIS, in the case of mapping.
- Identifying topics and tools for training, and focusing on those which has wider acceptance. The training on EMERGY should be carefully reconsidered considering its acceptance among implementers.

6.2 At the end of the training, training certificates were provided to the participants by KMI.

ANNEX

TRAINING KIT

2nd International Training Program on Marine Ecosystem Services Valuation and Spatial Management Tools

Da Nang City, Viet Nam • 16 November 2015

Co-Organizers

KMI PEMSEA

Co-Sponsors

MOF KOEM

Toolkit

2nd International Training Program on Marine Ecosystem Services Valuation and Spatial Management Tools

Da Nang City, Viet Nam • 16 November 2015

Organized by
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Sponsored by
Ministry of Oceans and Fisheries
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Korea Marine Environment Management Corporation

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Introduction of 2nd Training Program

1. Backgrounds and Objectives

A group of experts from Asian countries and Western communities, in November of 2013, had a meaningful meeting on ecosystem service valuation and its application to marine spatial planning & management. The experts shared experiences on ecosystem service valuation and development of spatial management tools, and discussed how to incorporate the valuation process into spatial planning & management mechanism. It was, in Asian region, the first meeting dealing with ecosystem service valuation and its application to spatial management. All attendants recognized importance of development of sophisticated management tools, and as well capacity building.

In line with capacity building, the 1st training program was organized by Korea Maritime Institute (KMI) in cooperation with PEMSEA, Marine InVEST and PacMARA. 20 trainees participated in the training program from Korea, China, Cambodia, Indonesia Philippines, and enjoyed learning of spatial management tools developed by KMI, Marine InVEST, and PacMARA. Organizers and trainers had encouraged trainees to challenge a development of the tools for their countries. Also, all trainees and experts attended the 2nd International Workshop on Marine Ecosystem Valuation and Spatial Management Tools. Issues were identified in developing the management tools and institutionalizing them in national policy regime. Enhancement of international networking and cooperation was firmly acknowledged as a common base that would contribute to tackling the issues.

Trainees and experts will also attend the 3rd International Workshop on Marine Ecosystem Valuation and Spatial Management Tools to discuss the linkage between valuation of coastal ecosystem services and benefits and coastal use zoning and other tools, and how they are used to support better planning and management of coastal and marine areas and resources, to provide social and economic benefits for coastal communities.

2. Program

08:00 - 08:30	***REGISTRATION***

Opening Ceremony and Introduction to the program

08:30 – 08:50	Opening Ceremony

- Opening Remarks (KMI)
- Welcoming Remarks (PEMSEA)
- Congratulatory Remarks (MOF, RO Korea)
- Congratulatory Remarks (KOEM, RO Korea)

08:50 – 09:00	Introduction to the program

- Backgrounds and Objectives
- Overview of the course
- Expected outputs

Course 1: Marine Assessment and Planning Support System – Marine Suitability Assessment (MAPS-MSA)

09:00 – 10:30	Instructor: Dr. Jungho NAM (Korea Maritime Institute)

- Introduction of Marine Suitability Assessment (MSA)
- Overview of major steps in MSA application
- Preparation for assessment
- Planning area delineation
- Data collection & pre-processing
- Score Calculation & Integration
- Standardization of scores
- Spatial classification
- Application for spatial planning
- GIS Toolkit for MAPS-MSA
- The Case study of Gamak-bay

10:30 - 11:00	***Refreshment***

Course 2: Marine Assessment and Planning Support System – Spatial Ecosystem Service Valuation (MAPS-SEV)

11:00 – 12:30	Instructor: Prof. Daeseok KANG (Pukyong National University)

- Emergy Methodology - Energy Concept & Emergy Evaluation Procedure
- Overview of MAPS-SEV – Structure, Tools Needed, Procedure, Participants
- Valuation Boundary Delineation
- Issue Identification
- Data Collection
- Map Preparation – Process overview, Base map preparation, Raw data file preparation, Spatial interpolation, Spatial grid construction
- Spatial Emergy Mapping - Intermediate data calculation, Emergy calculation, Emvalue calculation, Emergy maps
  * The case study of the Gyeonggi Bay
- Application of MAPS-SEV

12:30 - 14:00	***Lunch***

Course 3: Marine InVEST

14:00 – 15:30	Instructor: Dr. Choong-Ki KIM (Korea Environment Institute)

- Natural Capital – Concepts, methods and initiatives
- InVEST (Integrated valuation of environmental services and tradeoffs)
- Marine Spatial Planing using InVEST Models
- Ecosystem Service Model Applications for Decision Making
  * The case study of Jeju Island

Wrap-up of the Training Program

15:30 – 16:00	Dr. Jungho NAM (Korea Maritime Institute)

- Wrap-up
- Presentation certificate & Introduction to 3rd training program
- Closing of the 2nd training program

Course 1:

Marine Assessment and Planning Support System – Marine Suitability Assessment (MAPS-MSA)

MAPS-MSA

(Marine Assessment & Planning Support system - Marine Suitability Assessment)

Instructor
Jungho Nam, Korea Maritime Institute

Contributors

Jungho Nam, Korea Maritime Insitute

Jongseo Lim, Seoul National University

Heejung Choi, Korea Maritime Institute

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I Introduction

II Following Assessment Steps

III Analyzing with GIS toolkits

I. Introduction

Marine Suitability Assessment

- Objective
- Application
- Overview of major steps

Objective

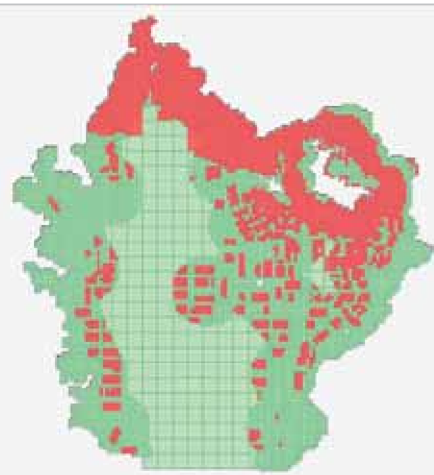
- Supporting decision-making on coastal & marine spatial planning and management
  - coastal seawater zoning
  - site designation for specific uses
  - screening & scoping in EIA & SEA

Marine Suitability Assessment

- Purpose
- Application
- Overview of major steps

Amendment of Coastal Management Act in 2009

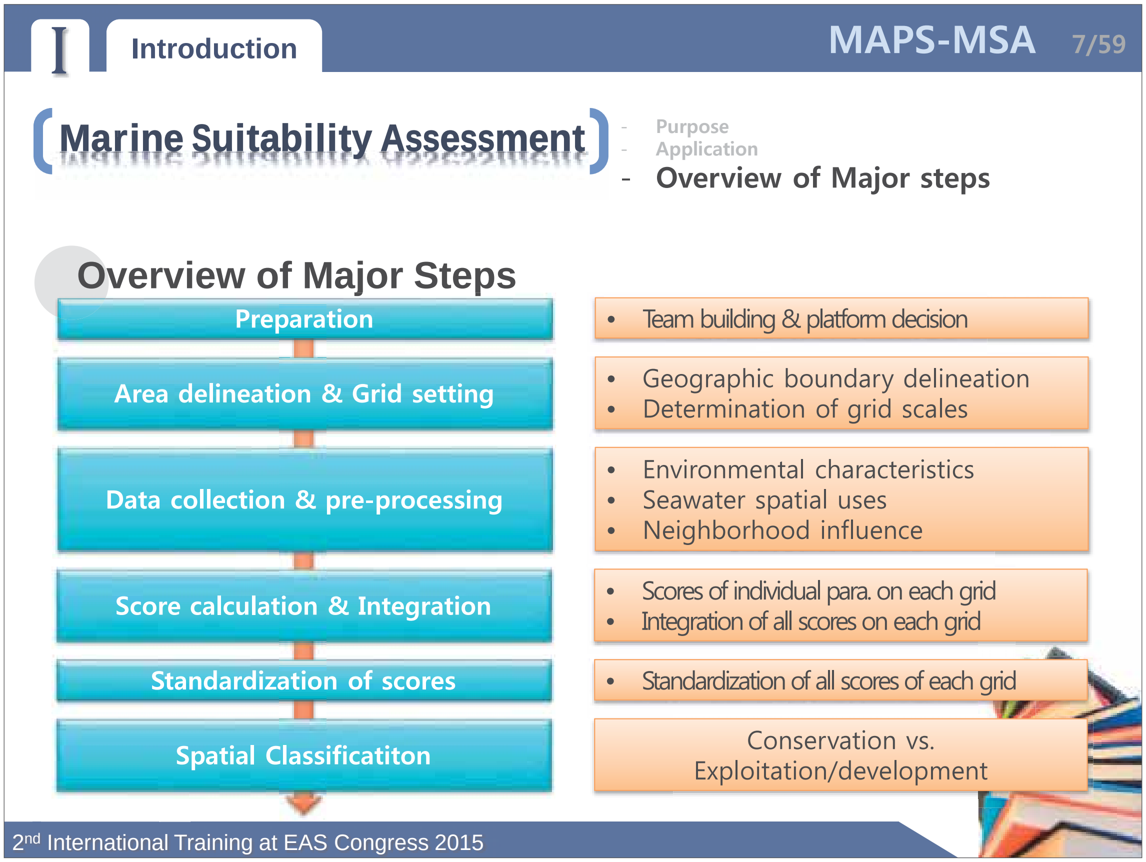
Application to ICM local plans

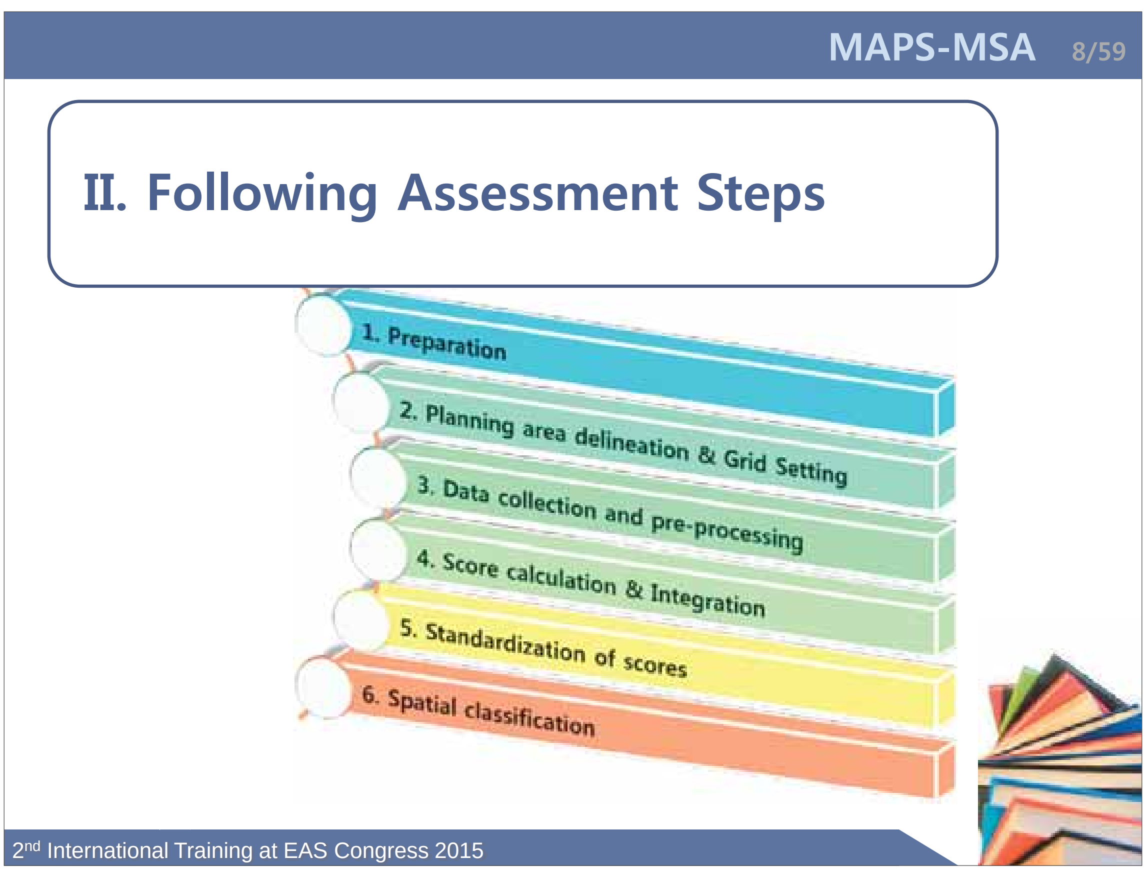


- Mayors : preparation of plans
  - determination and changes of use zones on ICM local plans

Stakeholders' involvement

- Minister, MOF
  - review and approval of the local plans


I
Introduction
MAPS-MSA 7/59
Marine Suitability Assessment
- Purpose
- Application
- Overview of Major steps
Overview of Major Steps
Preparation
Area delineation & Grid setting
Data collection & pre-processing
Score calculation & Integration
Standardization of scores
Spatial Classificatiton
• Team building & platform decision
• Geographic boundary delineation
• Determination of grid scales
• Environmental characteristics
• Seawater spatial uses
• Neighborhood influence
• Scores of individual para. on each grid
• Integration of all scores on each grid
• Standardization of all scores of each grid
Conservation vs.
Exploitation/development
2nd International Training at EAS Congress 2015


MAPS-MSA 8/59
II. Following Assessment Steps
1. Preparation
2. Planning area delineation & Grid Setting
3. Data collection and pre-processing
4. Score calculation & Integration
5. Standardization of scores
6. Spatial classification
2nd International Training at EAS Congress 2015

II Following Assessment Steps

MAPS-MSA 9/59

1

1. Preparation for Assessment

- Team Building
- Platform Determination

Technical Team Building

2nd International Training at EAS Congress 2015

II Following Assessment Steps

MAPS-MSA 10/59

1

1. Preparation for Assessment

- Team Building
- Platform Determination

Assessment Platform Determination

ArcGIS

Pros

- Extensive technical support resources
- Powerful & user-friendly inventory setting of tools and data
- All-in-one & one-stop software package

2nd International Training at EAS Congress 2015

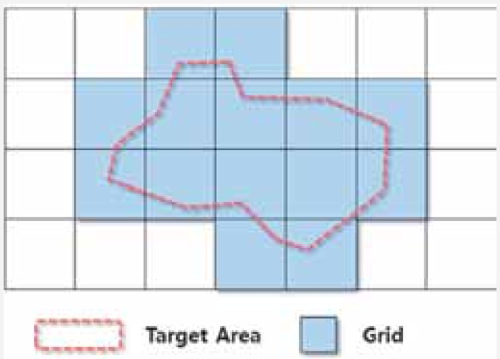
II Following Assessment Steps

2

MAPS-MSA 11/59

2. Planning Area Delineation

Area Delineation & Grid Setting



- **Boundary delineation**
  - Entire jurisdiction area or specific boundary for controversial issues
- **Assessment Grid Setting**
  - area size, geographic/environmental /socio-economic characteristics
  Basal grid & secondary grid (single or mixed grid settings)

100m, 500m, 1000m & others

II Following Assessment Steps

3

MAPS-MSA 12/59

3. Data collection & pre-processing

- Identification of Issues & Features
- Parameter Setting & Data Collection
- Data/Information Confirmation
- Preprocessing & weighting factor setting

Identification of Issues & Major Features

- **Ecological Issues & Features : Change of ecosystem**
  - corals, mangroves, tidal flats, protected species, water quality etc (degradation, loss & risks)
- **Socio-economic Issues & Features : Change of society**
  - Local economic condition, livelihoods, coastal economic activities etc

II Following Assessment Steps

3

MAPS-MSA 13/59

3. Data collection & pre-processing

- Identification of Issues & Features
- **Setting & Data Collection**
- Data/information Confirmation
- Preprocessing & weighting factor setting

Parameter Setting & Data/Information Collection

- **Basic Data: base maps (digital maps)**
  - coastline, coastal lands and seawaters
- **Assessment Parameter Set & Data/information collection**
  - 1st Tier
    - Environmental Characteristics, Spatial Uses, Neighborhood Influence
  - 2nd Tier : sub-parameters of each category on 1st Tier
- **Collection of available data/information**

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II Following Assessment Steps

3

MAPS-MSA 14/59

3. Data collection & pre-processing

- Identification of Issues & Features
- Parameter Setting & Data Collection
- **Data Confirmation**
- Preprocessing & weighting factor setting

Data/Information Confirmation for Assessment

- **Representativeness**
  - legal/institutional, ecological, socio-economic characteristics representing the planning area
- **Availability**
  - low priority on less available or less qualified data/information
    - ★ Alternative data : remote-sensing, global scale statistic data etc
- **Applicability : data type**
  - Geocoded Data (CAD, shp, KML files) / drawings / sheets (Excel)

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3. Data collection & pre-processing

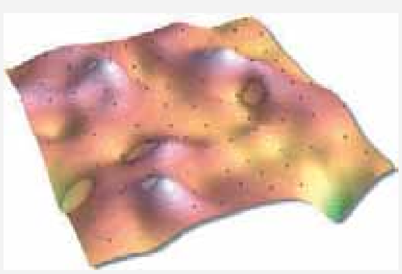
Examples of Confirmation and Applicability

Categories & Parameters		Description	Data Types
Environment	Protected Species and their Habitats	Protected species, endangered species, natural monuments etc	
	Water Quality	COD-based classification (10 year's averaged)	
	Tidal Wetlands	Tidal flats or wetlands / mangroves	
	Distinguished CoastalScapes	Classification of all types of landscapes	
		legally designated landscape areas	
	Estuarine Areas	Connectedness with estuaries from each grid	
Coastal Uses	Uses and occupation of public owned waters	Accumulated uses on each grid during last 1 year	
Neighborhood Influence	Protected Areas	Influence on marine & coastal protected areas	
	Terrestrial areas	Influence from land-based activities	
	Development areas	Influence from development projects	

3. Data collection & pre-processing

- Basic data & data for assessment
- Identification of Issues & Socioeconomic Activities
- Determination & Preparation of Data for Analysis
- **Preprocessing & weighting**

Preprocessing & weighting factor setting



- **Data preprocessing**
  - transforming point data to polygon data (ex. extra- or interpolation)
- **Weighting factor setting**
  - WF differentiation based on ecological and socio-economic relevance

Intersubjective approach
- Expert judgement
- stakeholder consultation

4. Score Calculation & Integration

- Score Calculation
- Integration of all scores

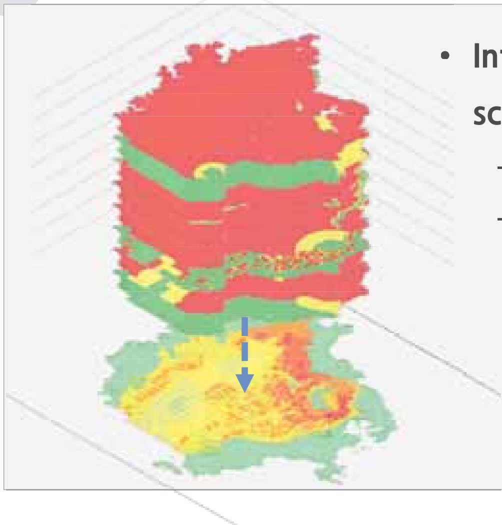
Score Calculation on each Grid

Categories and Parameters		Score		
		1	0	-1
		Conservation-------------------------		---use/development
Environmental Characteristics	Protected Species	< 500m	< 1,000m	> 1,000m
	Water Quality Class	1st	2nd	3rd
	Ratio of Tidal Wetlands	> 50% on grids	0~50%	0%
	1st Class landscape or legally designated areas	On grids	Neighboring grids	Other grids
	Estuarine Proximity	< 1,000m	< 2,000m	> 2,000m
Spatial Uses	Ratio of uses/occupation Fishing rights	0% on grids	0~20%	> 20%
Neighborhood Influence	Coastal & Marine PAs	On grids	< 1,000m	> 1,000m
	Land area	> 2,000m	< 2,000m	< 1,000m
	Development Area	> 2,000m	< 2,000m	< 1,000m

4. Score Calculation & Integration

- Score Calculation
- Integration

Integration of suitability scores



- **Integration of individual parameter's score on each grid**
  - m, a number of parameters
  - i, ith grid

$$S_i = \sum_{n=1}^{m} P_{ni} \quad \text{without WF}$$

$$S_i = \sum_{n=1}^{m} w_n P_{ni} \quad \text{with WF}$$

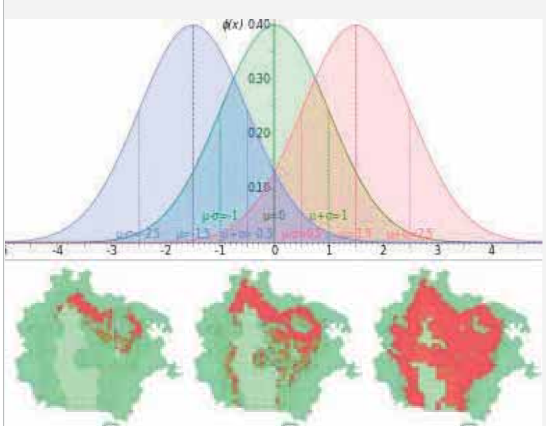
5. Standardization of scores

Standardization of Suitability Assessment Scores

- Z-score by using Mean and Standard Deviation of integrated scores on each grid

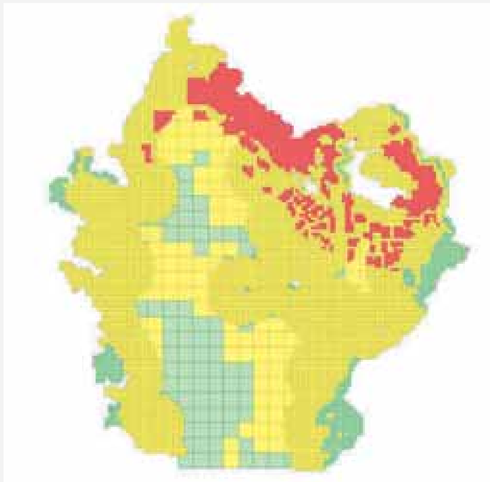
$$Z_i = \frac{S_i - \bar{S}}{\sigma}$$

6. Spatial Classification



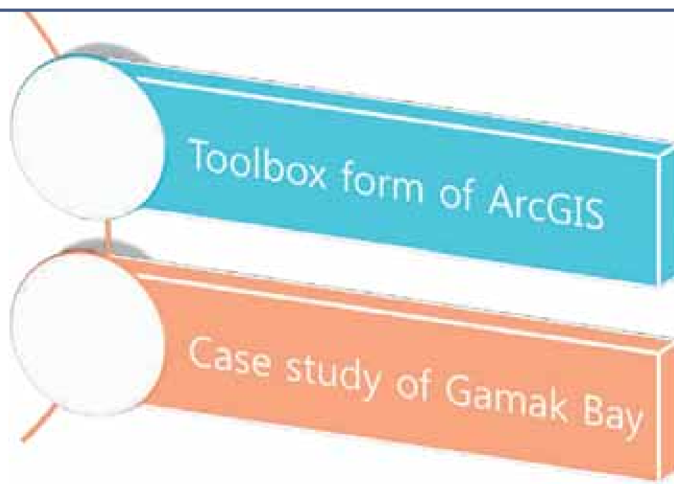
- Transformation of standardized scores (SS) into suitability class
  - Conservation : SS >= 0
  - Uses/Development : SS < 0
- Shifting of the curve for policy environment
  - allowable shifting range : ±1

7. Application for Spatial Planning



- **Zoning**
- **EIA & SEA**
- **Permission & license issuance**
- **Site designation for specific needs** (protection or development)

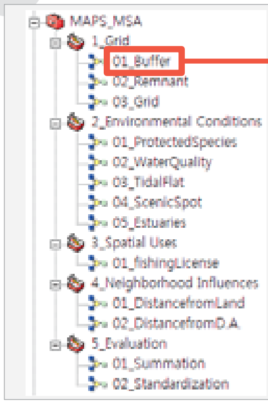
III. Analyzing with GIS Toolkits



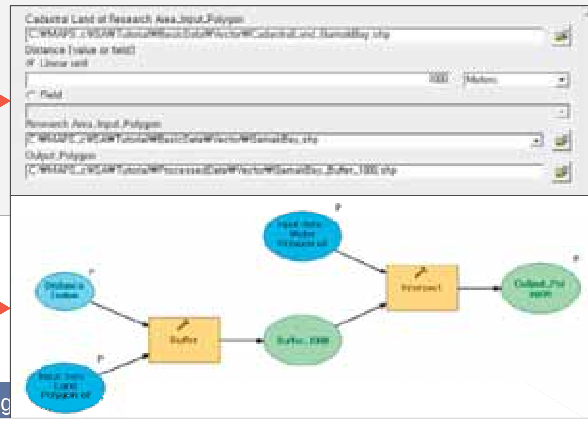
1. GIS Toolkit for MAPS_MSA

- Toolbox Design at ArcGIS
- Assessment Flow

Toolbox Design at ArcGIS



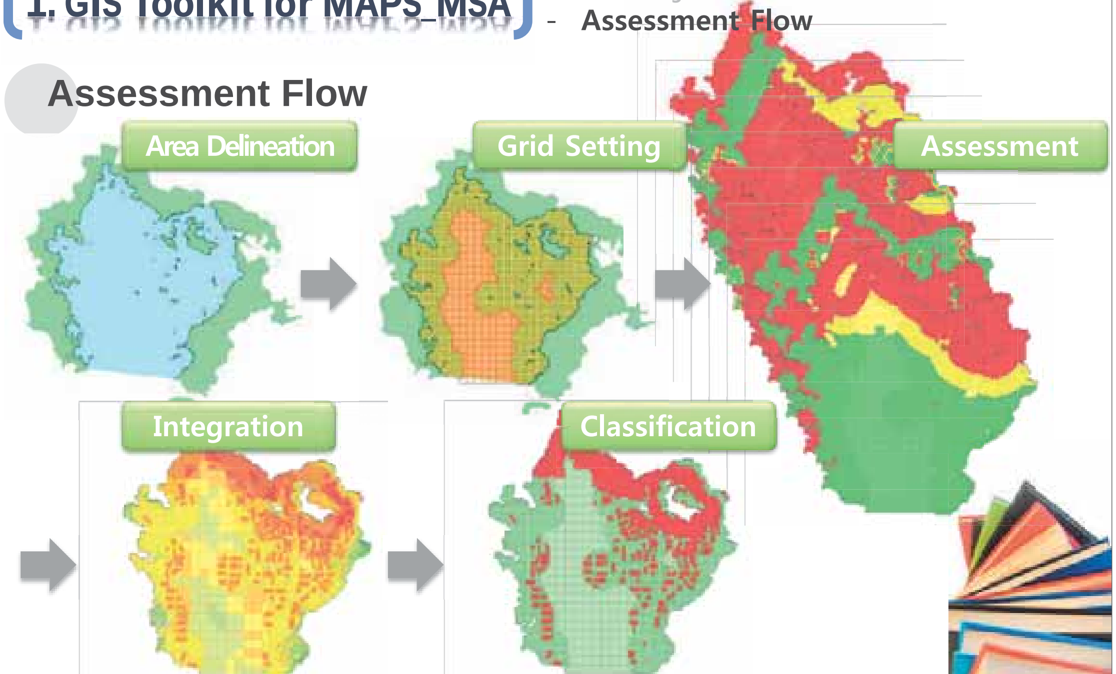
- **Toolset design based on assessment flow**
  - Modification of automated stepwise models
  - Resetting variables' values



1. GIS Toolkit for MAPS_MSA

- Toolbox design at ArcGIS
- Assessment Flow

Assessment Flow



2. Case study of Gamak-bay

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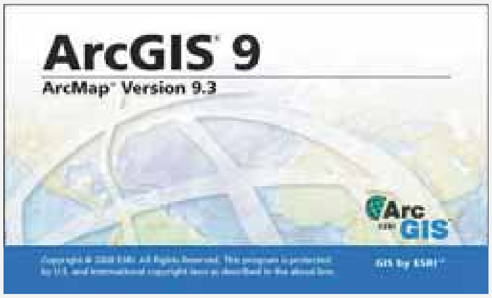
0. Environmental setting



- **Installation of ArcGIS**
  - ArcGIS 9.3 recommended for MAPS-MSA application

2. Case study of Gamak-bay

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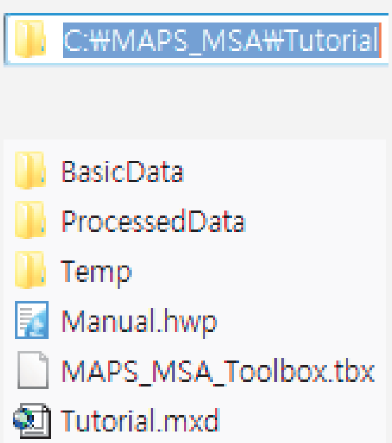
0. Environmental setting (cont.)

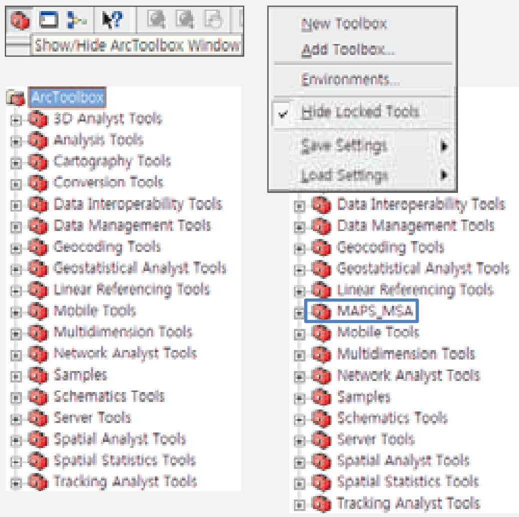


- **Locating the Tutorial folder**
  - The tutorial folder should be located under ‘C:₩MAPS_MSA’ folder

2. Case study of Gamak-bay

0

0. Environmental setting (cont.)

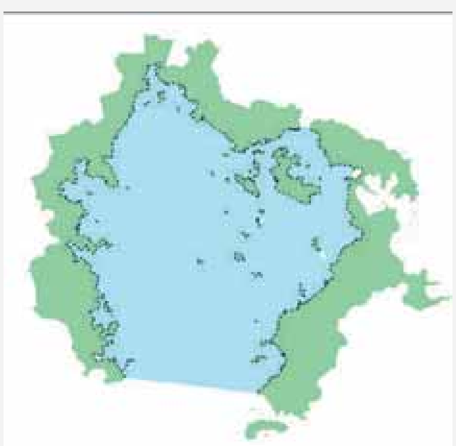


- **Load the MAPS_MSA toolkit**
  - Add an ‘ArcToolbox Window’ by clicking a GUI button in an editor toolbar
  - Add a ‘MAPS_MSA toolbox’ from ArcToolbox menu (click the right mouse button for pop-upping the menu)
    - The toolbox file with a name of ‘MAPS_MSA_Toolbox.tbx’ is located in the tutorial folder

2. Case study of Gamak-bay

1

(1) Regional Setting

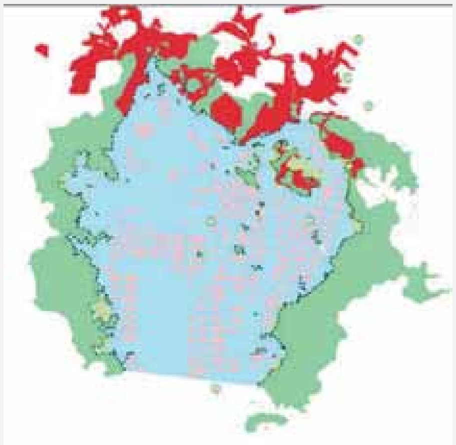


- **Selection and delineation of the planning area**
  - preparation of base maps for coastal waters and lands
- **Add data by button**
  - Load **‘BasicData.lyr’** file that located in ‘BasicData₩Layer₩’ of the Tutorial folder

2. Case study of Gamak-bay

2

(2) Data File Loading

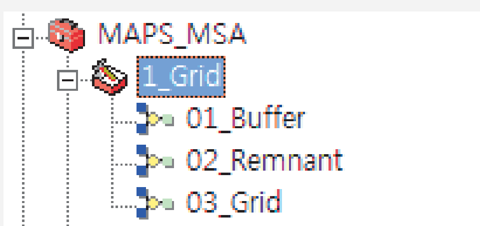


- **Data/information Preparation**
  - Acquired from legally-binding regular surveys in this study
- **Add data by button**
  - Load **'Properties.lyr'** file located in 'BasicData₩Layer₩' of the Tutorial folder

2. Case study of Gamak-bay

3

(3) Grid Setting



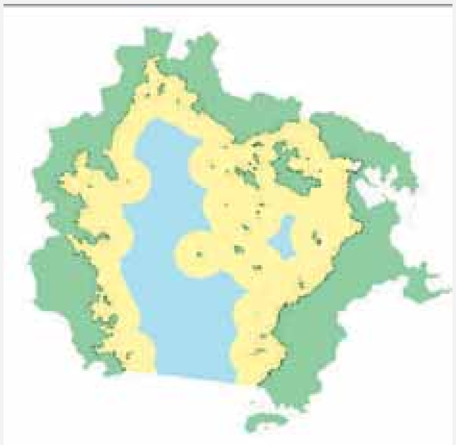
- **Generate an assessment grid**
- **Input Data for grid generation**
  - Land polygon
  - water polygon
- **Expected Output Data**
  - Grid polygon

III Analyzing with GIS Toolkits MAPS-MSA 31/59

2. Case study of Gamak-bay

3

(3) Grid Setting (cont.)



Step 1 : 100m grid buffer layer

- generate a buffer layer within 1,000 m from coastlines
  - applied for 100m grid set area

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III Analyzing with GIS Toolkits MAPS-MSA 32/59

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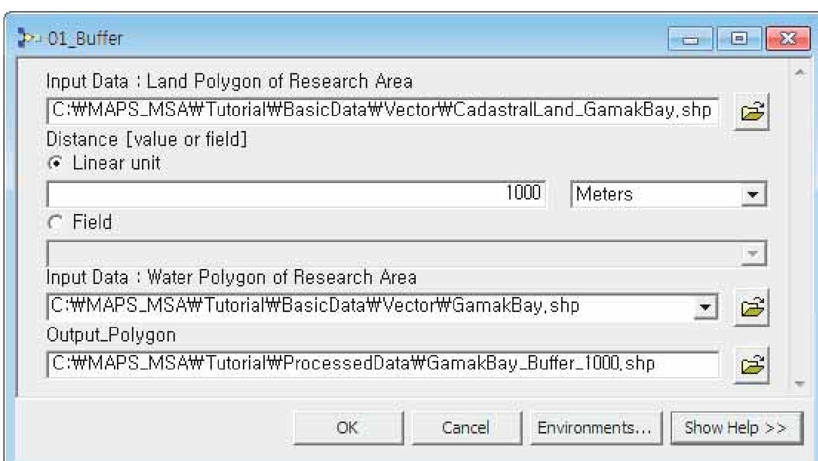
3

(3) Grid Setting (cont.)



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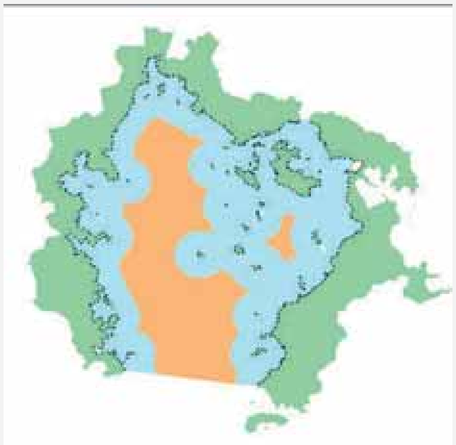
3

(3) Grid Generation (cont.)



Step 2 : 500m grid buffer layer

- generate a buffer layer in 1 km ~ 10 km from coastlines
  - applied for 500m grid set area

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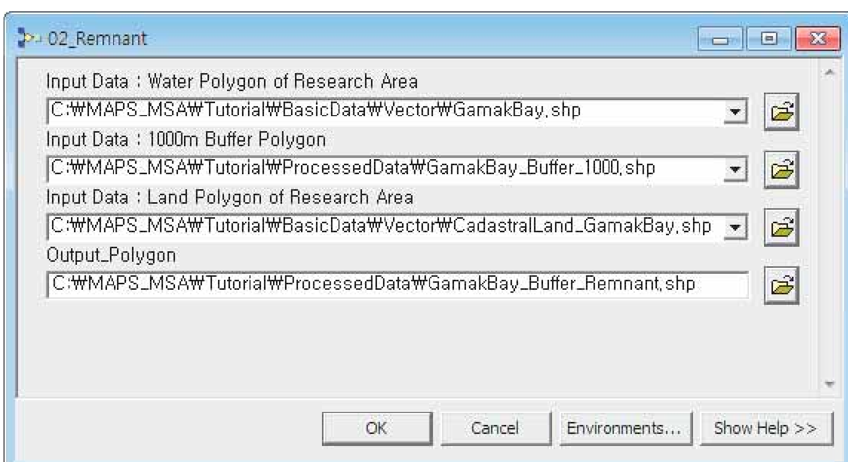
3

(3) Grid Setting (cont.)



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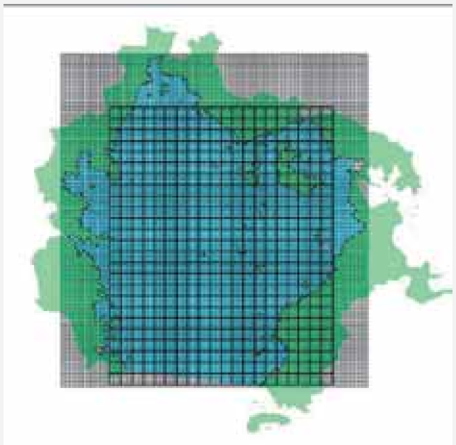
(3) Grid Setting (cont.)



Step 3 : Grid layer generation

- Build grid files of 100m & 500m intervals by HawthsTools" tool

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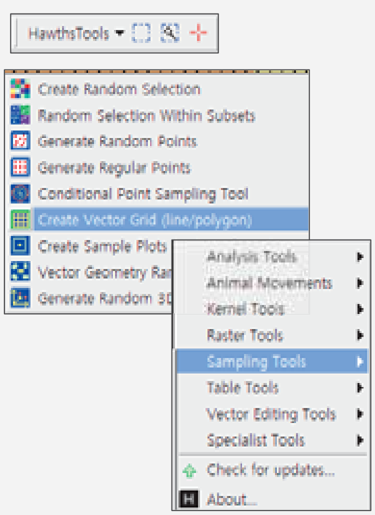
(3) Grid Setting (cont.)



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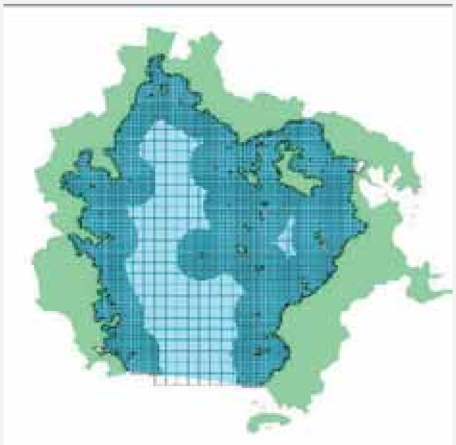
3

(3) Grid Setting (cont.)



Step 4 : Merging grid layers

- Merging layers of each grid set area by the MAPS_MSA tool

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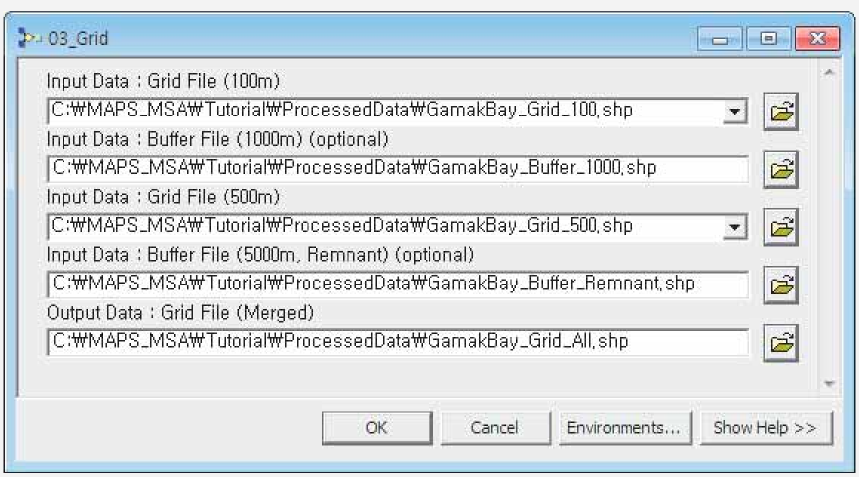
3

(3) Grid Setting (cont.)



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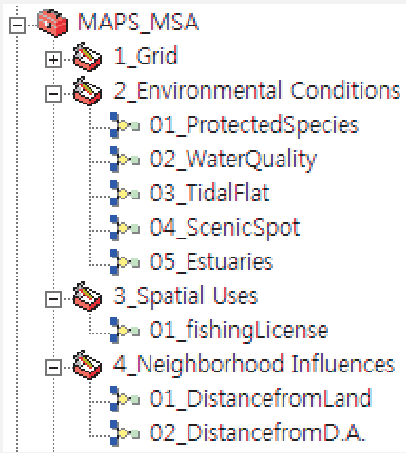
4

(4) Assessment



- **Input Data : polygons**
  - Data/information of parameters
  - * Point data : transformed to polygon type data through buffering or extrapolation
- **Output Data**
  - Scores of individual parameter on each grid

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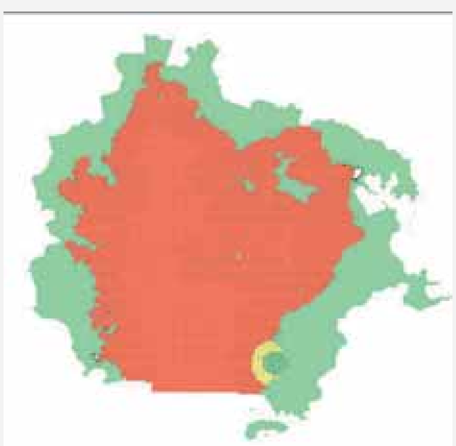
4

(4) Assessment –*Environmental Characteristics*



- **Legally protected species**
  - point data on observed sites
  - *1* : < 500 m from observed sites
  - *0* : < 1,000m form the sites
  - *-1* : > 1,000m form the sites

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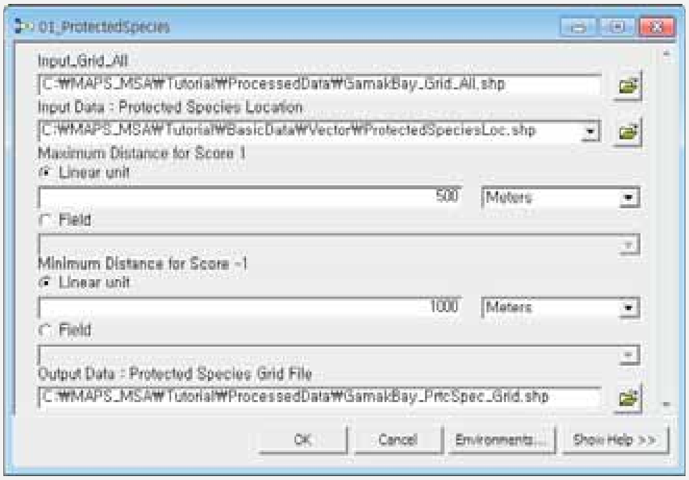
4

(4) Assessment – *Environmental Characteristics* (cont.)



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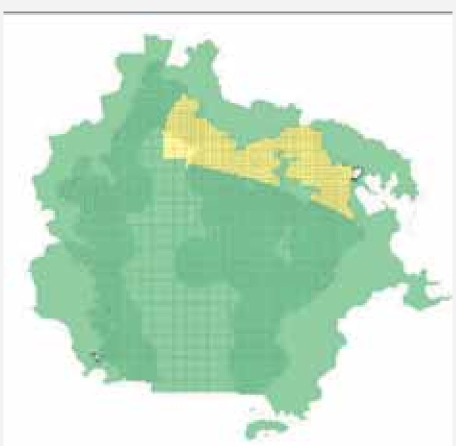
4

(4) Assessment – *Environmental Characteristics* (cont.)



- **Water Quality Class**
  - Extrapolating point data of COD class
    - *1* : 1st class water quality
    - *0* : 2nd class WQ
    - *-1* : 3rd Class WQ

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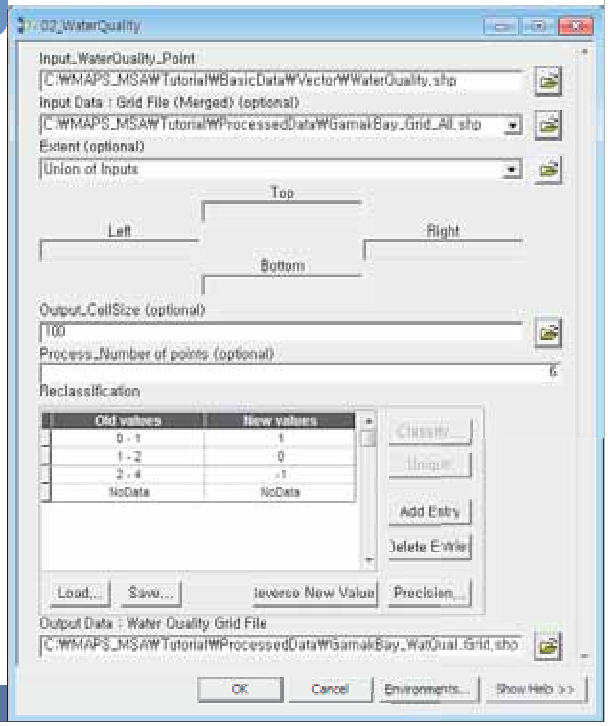
4

(4) Assessment – *Environmental Characteristics* (cont.)



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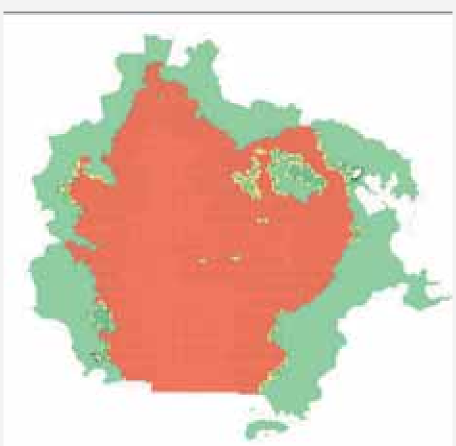
4

(4) Assessment – *Environmental Characteristics* (cont.)



- **Tidal wetlands**
  - Polygon data on wetlands' survey
    - *1* : 〉 50% coverage of grid size
    - *0* : 〈 50% coverage
    - *-1* : zero coverage

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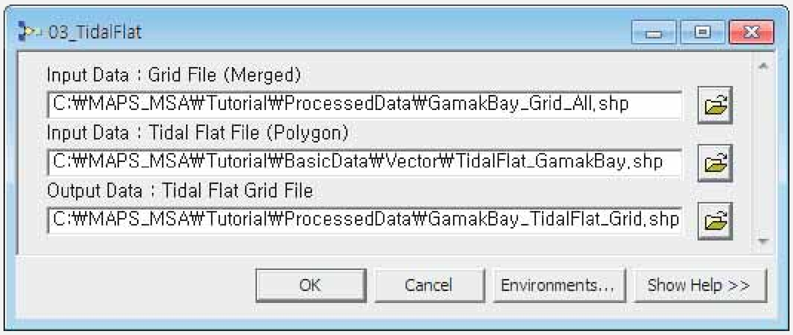
4

(4) Assessment – *Environmental Characteristics* (cont.)



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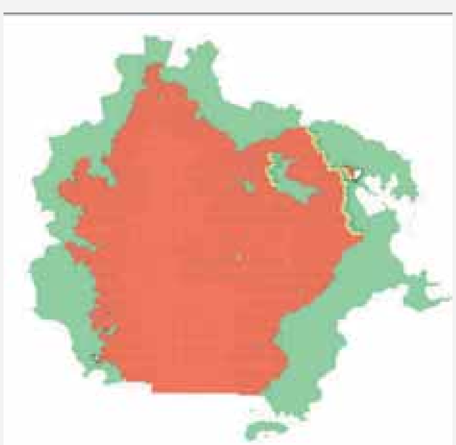
4

(4) Assessment – *Environmental Characteristics* (cont.)



- **CoastalScape condition**
  - Polygon data on 1st class landscape area or legally designated landscape zones
    - *1* : including the area / zones
    - *0* : adjacent to the area/zones
    - *-1* : other grids

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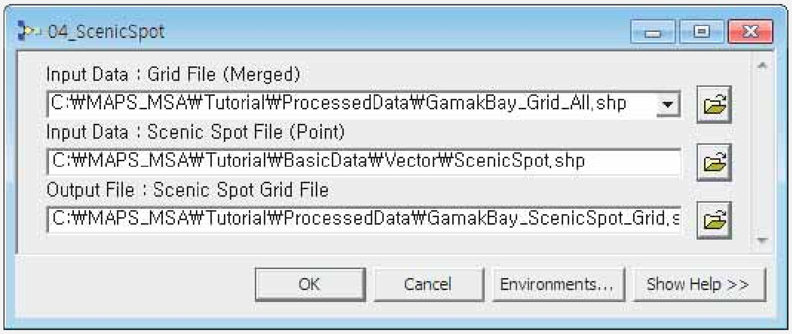
4

(4) Assessment – *Environmental Characteristics* (cont.)



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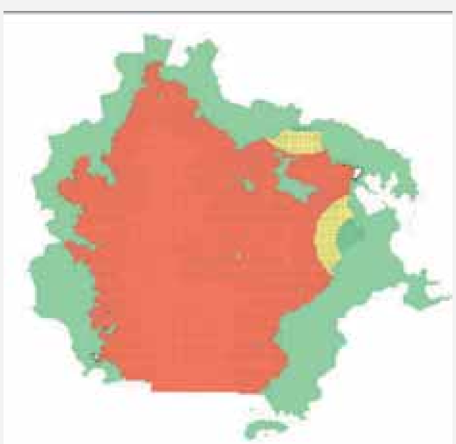
4

(4) Assessment – *Environmental Characteristics* (cont.)



- **Estuarine Proximity**
  - Distance to grids from sea-river boundary
  - *1* : < 1,000 m from the boundary
  - *0* : < 2,000 m
  - *-1* : > 2,000 m

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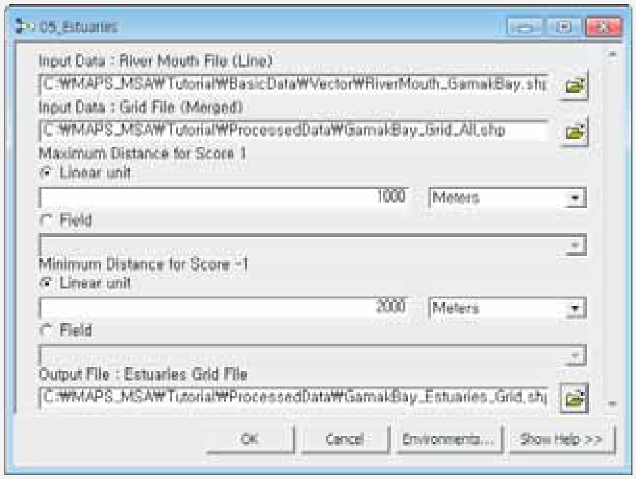
4

(4) Assessment – *Environmental Characteristics* (cont.)



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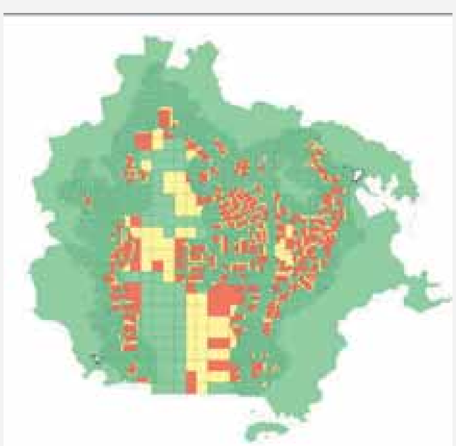
4

(4) Assessment – *Spatial Uses*



- **Spatial uses**
  - Polygon data on fishing rights
    - *1* : 0% coverage of a grid size
    - *0* : < 20% coverage
    - *-1* : > 20% coverage

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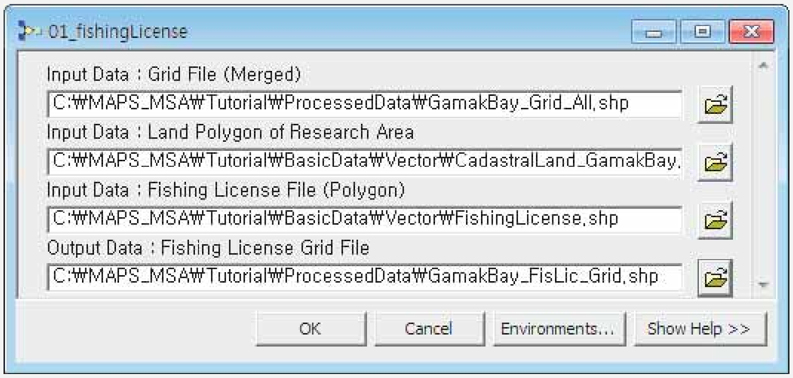
4

(4) Assessment – *Spatial Uses* (cont.)



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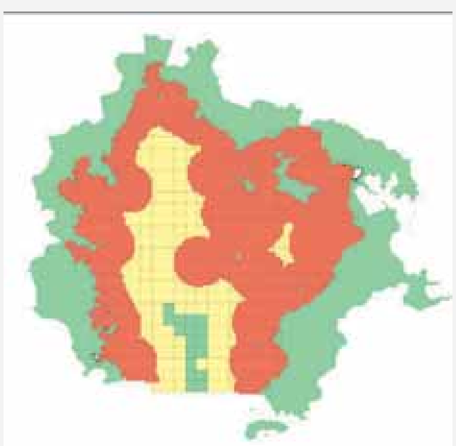
4

(4) Assessment – *Neighborhood Influence*



- **Distance from coastlines**
  - Polygon data on coastlines
    - *1* : 〉2,000 m from the line
    - *0* : 〈 2,000 m
    - *-1* : 〉1,000 m

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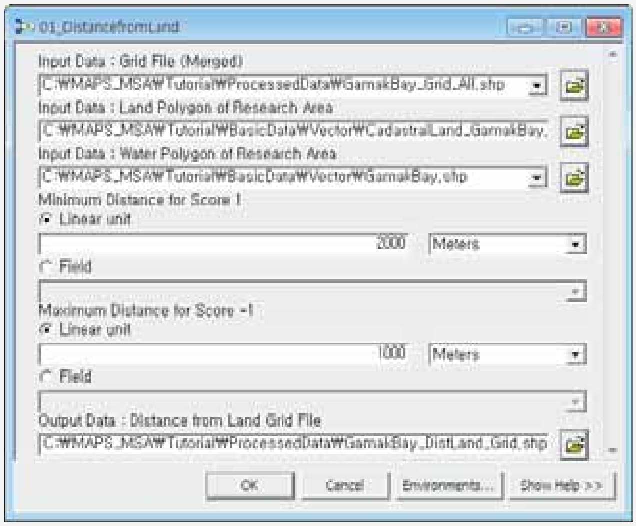
4

(4) Assessment – *Neighborhood Influence* (cont.)



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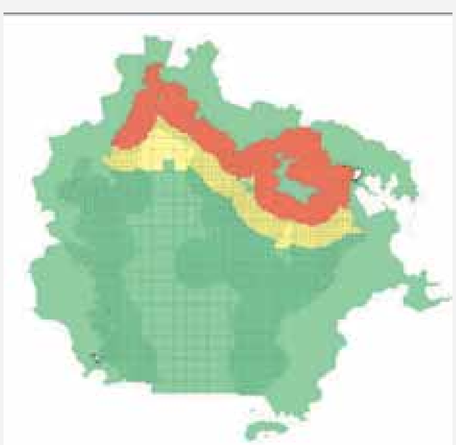
4

(4) Assessment – *Neighborhood Influence* (cont.)



- **Distance from development planning sites/area**
  - polygon data on land use plans of local governments

  - *1* : > 2,000 m from sites/areas
  - *0* : < 2,000 m
  - *-1* : > 1,000 m

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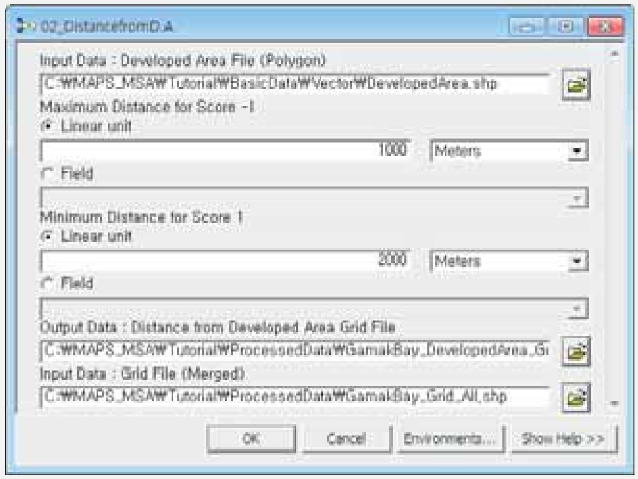
4

(4) Assessment – *Neighborhood Influence (cont.)*



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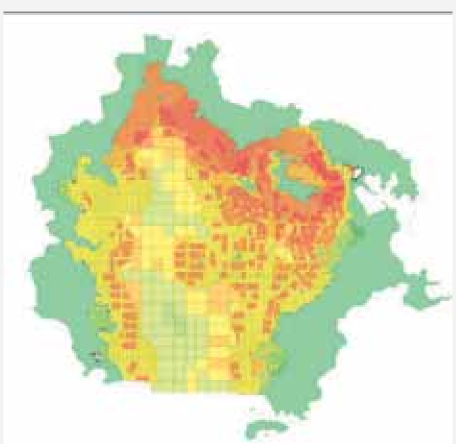
5

(5) Integration



- **Integration of individual parameter's score on each grid**
  - m, a number of parameters
  - i, ith grid

$$S_i = \sum_{n=1}^{m} P_{ni} \quad \text{without WF}$$

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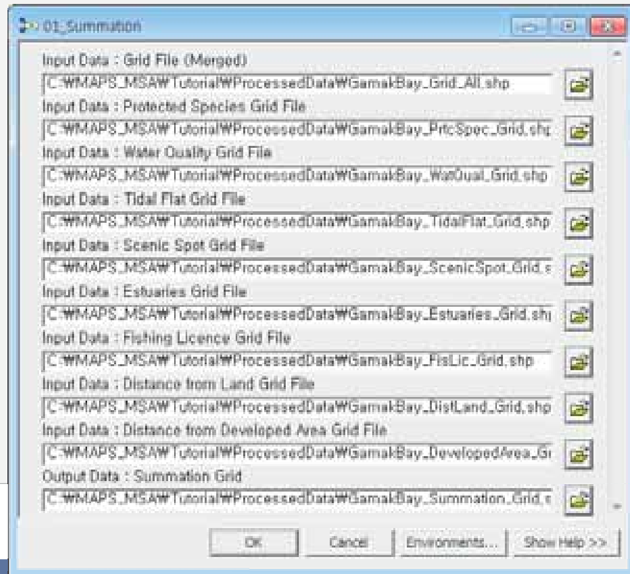
5

(5) Integration (cont.)



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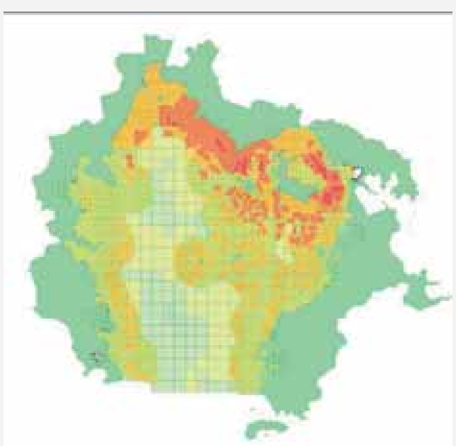
6

(6) Standardization of Suitability Assessment Scores



- Z-score by using Mean and Standard Deviation of integrated scores on each grid

$$Z_i = \frac{S_i - \bar{S}}{\sigma}$$

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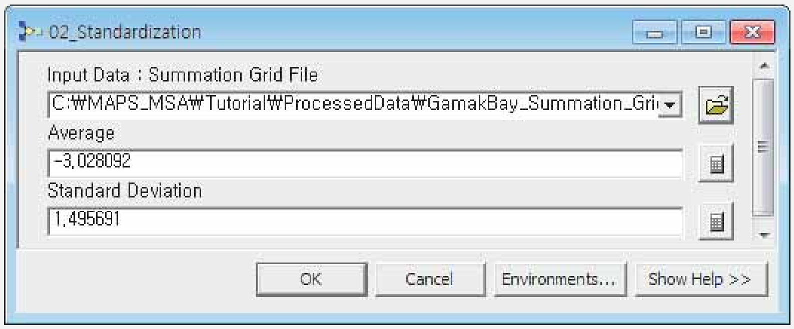
6

(6) Standardization of Suitability Assessment Scores (cont.)



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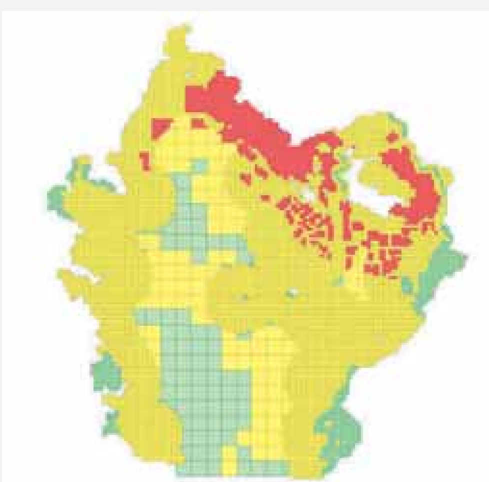
7

(7) Spatial Classification



- **Transformation of standardized scores (SS) into suitability class**
  - Conservation : SS >= 0
  - Uses/Development : SS < 0
- **Shifting of the curve for policy environment**
  - allowable shifting range : ±1

Course 2:

Marine Assessment and Planning Support System – Spatial Ecosystem Service Valuation (MAPS-SEV)

MAPS-SEV

(Marine Assessment & Planning Support system - Spatial Ecosystem service Valuation)

Instructor
Daeseok Kang, Pukyong National University

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MAPS-SEV

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Contents

I. **Emergy Methodology**
II. **Overview of MAPS-SEV**
III. **Valuation Boundary Delineation**
IV. **Issue Identification**
V. **Data Collection**
VI. **Map Preparation**
VII. **Spatial Emergy Mapping**
VIII. **Application of MAPS-SEV**

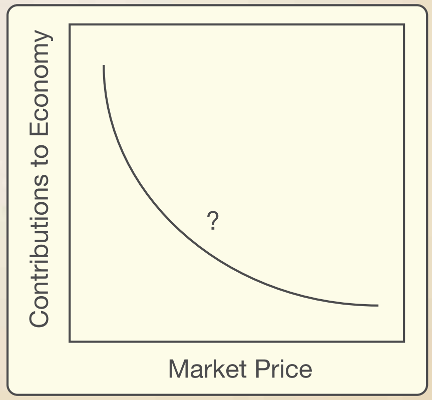
I. Emergy Methodology

1. **Energy Concept**
2. **Emergy Evaluation Procedure**

MAPS-SEV

I-1. Emergy concept

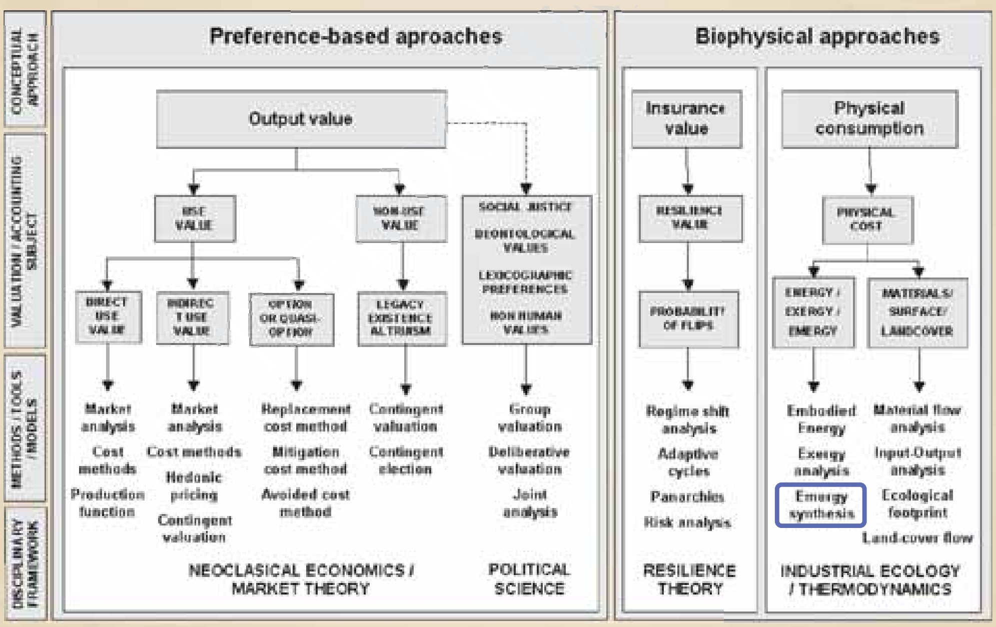
- Relationship between real wealth and market price
  - Real wealth = products of work (Odum, 1996)
    - clothes, books, food, minerals, fuels, information, art, technology, species, electricity, biodiversity, etc
    - produced and maintained by work processes from the environment, sometimes helped by people



MAPS-SEV

I-1. Emergy concept

- Ecosystem service valuation and Emergy



Source : TEEB (2010)

MAPS-SEV *I-1. Emergy concept*

- Ecosystem valuation and Emergy
  - Any other common denominators instead of money?
    - energy as an alternative because it is involved in every processes on earth
  - Energy Memory, Energy History
    - Use energy as a common currency to compare vastly different resources
  - **Definition**: Available energy of one kind previously required directly and indirectly to make a product or service (Odum, 1996)
    - Unit: emjoules
    - Solar emergy: Available solar energy used up directly and indirectly to make a service or product (Unit: solar emjoules, sej)
  - **Biophysical approach** in valuing contributions of ecosystem services to the real wealth of our economy
    - An effort to include both human efforts and nature's work put into the production of ecosystem services

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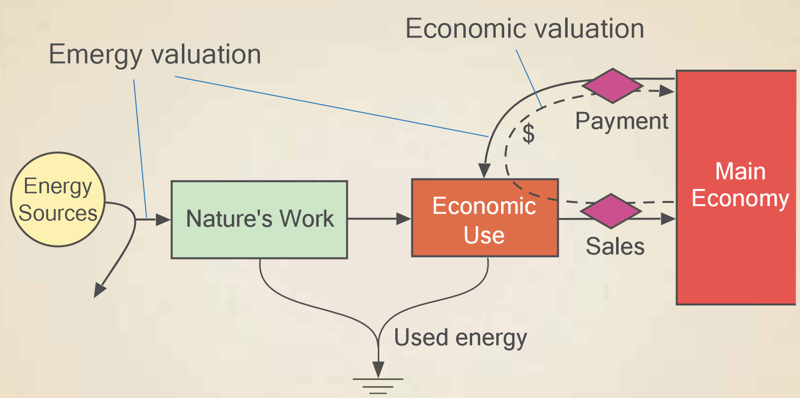
MAPS-SEV *I-1. Emergy concept*

- Emergy Valuation vs Economic Valuation



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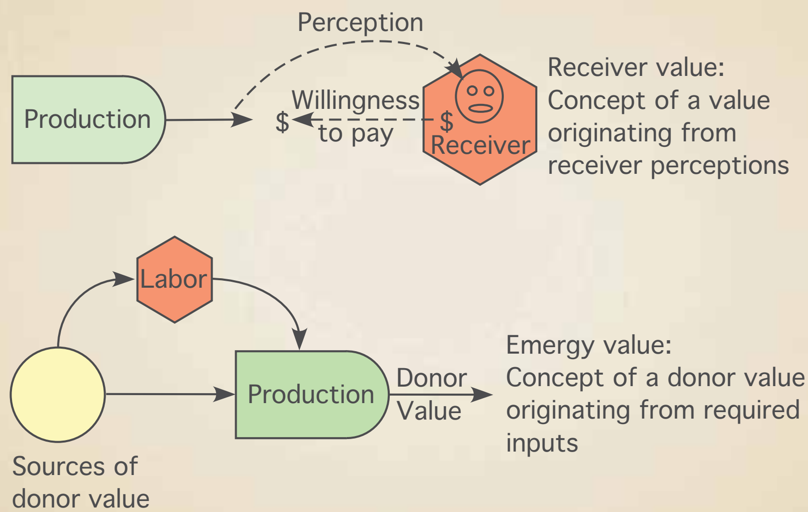
MAPS-SEV *I-1. Emergy concept*

- Emergy Valuation vs Economic Valuation



Source : Odum (1996)

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MAPS-SEV *I-1. Emergy concept*

- Energy quality concept
  - How do we compare different things?
  - How much money do I have?
    - $100 + ₩100 + €100 + ¥100 = 400 ???
      - Conversion factors needed to compare different things
    - Exchange rate as a conversion factor to compare different currencies
      - $100×1,040.90₩/$ + ₩100 + €100×1,414.16₩/€ + ¥100×10.18₩/¥
        = ₩ 246,624 (Exchange rate as of June 18, 2014)

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MAPS-SEV *I-1. Emergy concept*

- Energy quality concept
  - Energy of one kind is not equivalent in its ability to do work to energy of another kind
    - Different ability to do work
    - Conversion factors are needed to compare different energies
      - Reference energy equivalent
  - Unit emergy value: the conversion factors with solar energy as the reference
    - Transformity (sej/J), specific emergy (sej/g), emergy-money ratio (sej/$), etc

Sun	1	sej/J	Odum (2000)
Wind	2,450	sej/J	Odum (2000)
Rain	30,500	sej/J	Odum (2000)
Wave	51,000	sej/J	Odum (2000)
Tide	73,900	sej/J	Odum (2000)
Iron ore	5.78×10^{9}	sej/g	Cohen (2005)
Gold	5.04×10^{11}	sej/g	Cohen (2005)
EMR for Korea in 2011	5.36×10^{12}	sej/$	Kang (2013)

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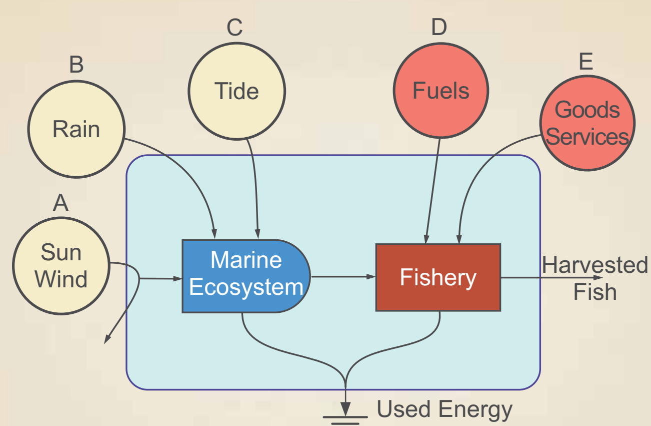
MAPS-SEV *I-1. Emergy concept*

- Calculation of emergy and unit emergy value



Solar emergy of harvested fish = Sum of all emergy inputs
A (or B, C) + D + E

Solar transformity (sej/J) = Emergy / energy content of harvested fish

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MAPS-SEV

I-1. Emergy concept

- Emergy and Money
  - Emvalue: em\$, em₩, etc
    - Money equivalent of emergy
    - Emergy is converted to a money unit to be compared with other works that provide monetary quantities on the value of ecosystems and resources
  - Emergy-money ratio (EMR) = Total emergy used in an economy / GDP
    - Unit: sej/\$, sej/₩, etc
    - EMR of Korea in 2011: 5.36×10^{12} sej/\$
      - Total emergy use (5.98×10^{24} sej/yr) / GDP (1.11×10^{12} \$/yr)
  - Emvalue = Emergy flow / Emergy-money ratio
    - Emvalue of tidal energy in Korea in 2011 = 5.40×10^{10} em\$/yr
      - (2.89×10^{23} sej/yr) / (5.36×10^{12} sej/\$)

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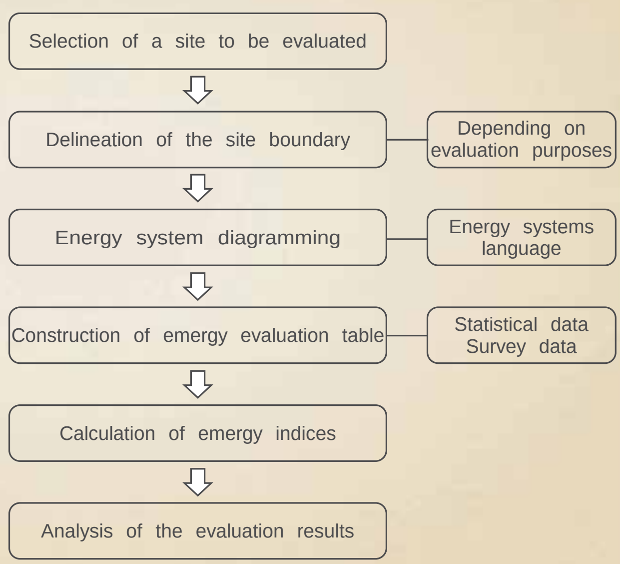
MAPS-SEV

I-2. Emergy Evaluation Procedure

- Procedure for environmental accounting with emergy
  - Energy systems diagramming
  - Construction of emergy evaluation table
  - Calculation of emergy indices



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MAPS-SEV *I-2. Emergy Evaluation Procedure*

- Energy systems diagramming

Delineation of the system boundary

⇩

Identification of outside sources

⇩

Identification of internal components

⇩

Indentification of major flows

⇩

Interconnection of sources and components

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MAPS-SEV *I-2. Emergy Evaluation Procedure*

- Energy systems diagramming steps (Odum, 1996)
  - Define the boundary of the window of the systems overview, thus separating the internal components and processes from the influences from outside that boundary
  - List the important sources (external causes, external factors, and forcing functions). Importance means that an effect is suspected to be 5% or more of the total system function.
  - List the principal components within the boundary and units believed to be important considering the scale of the system defined.
  - List the processes (flows, relationships, interactions, production and consumption processes, and so on). Include flows and transactions of money believed to be important
  - Draw the systems diagram, starting with the external sources arranged around the rectangular frame marking the boundary. Draw in the symbols for components. Arrange sources and components in order of transformity from left to right. Then connect pathways between the symbols.

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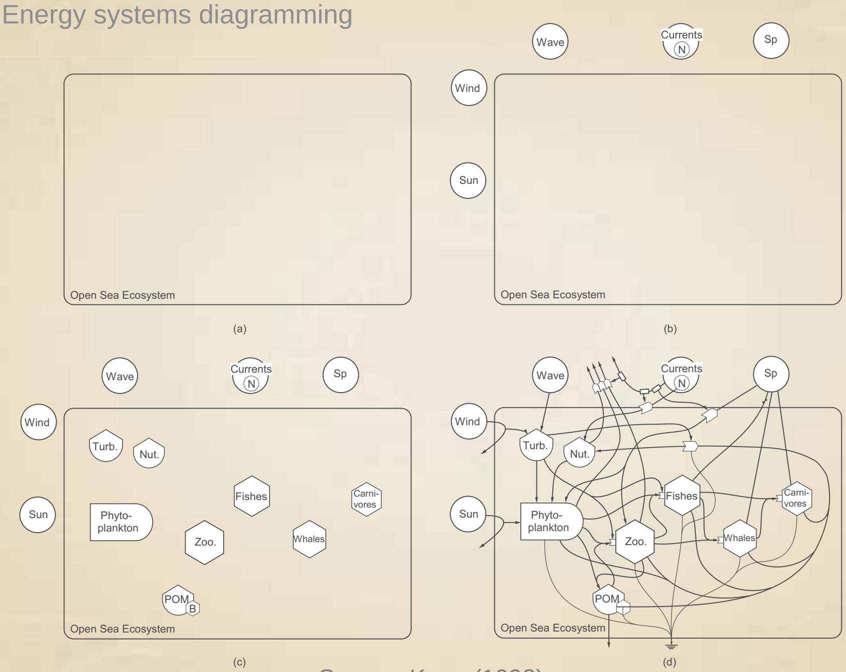
MAPS-SEV *I-2. Emergy Evaluation Procedure*

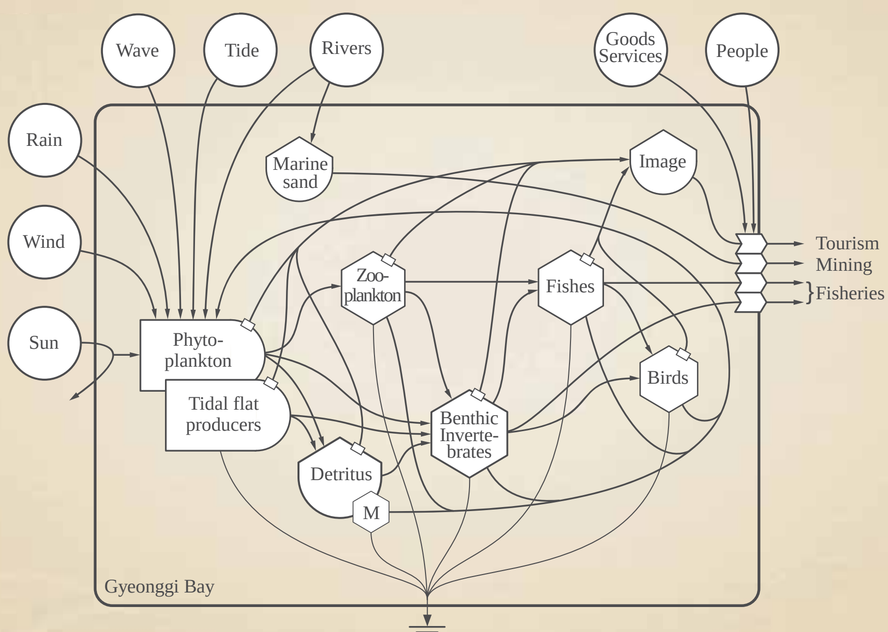
- Energy systems diagramming



Source: Kang (1998)

MAPS-SEV *I-2. Emergy Evaluation Procedure*

- Energy systems diagram for the Gyeonggi Bay, Korea



- Construction of emergy evaluation table
  - Typical format for the table

Note	Item	Data	Unit Emergy Value (solar transformity, specific emergy, etc)	Solar Emergy	Emvalue
1	Sun	J/yr, g/yr, $/yr, etc	sej/J, sej/g, sej/$, etc	sej/yr	em$/yr, em₩/yr, etc

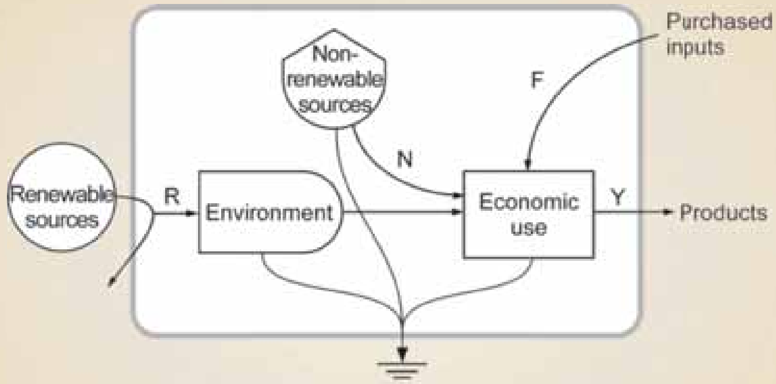
MAPS-SEV I-2. Emergy Evaluation Procedure

- Emergy evaluation table for the Gyeonggi Bay

No.	Item	Raw Data		UEV		UEV Source	Solar Emergy (sej/yr)	Emvalue	
Environmental inputs									
1	Sunlight	1.60E+19	J/yr	1	sej/J	a	1.60E+19	2.98E+06	em$/yr
2	Wind	1.37E+16	J/yr	2450	sej/J	a	3.35E+19	6.24E+06	em$/yr
3	Rain, chemical	2.43E+16	J/yr	30500	sej/J	a	7.41E+20	1.38E+08	em$/yr
4	Wave	3.03E+15	J/yr	51000	sej/J	a	1.54E+20	2.88E+07	em$/yr
5	Tide	3.52E+17	J/yr	73900	sej/J	a	2.60E+22	4.86E+09	em$/yr
6	River, chemical	2.02E+17	J/yr	81300	sej/J	a	1.64E+22	3.07E+09	em$/yr
Storage									
7	Benthos	4.17E+15	J	3.30E+06	sej/J	b	1.37E+22	2.56E+09	em$
Ecosystem services									
8	Fishery production	7.62E+12	J/yr	8.40E+06	sej/J	c	6.40E+19	1.19E+07	em$/yr
9	Marine sand extraction	6.25E+06	g/yr	2.13E+09	sej/g	d	1.33E+16	2.48E+03	em$/yr

MAPS-SEV I-2. Emergy Evaluation Procedure

- Calculation of emergy indices
  - To understand the characteristics of a system under consideration



Emergy Yield Ratio (EYR) = Y / F
Emergy Investment Ratio (EIR) = F / (R + N)
Environmental Loading Ratio (ELR) = (N + F) / R
Emergy Sustainability Index (ESI) = EYR / ELR

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MAPS-SEV I-2. Emergy Evaluation Procedure

- Examples of emergy indices

Emergy indices	Definitions (Odum, 1996)
Emergy-money ratio (EMR)	Total emergy use of a system divided by gross domestic product. It shows the buying power of money of a system in terms of real wealth. Decrease in EMR indicates decrease in the amount of real wealth that the currency of the system under consideration could buy.
Emvalue	Emergy of products divided by the emergy-money ratio. It converts the emergy term in monetary term for comparison. Unit : Emdollar(Em$), Emwon(Em₩), etc, depending on the currency.
Emergy use per capita	It represents the standard of living of a system, and obtained by dividing the total emergy use of a system by the number of people. Unit : sej/capita
Emergy yield ratio (EYR)	EYR is calculated by dividing total emergy of products by purchased emergy from outside the system. The higher EYR, the more competitive of an economy or process.

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- Examples of emergy indices

Emergy indices	Definitions (Odum, 1996)
Population carrying capacity	The number of people that could be supported by the environment and economy. Renewable carrying capacity is obtained by multiplying the fraction of renewable emergy in the total emergy use of a system by the number of people. Developed carrying capacity is the number of people that could be supported by the environment and economy of a system if the system develops at the level of developed countries.
Eemergy use per unit area	Total emergy use by an economic system divided by area of the system. It indicates the spatial concentration of economic activities. Unit : sej/m^2
Environmental loading ratio (ELR)	It represents the degree of environmental stress caused by socioeconomic activities. ELR is calculated by dividing the sum of outside emergy and internal nonrenewable emergy by internal environmental emergy. Low ELR means that socioecoonmic activities have less impact on the environment.
Emergy sustainability index (ESI)	ESI is obtained by dividing emergy yield ratio by environemental loading ratio. The smaller ESI, the higher the dependency of a system on nonrenewable resources and outside sources, and the higher the stress of socioeconomic activities on environment.

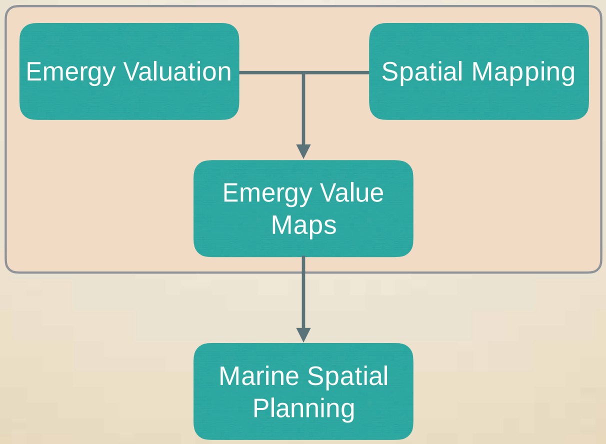
II. Overview of MAPS-SEV

1. **Structure**
2. **Tools Needed**
3. **Procedure**
4. **Participants**

MAPS-SEV

II-1. Structure

- Structure of MAPS-SEV
  - **Emergy valuation** using **Spatial information** on the natural capital (NC) and ecosystem services (ES) of marine and coastal ecosystems for helping decision making in the **Marine spatial planning**
    - Emergy valuation to quantify the value of NC and ES
    - Spatial mapping to visualise the value of NC and ES



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MAPS-SEV

II-2. Tools Needed

- Tools needed to implement MAPS-SEV
  - GIS program
    - ArcGIS used for a demonstration site
  - MS Excel program
    - Raw data management for the calculation and mapping of the value of natural capital and ecosystem services of marine and coastal systems

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MAPS-SEV | *II-3. Procedure*

- Spatial emergy mapping procedure

	Environmental Inputs	Stored Resources	Ecosystem Services	Purchased Inputs	
Raw Data Map	Annual inputs (sun, tide, river, etc)	Stock (biomass, sand reserve, etc)	Annual production (fishery, mining, etc)	Purchased inputs (fuel, equipments, labor, etc)	Statistics, literature, and estimation
Energy, Mass, Money Map	Annual inputs (J/yr, g/yr, $/yr, etc)	Stock (J, g, $, etc)	Annual production (J/yr, g/yr, etc)	Purchased inputs (J/yr, g/yr, $/yr, etc)	Multiplied by Unit Emergy Value
Emergy Map	Emergy Flow (sej/yr)	Emergy Storage (sej)	Emergy Flow (sej/yr)	Emergy Flow (sej/yr)	Emergy divided by Emergy-money ratio
Emvalue Map	Environmental Flow Value Map	Stored Resource Value Map	Ecosystem Services Value Map	Purchased Input Value Map	

- Emergy (sej/yr) = Raw data × Unit emergy value (sej/J, sej/g, sej/$, etc)
- Emvalue (em$/yr) = Emergy (sej/yr) / Emergy-money ratio (sej/$)
  - Emergy-money ratio for Korea in 2011 = 5.36×10^{12} sej/$

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MAPS-SEV | *II-4. Procedure*

- Overview of the MAPS-SEV procedure

Boundary Delineation	• Define the boundary of a system under consideration that reflects the purpose of the valuation • Determine appropriate spatial resolution
Issue Identification	• What are the important problems in the area that require MAPS-SEV application?
Data Collection	• Collect appropriate data and information for natural capital and ecosystem services that will be valued?
Map Preparation	• Prepare base maps and convert collected spatial data into GIS files
Spatial Emergy Maping	• Construct emergy maps for individual natural capital and services

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MAPS-SEV — *II-5. Participants*

- Who should be involved in the MAPS-SEV process?
  - Preliminary analysis: 5 experts in marine policy, valuation, GIS, and marine sciences
  - Main process: 7 participants including stakeholders

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MAPS-SEV

III. Valuation Boundary Delineation

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MAPS-SEV — III-1. Boundary Delineation

- Where is your area of concern?
  - Demonstration site: Gyeonggi Bay in the mid-western coast of ROK
  - Chosen as a demonstration site for MAPS-SEV due to
    - multiple uses and conservation needs exist
    - heavy development pressure and resultant marine ecosystem deterioration accumulating over the last decades

- Geographic features
  - Coastline length: 528 km
  - No. of islands: 130
  - Average depth: ca. 20 m
- Coastal population
  - 3.2 million people
  - density: 956 people/km^2

Map source: Google Maps (www.googlemap.com)

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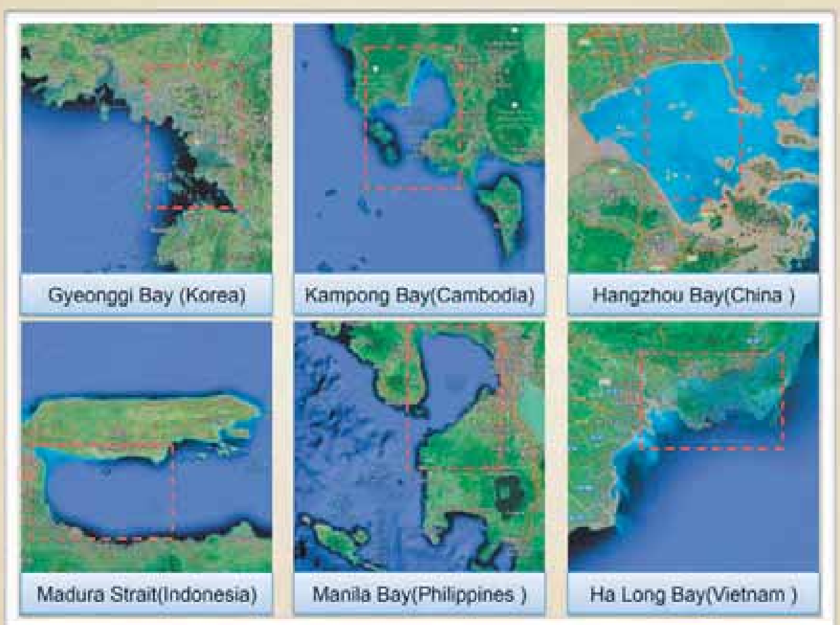
MAPS-SEV — III-1. Boundary Delineation

- How big is the Gyeonggi Bay?



Map source: Google Maps (maps.google.com)

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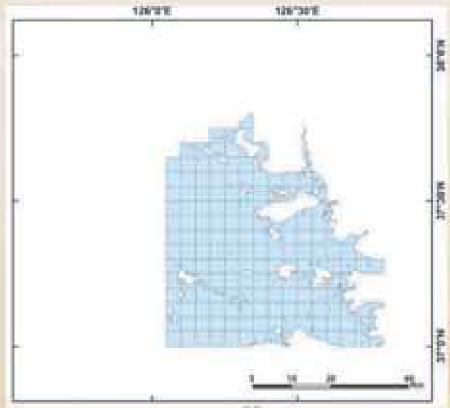
MAPS-SEV

III-1. Boundary Delineation

- Where to draw the boundary for the area of concern?
  - Criteria for boundary delineation
    - Environmental features, socioeconomic activities, available data and information, etc
  - Demonstration site
    - Environmental features : spatial range of freshwater influence
    - Socioeconomic characters: intensity of socioeconomic activities
    - Information: availability of reliable data and information



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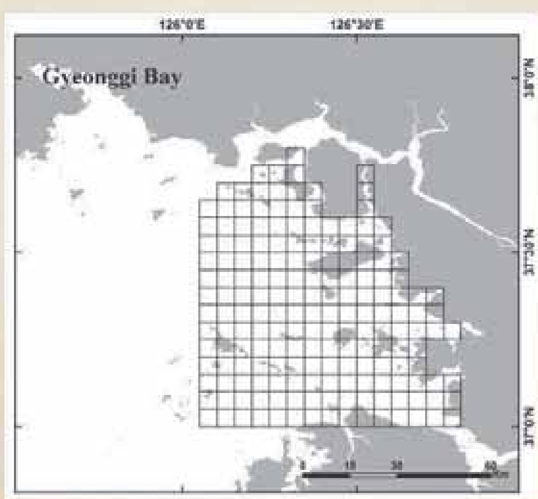
MAPS-SEV

III-1. Boundary Delineation

- Spatial resolution of the mapping
  - 1/20° (ca. 5 km, 24.5 km²) for the Gyeonggi Bay case
    - that reflects the spatial resolution of marine ecosystem data collected in the regular national surveys
    - for efficient handling of data in the WGS84 datum



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MAPS-SEV

IV. Issue Identification

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MAPS-SEV

IV-1. Issue Identification

- What are the main issues in the area?
  - What are the uses or socioeconomic activities in the area?
  - Who are the stakeholders involved in the issues?

- Urban sprawl
- Industrial complexes
- Port expansion
- Overfishing
- Marine mining
- MPA management
- Energy development
- Endangered species management
- Lack of effective management mechanisms
- Weak informed decision making

- Coastal inhabitants
- Fishermen
- Port authority
- Industry
- NGOs
- Local governments
- National government

Map source: Google Maps (www.googlemap.com)

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MAPS-SEV

V. Data Collection

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MAPS-SEV

V-1. Data Collection

- Data and information required for the emergy valuation
  - Types of data for emergy calculation
    - Environmental sources: sun, wind, wave, rain, tide, river input, currents, etc
    - Natural capital: fishery resources, mineral and energy resources, etc
    - Ecosystem services (annual data): food production, mineral & energy production,
  - Data sources: preferable to have site specific data
    - Area specific scientific data and statistics
    - Estimation based on national scientific data and statistics, or
    - International database: FAO, IEA, UNEP, CBD, World Bank, NOAA, USGS, etc

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MAPS-SEV

V-1. Data Collection

- Data and information collected for the Gyeonggi Bay demonstration site
  - For natural capital and ecosystem services, items that have reliable data and information were only presented as a preliminary spatial mapping

Category	Items	Unit	Reference
Environmental inputs	Sunlight	Insolation, $J/m^2/yr$	KMA
	Wind	Average wind speed, m/sec	KMA
	Rainfall	Annual rainfall, m	KMA
	Wave	Wave energy density, kW/m	KIOST
	Tide	Average tidal range, m	KOHA
	River input	River discharge, m^3/yr	MLTM
Natural capital	Benthos	Biomass, g/m^3	KOEM
Ecosystem services	Fishery production	Production, kg/yr	Yearbook
	Marine sand extraction	Extraction volume, m^3/yr	Yearbook

- KMA = Korea Meteorological Administration
- KIOST = Korea Institute of Ocean Science and Technology
- MLTM = Ministry of Land, Infrastructure and Transport
- KOEM = Korea Marine Environment management Corporation
- Yearbook = Statistical Yearbook of Korea and local governments

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MAPS-SEV

VI. Map Preparation

1. Process Overview
2. Base Map Preparation
3. Raw Data File Preparation
4. Spatial Interpolation
5. Spatial Grid Construction

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MAPS-SEV

VI-1. Process Overview

- Flow diagram for map preparation of MAPS-SEV

Base Map Preparation
- Map acquirement
- Coastline extraction
- GIS shape file creation
- Coordinate system selection
- Polygon creation

- Digital nautical charts
- World countries map from internet, or
- Paper maps or Satellite Images

Raw Data File Preparation
- Coordinate format
- Excel data to GIS files

Data collection
- Environmental inputs
- Natural capital
- Ecosystem services

Spatial Interpolation
- Estimation of unknown values
  - IDW interpolation
  - Thiessen polygon interpolation

Spatial Grid Data Map
- Grid polygon creation
- Raster datasets to point features
- Point layers to grid layers

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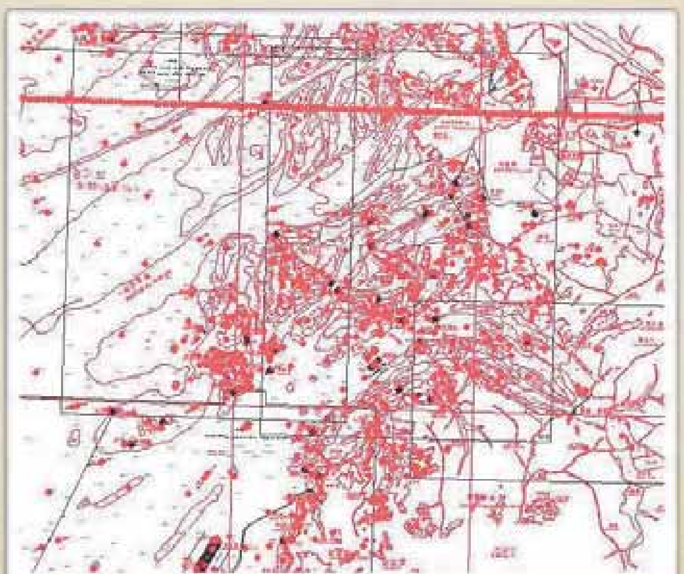
MAPS-SEV

VI-2. Base Map Preparation

- Maps required for the base map preparation
  - Digital nautical charts (WGS 1984 ellipsoid) in DXF format produced by KHOA for the Gyeonggi Bay case



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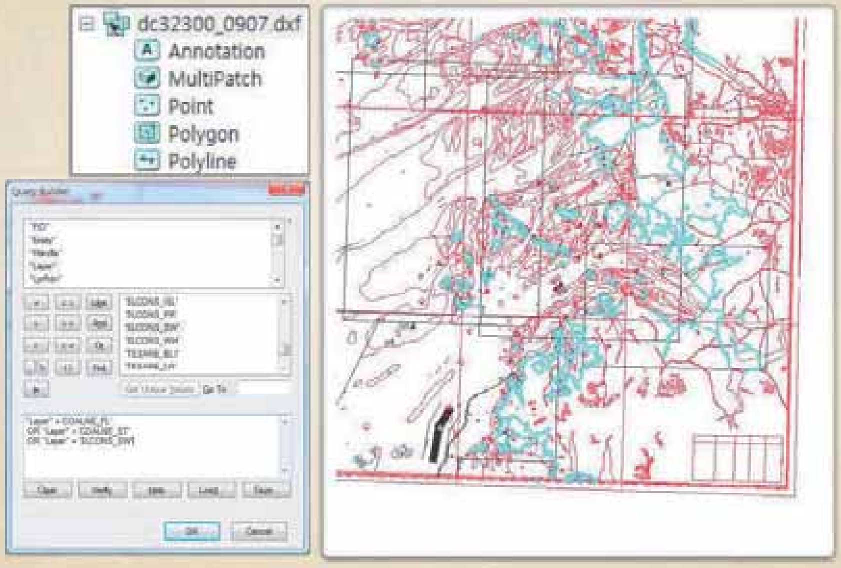
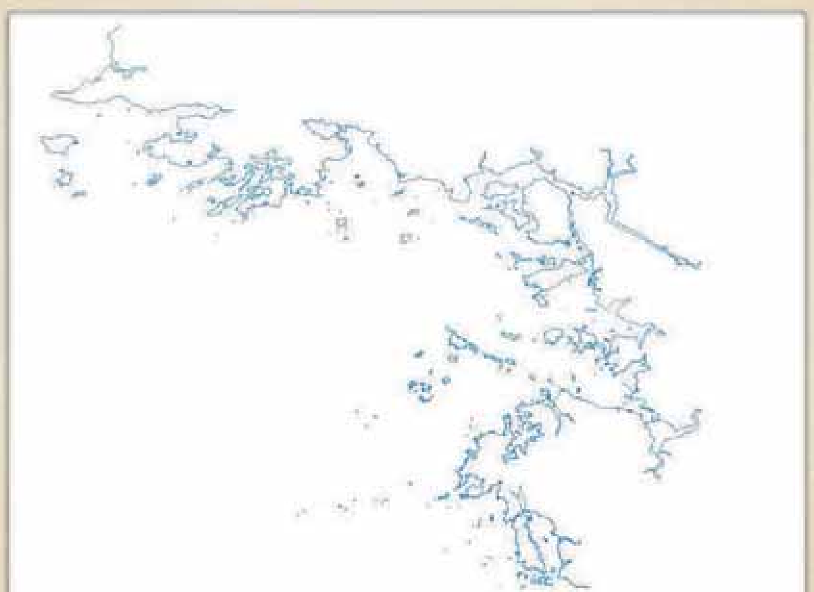
MAPS-SEV VI-2. Base Map Preparation

- Extract coastline from polyline feature in the DXF file
  - ArcGIS command: Query Builder for natural and artificial coastlines

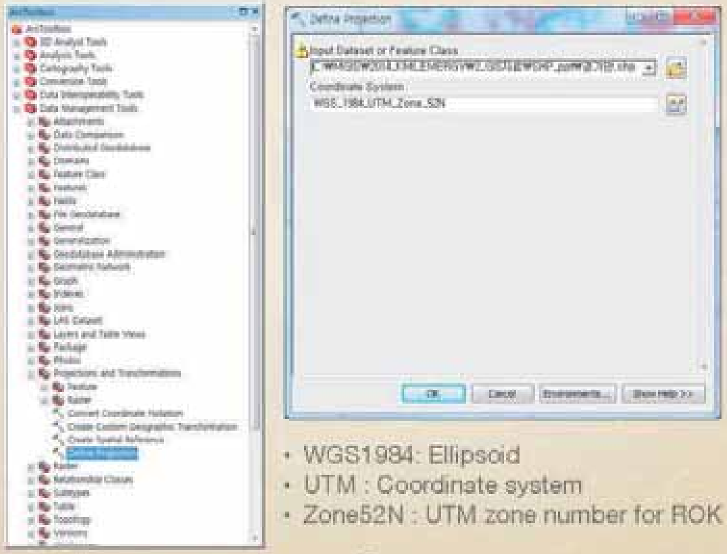


MAPS-SEV VI-2. Base Map Preparation

- Save the extracted coastline in a GIS shape file
  - ArcGIS command: Data ▷ Export Data



- Select a coordinate system
  - ArcGIS command: ArcToolbox ▷ Projections and Transformations ▷ Raster ▷ Define Projection
  - WGS1984_UTM_Zone52N for the Gyeonggi Bay case



- WGS1984: Ellipsoid
- UTM : Coordinate system
- Zone52N : UTM zone number for ROK

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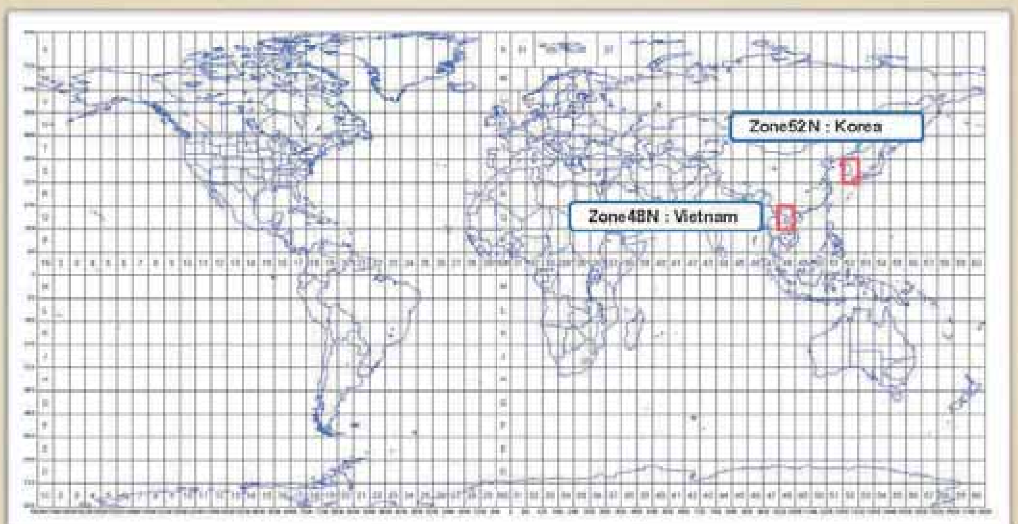
- UTM grid zones



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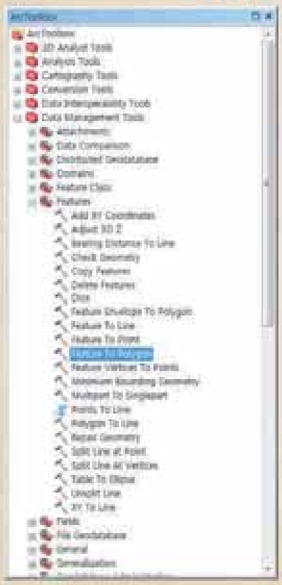
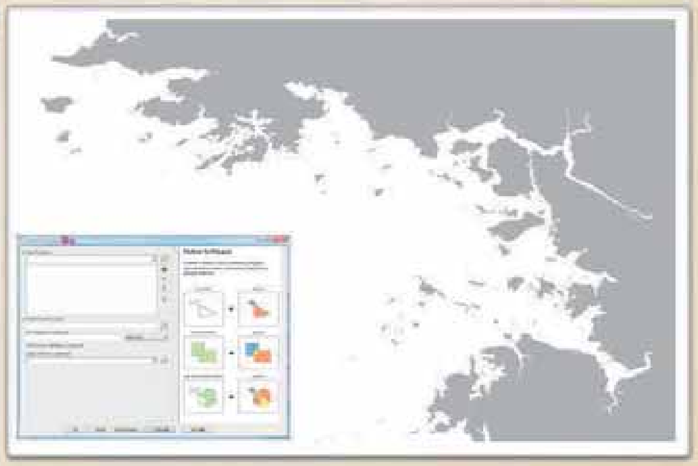
MAPS-SEV ***VI-2. Base Map Preparation***

- Close the coastline polyline and convert it to polygon
  - ArcGIS command: ArcToolbox ▷ Data Management Tools ▷ Features ▷ Feature to Polygon





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MAPS-SEV ***VI-2. Base Map Preparation***

- Alternative 1 based on downloadable maps from ESRI
  - When digital nautical charts are not available, data and maps can be downloaded from ESRI (Data and Maps for ArcGIS)

http://www.esri.com/data/data-maps/data-and-maps-dvd

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MAPS-SEV

VI-2. Base Map Preparation

- Alternative 1 based on downloadable maps from ESRI
  - Data and Maps for ArcGIS: World Countries

http://www.esri.com/data/data-maps/data-and-maps-dvd

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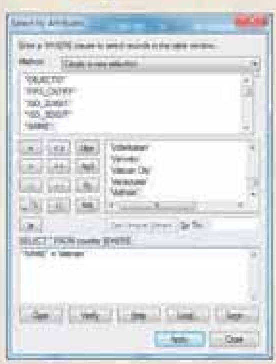
MAPS-SEV

VI-2. Base Map Preparation

- Alternative 1 based on downloadable maps from ESRI
  - Example of polygon created based on the ESRI's World Countries map

Country.gdb

Country selection
Select by Attributes



Shapefile export
Data ▷ Export Data

Vietnam.shp

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VI-2. Base Map Preparation

- Alternative 2 based on Paper maps or satellite images
  - Digitise coastline with the ArcGIS command Create Feature
    - For ArcGIS, world imageries are provided online
    - High resolution maps are required
    - Important to match ellipsoid and coordinate system

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MAPS-SEV

VI-3. Raw Data File Preparation

- Convert coordinate formats
  - Different coordinate formats of various types of raw data need to be converted to a single uniform format
  - Decimal degree format for the Gyeonggi Bay case

DMS format

Longitude			Latitude		
D	M	S	D	M	S
125	30	25	36	28	32
128	40	55	35	35	48
126	00	09	38	22	19
127	48	59	30	20	10

⇨

DM format

Longitude		Latitude	
D	M	D	M
125	30.41	36	28.53
128	40.91	35	35.8
126	0.15	38	22.3
127	48.98	30	20.16

⇨

Decimal degree format

Longitude	Latitude
D	D
125.50694	36.47555
128.68194	35.59667
126.0025	38.37166
127.81638	30.33611

Conversion formula M = M + S/60 D = D + M/60

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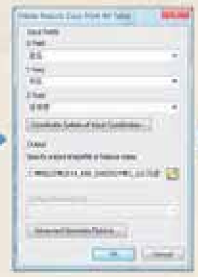
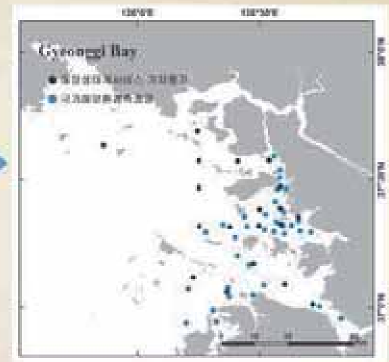
MAPS-SEV ***VI-3. Raw Data File Preparation***

- Convert excel data into ArchGIS point files
  - Various data stored in MS Excel files with coordinate information
  - ArcGIS command: Create Feature Class from XY Table

St.	Long.	Lat.	Biomass
CH-1-P1	126.8031111	36.96041667	24.814
CH-1-P2	126.7880278	36.95555556	533.714
CH-1-P3	126.8018056	36.93652778	65.024
CH-1-P4	126.8125833	36.93958333	77.97
CH-1-P5	126.8165556	36.92163889	183.312
CH-1-P6	126.8195556	36.90022222	4.244
CH-1-P7	126.8430056	36.90316667	153.98
CH-1-P8	126.8720833	36.89369444	234.634
CH-1-P9	126.8914444	36.89575	302.68
CH-2-P1	126.3774444	37.01411111	20.988
CH-2-P2	126.4127778	37.01516667	14.352
CH-2-P3	126.4392222	37.00938889	21.95
CH-2-P4	126.4621944	37.01211111	6.98
CH-2-P5	126.4188889	37.05044444	1.08
CH-2-P6	126.4315278	37.06422222	280.712
CH-2-P7	126.44975	37.05075	293.366
CH-2-P8	126.4557778	37.04138889	8.876





Data in excel spreadsheet

Point.shp

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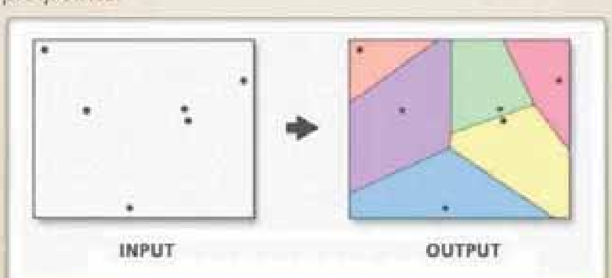
MAPS-SEV ***VI-4. Spatial Interpolation***

- Spatial interpolation is performed to estimate unknown values for parameters in the target area from a limited number of data points
- Two interpolation methods used for the Gyeonggi Bay case
  - Thiessen polygon interpolation for parameters with irregularly spaced points
  - Inverse Distance Weighted (IDW) interpolation for parameters with more regularly spaced data points
- Thiessen polygon interpolation
  - Polygons are generated from irregularly spaced data points.
  - Each Thiessen polygon defines an area of influence around its sample point, so that any location inside the polygon is closer to that point than any of the other sample points.



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MAPS-SEV

VI-4. Spatial Interpolation

- Inverse Distance Weighted (IDW) interpolation
  - A deterministic method for multivariate interpolation with a scattered set of points with measured values.
  - Values for any unmeasured location are predicted as weighted averages of measured values surrounding the prediction location.
  - Greater weights to points that are closer to the prediction location, with weights decreasing as a function of distance.

$$Z_p = \frac{\sum_{i=1}^{n} Z_i W_i}{\sum_{i=1}^{n} W_i}$$

Zp = Predicted value
Zi = Measured value for location *i*
Wi = Weighting factor
n = Number of measured values

$$W_i = \frac{1}{{d_i}^2}$$

Weighting factors as an inverse function of distance from surrounding points with measured values

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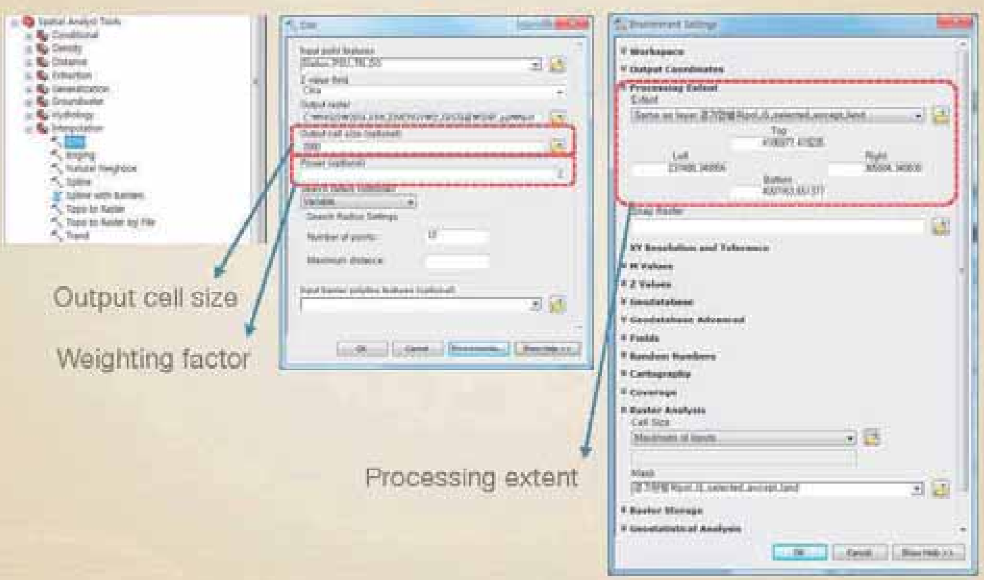
MAPS-SEV

VI-4. Spatial Interpolation

- Inverse Distance Weighted (IDW) interpolation
  - ArcGIS command: Spatial Analyst Tools ▷ Interpolation ▷ IDW



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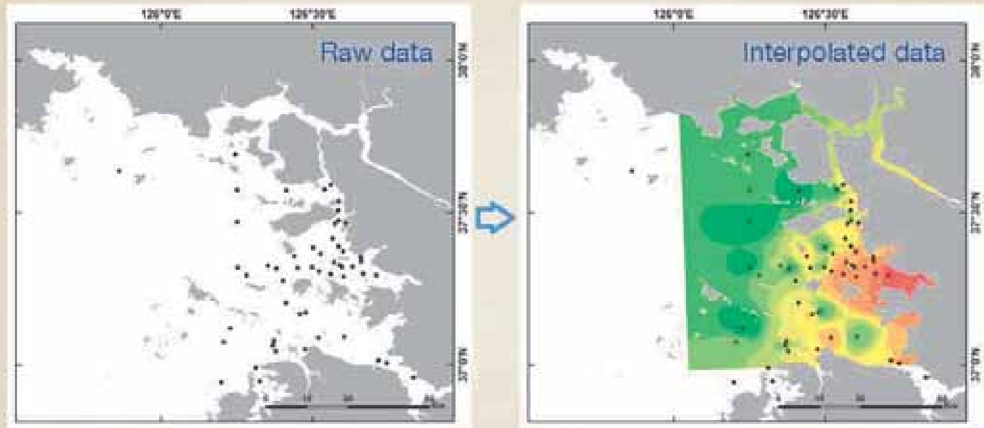
MAPS-SEV *VI-4. Spatial Interpolation*

- Inverse Distance Weighted (IDW) interpolation
  - An example from the Gyeonggi Bay case



Chlorophyll-a concentration in the Gyeonggi Bay

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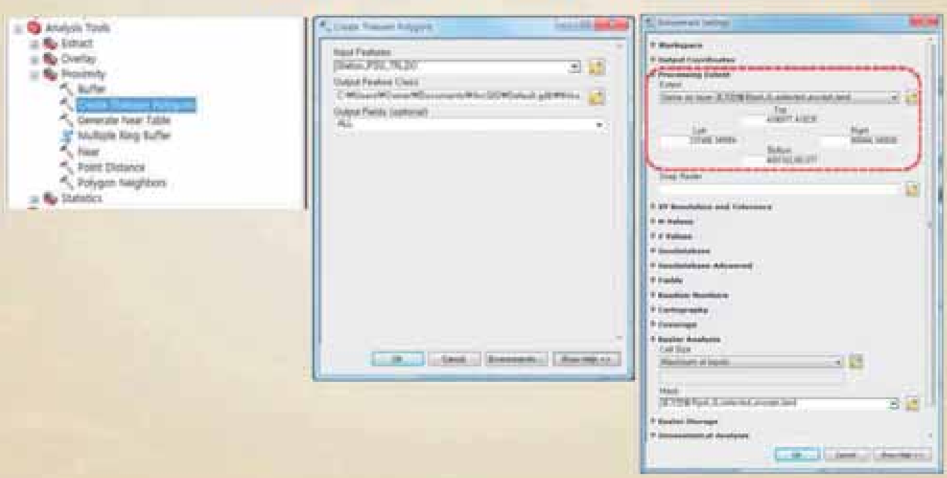
MAPS-SEV *VI-4. Spatial Interpolation*

- Thiessen polygon interpolation
  - For the Gyeonggi Bay case, Thiessen polygons were created for macrozoobenthic biomass because the data did not show the characteristics of spatially continuous distribution.
  - ArcGIS command: Analysis Tools ▷ Proximity ▷ Create Thiessen Polygon



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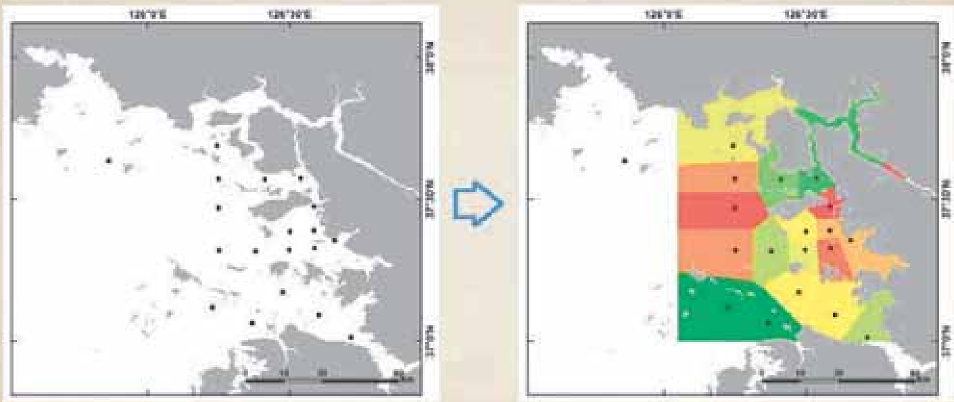
MAPS-SEV

VI-4. Spatial Interpolation

- Thiessen polygon interpolation
  - An example for the Gyeonggi Bay case



Thiessen polygons generated for macrozoobenthic biomass in the Gyeonggi Bay

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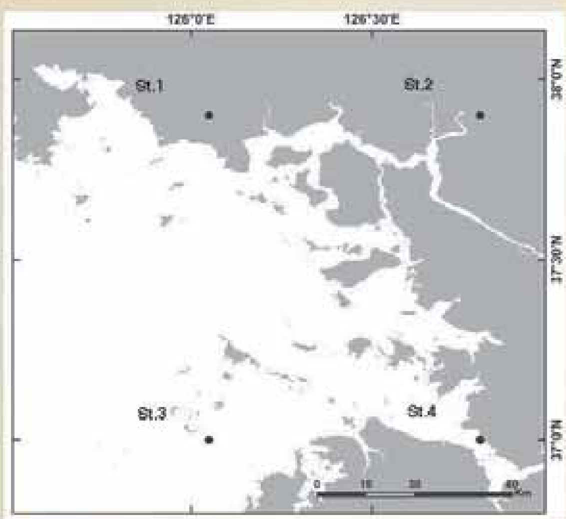
MAPS-SEV

VI-5. Spatial Grid Data Map Construction

- Spatial boundary for the Gyeonggi Bay case



Station	Latitude	Longitude
St.1	37.8°	126.05°
St.2	37.8°	126.80°
St.3	37.0°	126.05°
St.4	37.0°	126.80°

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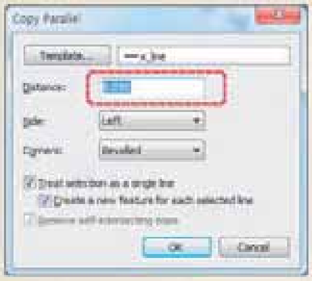
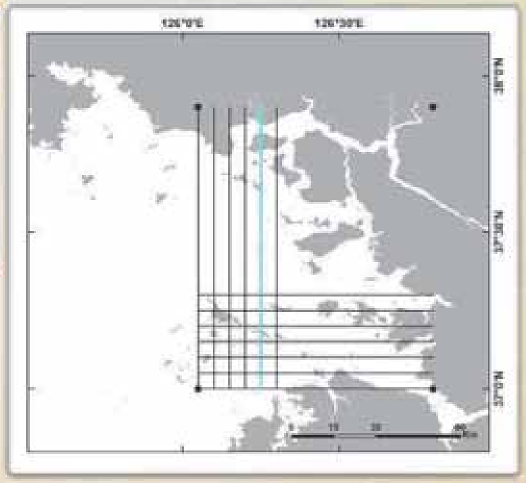
MAPS-SEV — VI-5. Spatial Grid Data Map Construction

- Create polyline by connecting the four boundary stations
  - 1/20° interval (~5 km) for the Gyeonggi Bay case
  - ArcGIS command: Editor ▷ Create Features ▷ Copy parallel

Grid interval





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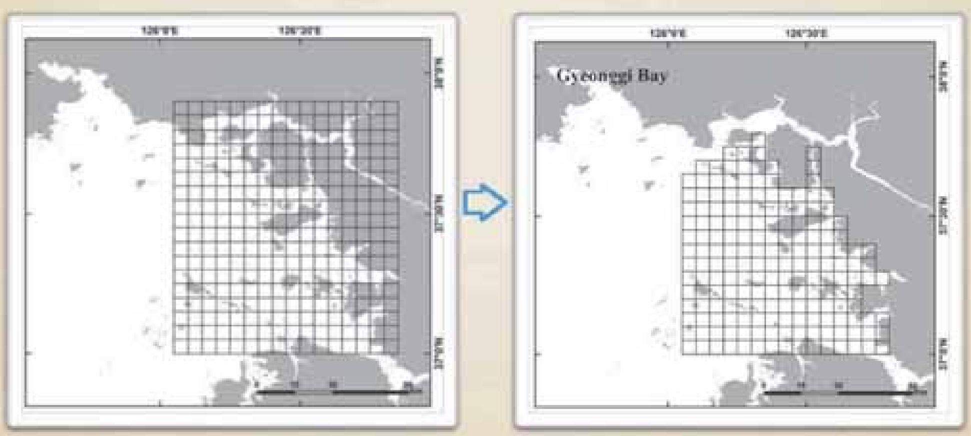
MAPS-SEV — VI-5. Spatial Grid Data Map Construction

- Close the polyline and then create grid polygons
  - ArcGIS command: Feature to polygon
  - Gyeonggi Bay case
    - 180 grids with a total area of 3,750 km²
    - A grid with an interval of 1/20° (~5 km) with an area of about 24.5 km²



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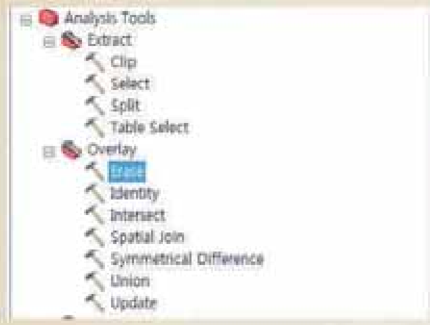
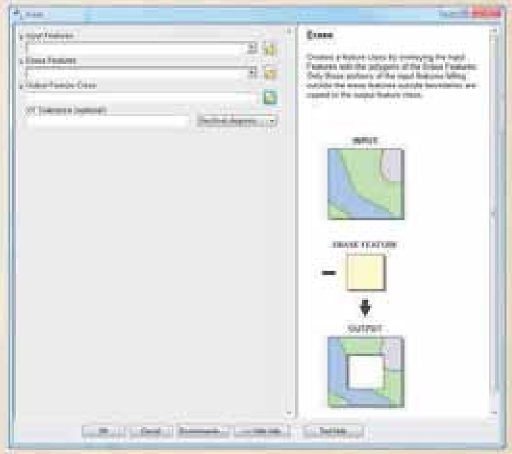
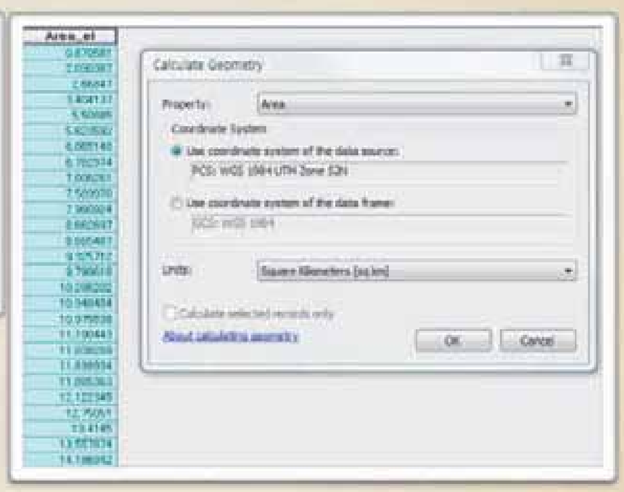
- Calculate area of grids
  - First remove land from the grid polygons
    - ArcGIS command: Analysis Tools ▷ Overlay ▷ Erase





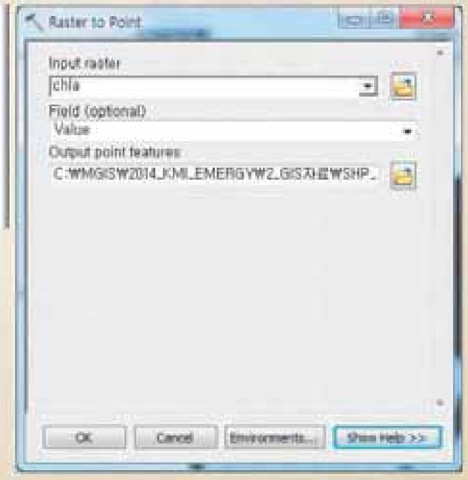
- Calculate area of grids
  - ArcGIS command: Table ▷ Calculate Geometry



MAPS-SEV

VI-5. Spatial Grid Data Map Construction

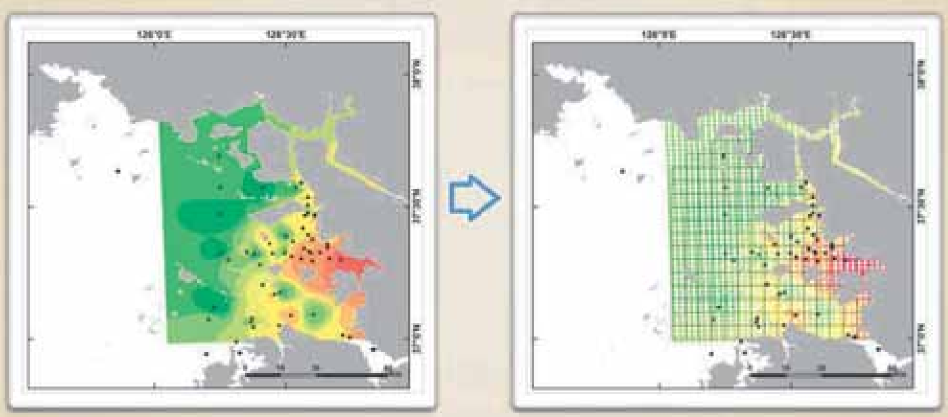
- Conversion of raster datasets to point features
  - Conversion of raster data from IDW interpolation to point data for Spatial join
    - Raster data not applicable for spatial join
  - ArcGIS command: Conversion Tools ▷ From Raster ▷ Raster to Point



MAPS-SEV

VI-5. Spatial Grid Data Map Construction

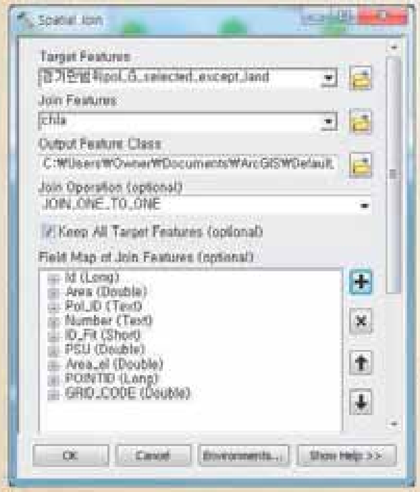
- Conversion of raster datasets to point features
  - An example of conversion of raster data from IDW interpolation to point data

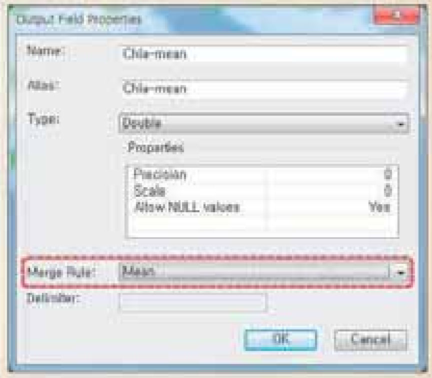


Chlorophyll-a in the Gyeonggi Bay

MAPS-SEV — VI-5. Spatial Grid Data Map Construction

- Convert point layers to grid layers: IDW interpolated data
  - Spatial Join is performed to combine point data in a grid
  - ArcGIS command: Analysis Tools ▷ Overlay ▷ Spatial Join



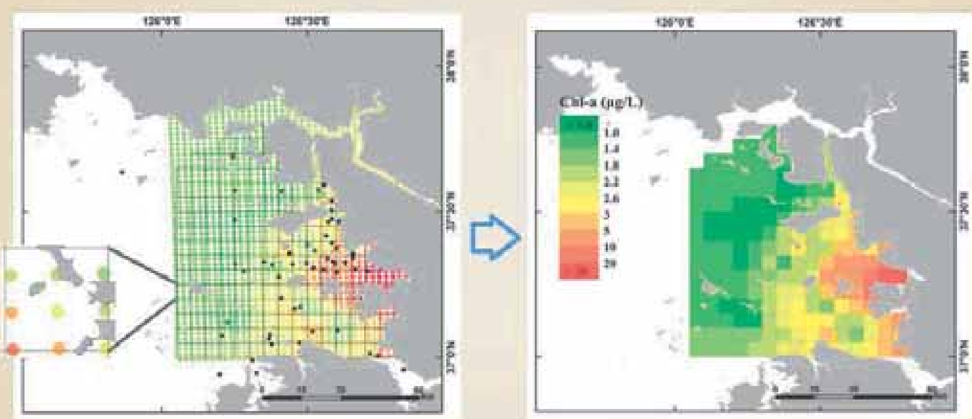


- Select merge rule
  - First, Last, Count, Minimum, Maximum, Sum, Mean, Standard Deviation, Median, Mode, Range

67

MAPS-SEV — VI-5. Spatial Grid Data Map Construction

- Convert point layers to grid layers: IDW interpolated data
  - An example for the Gyeonggi Bay case



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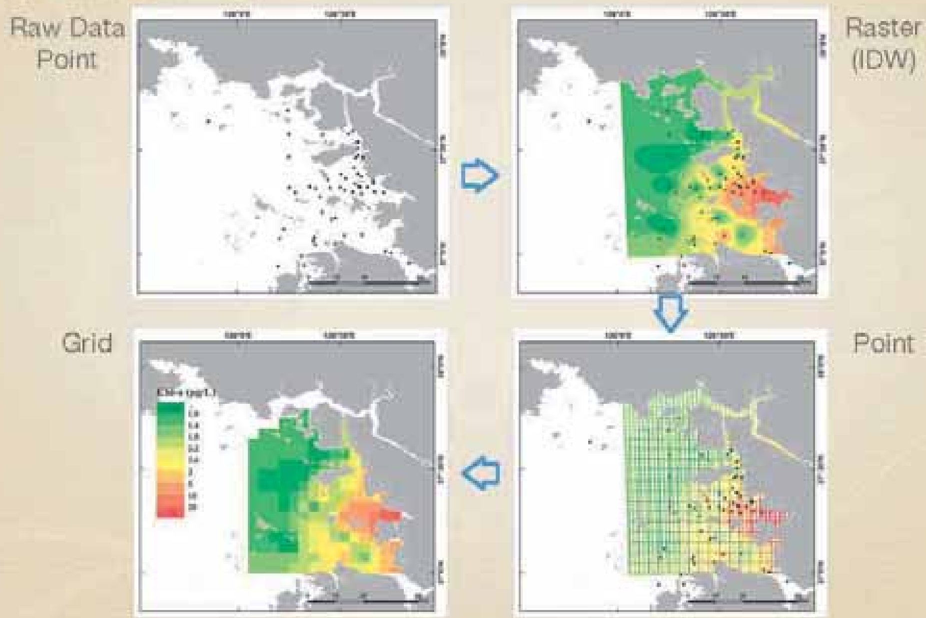
MAPS-SEV

VI-5. Spatial Grid Data Map Construction

- Convert point layers to grid layers: IDW interpolated data
  - Process summary



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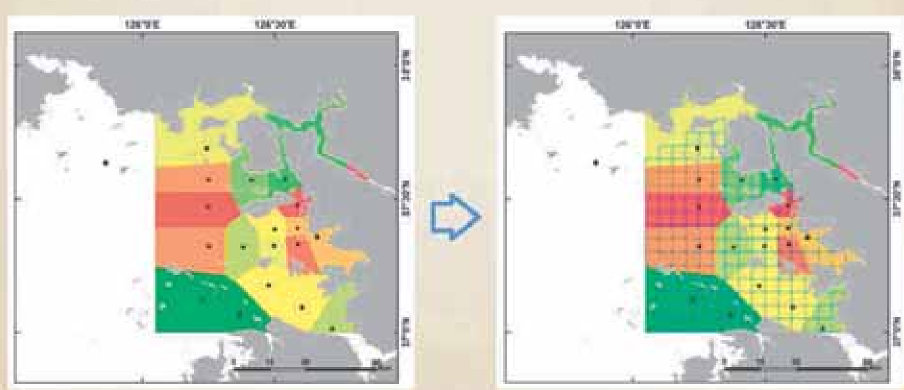
MAPS-SEV

VI-5. Spatial Grid Data Map Construction

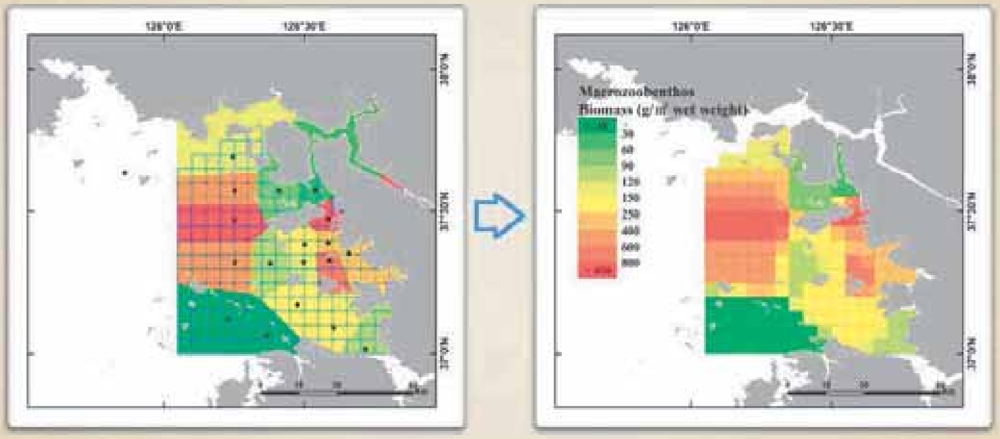
- Convert point layers to grid layers: Thiessen polygons
  - Convert Thiessen polygons to grid layer
  - Grid area calculation
    - ArcGIS command: Table ▷ Calculate Geometry
  - Weighting factors are used to calculate mean value of a grid for data from different polygons
    - Weighting factor based on the fraction of area in a grid



70

MAPS-SEV — VI-5. Spatial Grid Data Map Construction

- Convert point layers to grid layers: Thiessen polygons
  - An example for the Gyeonggi Bay case

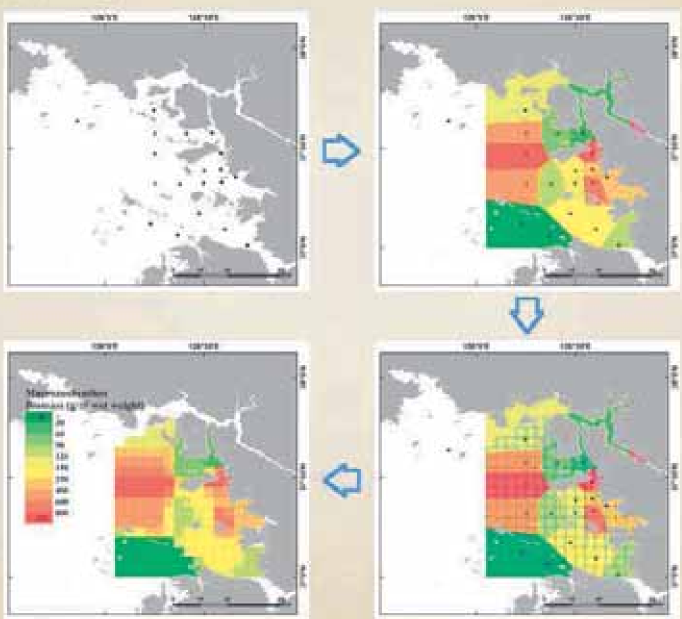


MAPS-SEV — VI-5. Spatial Grid Data Map Construction

- Convert point layers to grid layers: Thiessen polygons
  - Process summary

Raw Data Point

Thiessen Polygon



Grid

Point

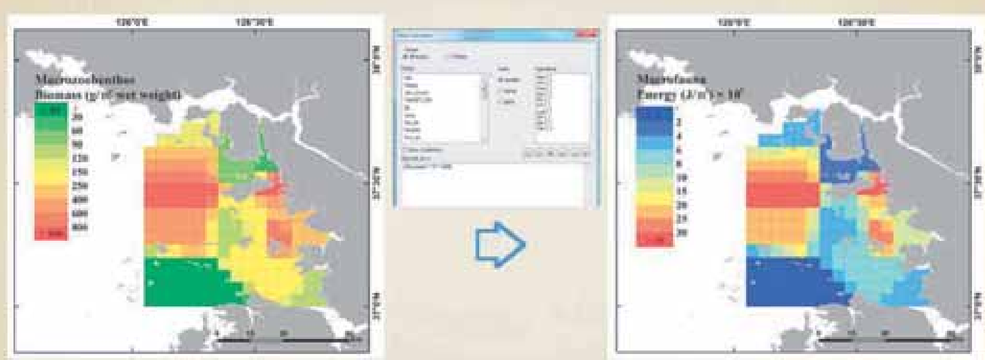
VII. Spatial Emergy Mapping

1. Intermediate Data Calculation
2. Emergy Calculation
3. Emvalue Calculation
4. Emergy Maps

73

MAPS-SEV *VII-1. Intermediate Data Calculation*

- Raw data to intermediate data, if needed
  - ArcGIS command: Field Calculator
  - Example: Energy calculation from macrofauna biomass for the Gyeonggi Bay case



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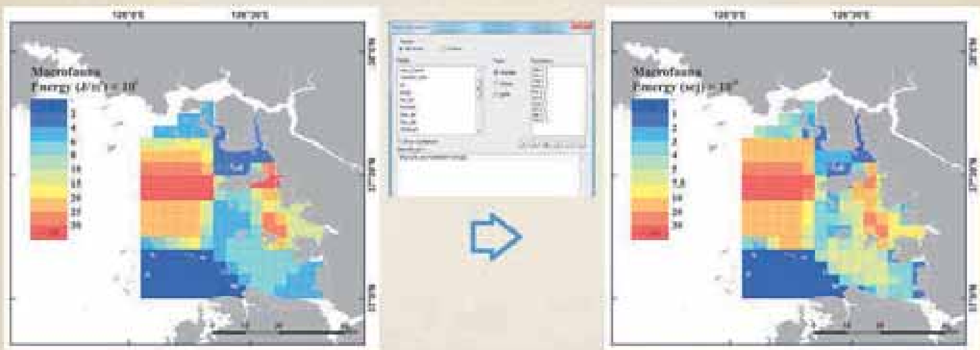
MAPS-SEV

VII-2. Emergy Calculation

- Emergy calculation from maps for raw or intermediate data
  - ArcGIS command: Field Calculator
  - Example : Emergy calculation from macrofauna energy data for the Gyeonggi Bay case

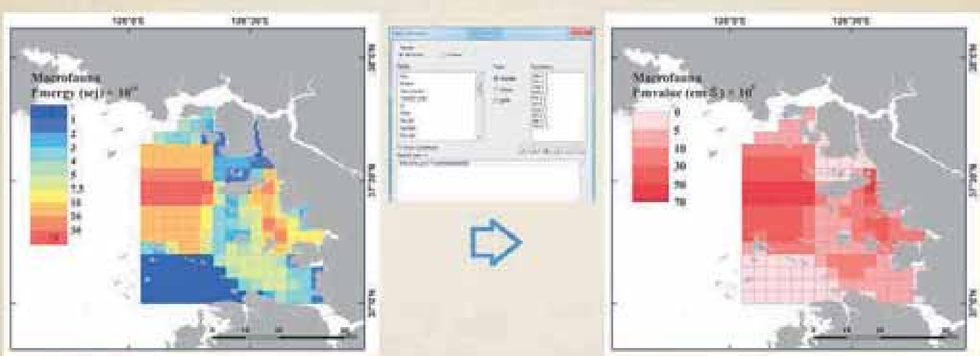


75

MAPS-SEV

VII-3. Emvalue Calculaton

- Emvalue calculation from emergy maps
  - ArcGIS command: Field Calculator
  - Example : Emvalue calculation from macrofauna emergy data for the Gyeonggi Bay case

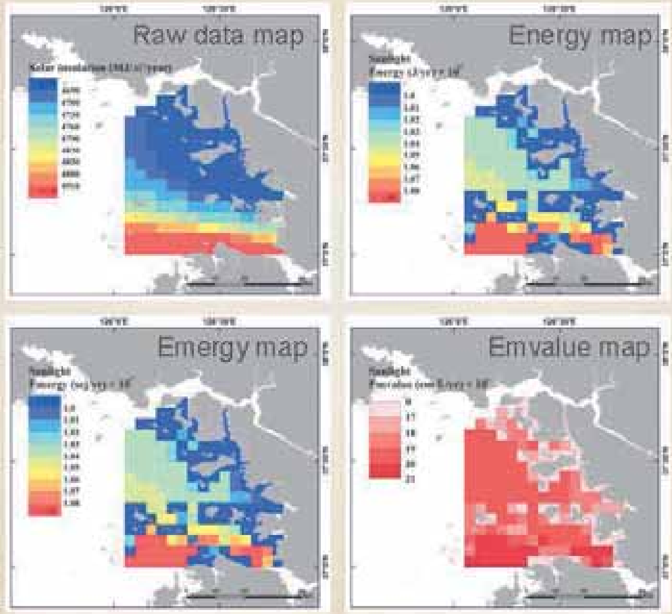


76

MAPS-SEV

VII-4. Emergy Maps

- Environmental inputs: Sun



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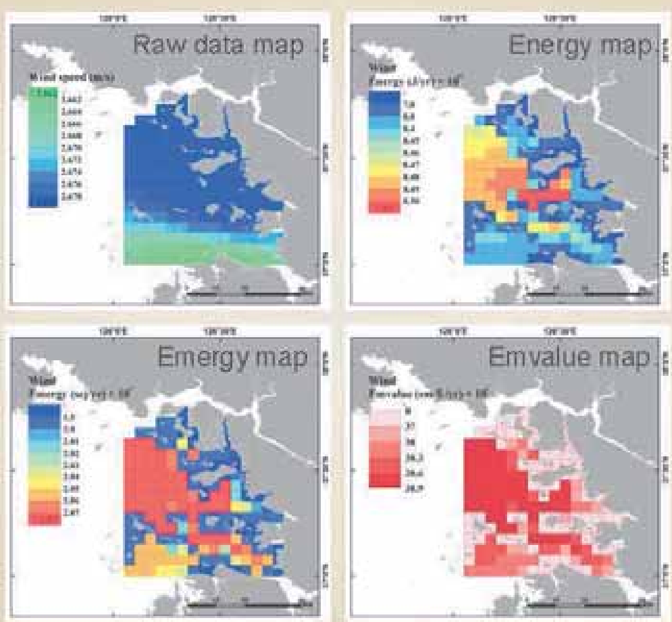
MAPS-SEV

VII-4. Emergy Maps

- Environmental inputs: Wind



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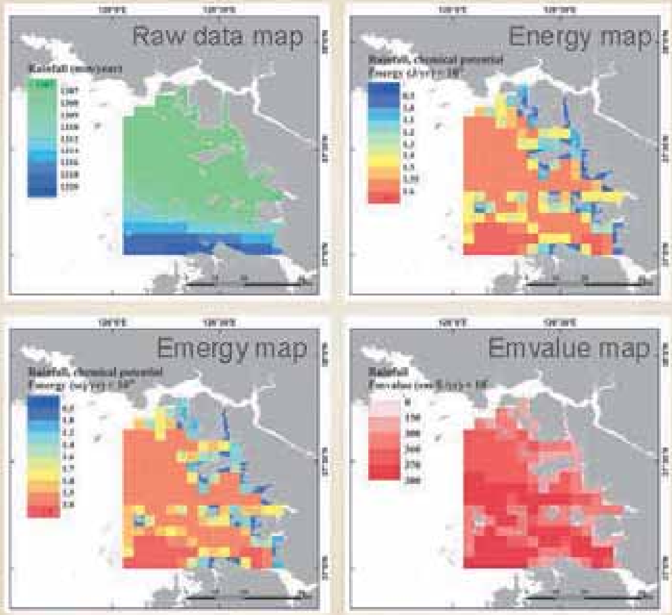
MAPS-SEV

VII-4. Emergy Maps

- Environmental inputs: Rain, chemical potential energy



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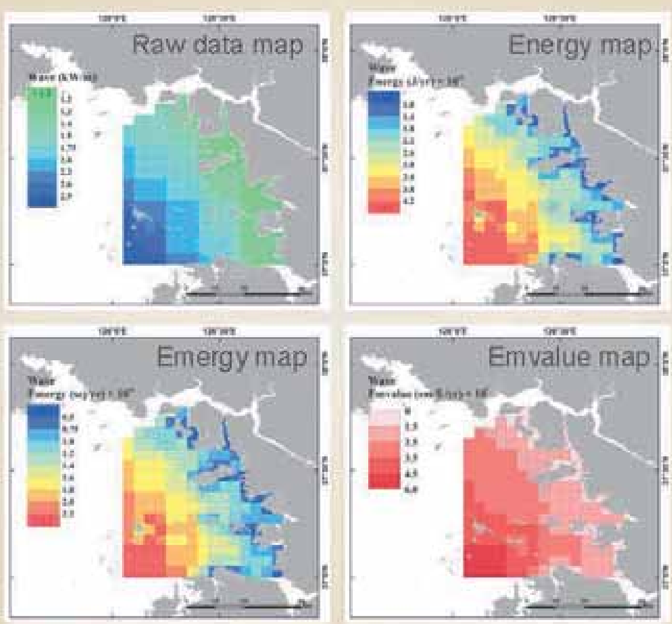
MAPS-SEV

VII-4. Emergy Maps

- Environmental inputs: Wave

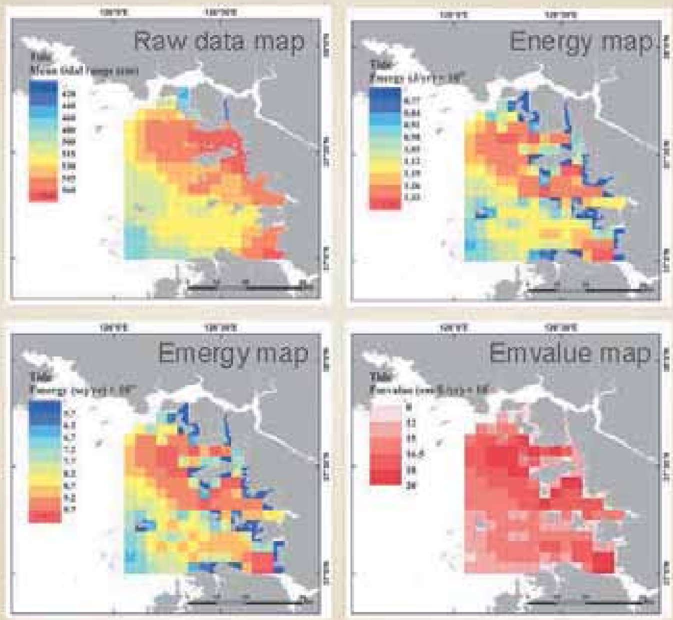


80

MAPS-SEV

VII-4. Emergy Maps

- Environmental inputs: Tide

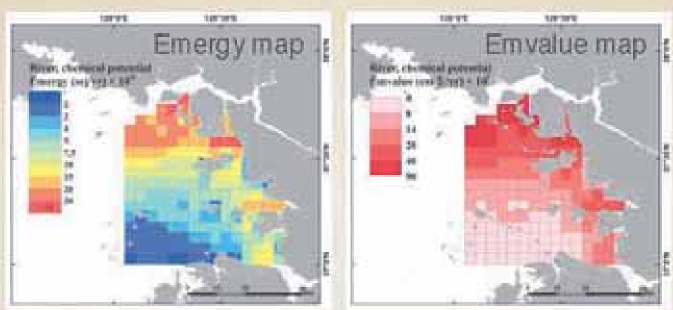


81

MAPS-SEV

VII-4. Emergy Maps

- Environmental inputs: River, chemical potential energy



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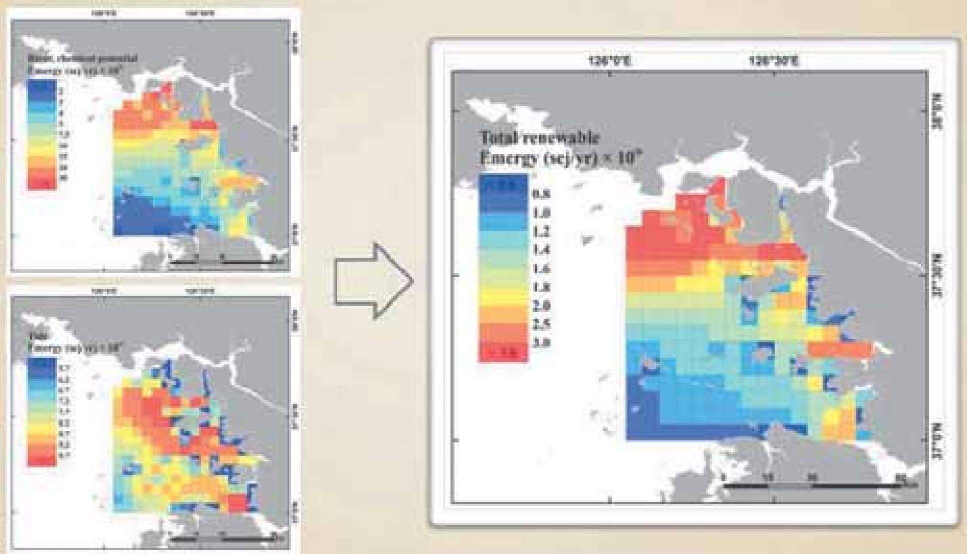
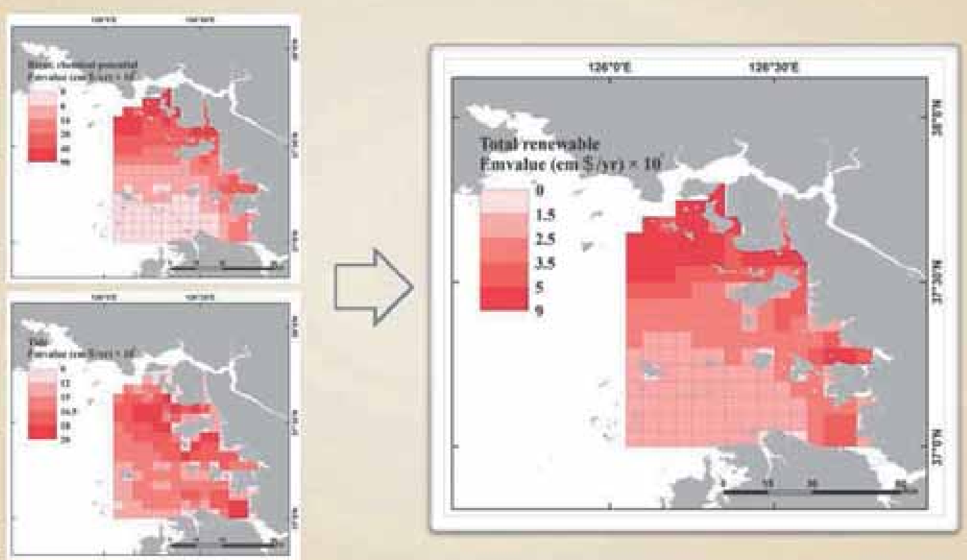
- Total renewable emergy input to the Gyeonggi Bay
  - Tide emergy + River inflow emergy



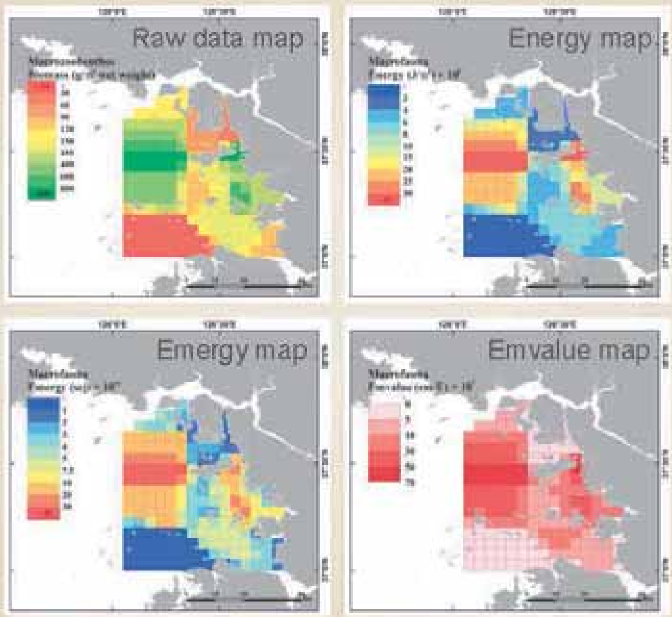
- Total emvalue of renewable emergy input to the Gyeonggi Bay
  - Tide emvalue + River inflow emvalue



MAPS-SEV

VII-4. Emergy Maps

- Natural Capital: Macrozoobenthos

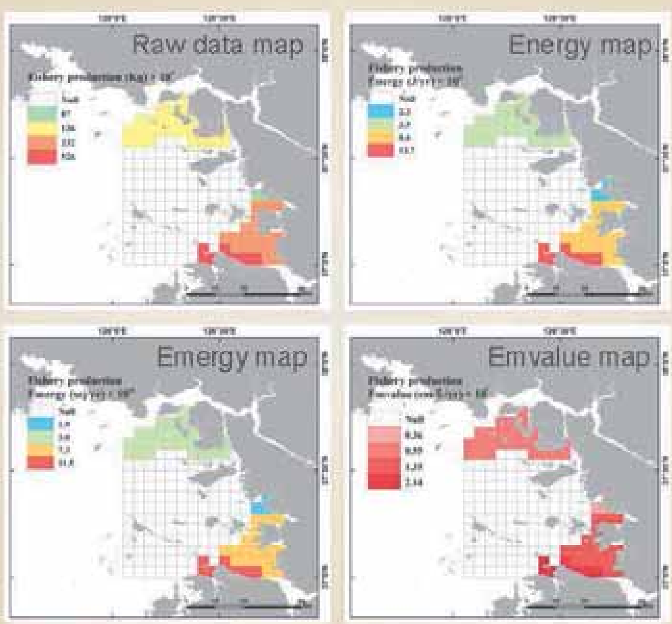


85

MAPS-SEV

VII-4. Emergy Maps

- Ecosystem services: Fishery production



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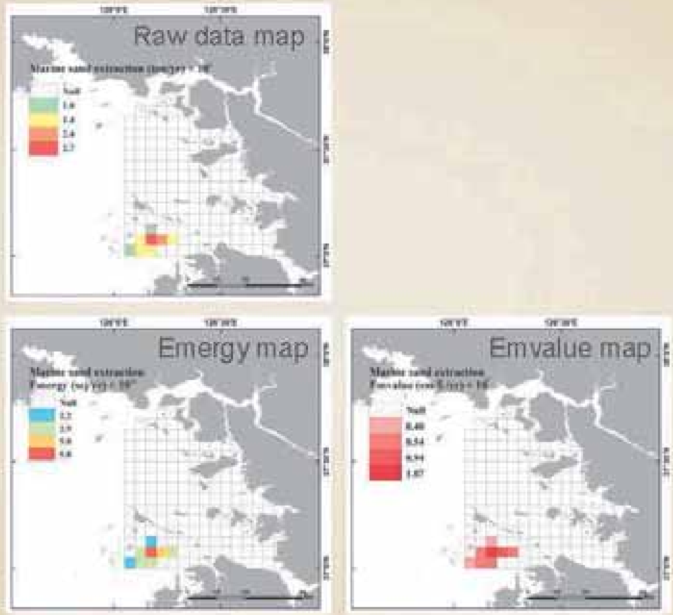
MAPS-SEV

VII-4. Emergy Maps

- Ecosystem services: Marine sand extraction



87

MAPS-SEV

VIII. Application of MAPS-SEV

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MAPS-SEV | **VIII-1. Application**

- What are the potential uses of ecosystem value maps produced by MAPS-SEV?
  - Spatial decision making on the selection of priority areas for conservation and management alternatives
  - Trade-off analysis among different ecosystem services, especially conflicting uses among different stakeholders
  - Reference data for potential compensation and environmental taxes on marine and coastal activities
  - Integration of the value of natural capital and ecosystem services into environmental impact assessment
  - Cost-benefit analysis of development proposals and restoration projects
  - Awareness raising and education on the importance of marine and coastal ecosystems

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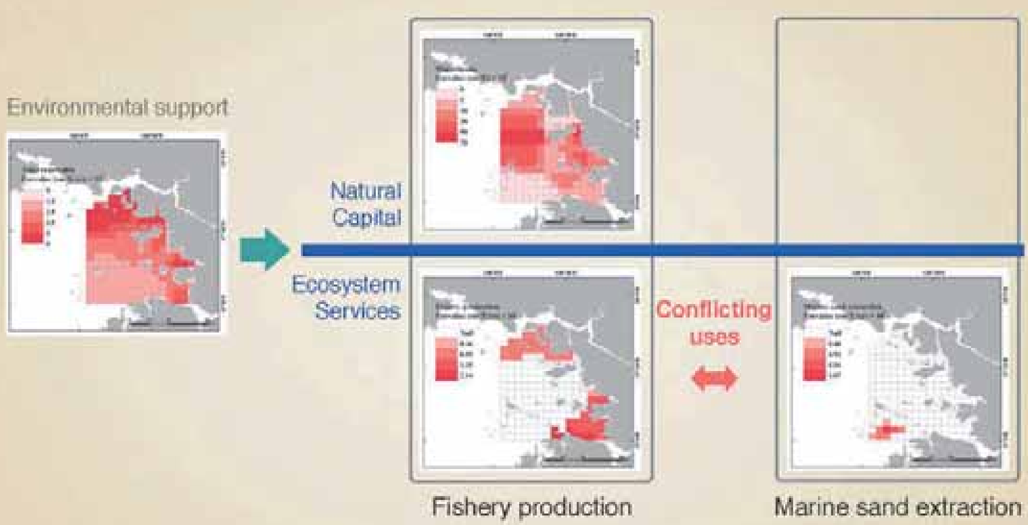
MAPS-SEV | **VIII-1. Application**



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Course 3:

Marine InVEST

(Integrated valuation of environmental services and tradeoffs)

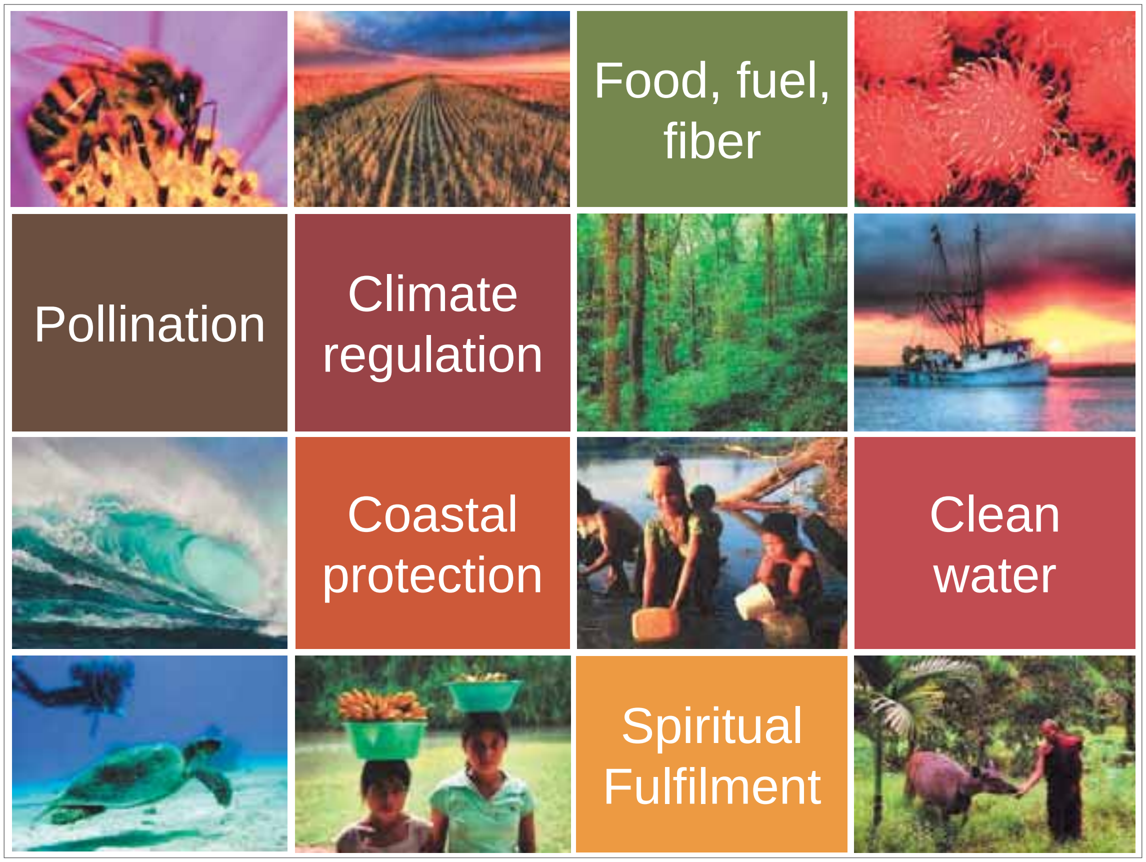
Outline

- Introduction to concepts
- Evolution of natural capital thinking globally
- Diversity of assessment methods and tools

capital is the stock of assets that can be used to produce goods and services that provide benefits to consumers

natural capital is the stock of assets provided by natural systems that can be used—together with other assets—to produce ecosystem goods and services that deliver benefits to consumers

ecosystem services are the benefits that flow from natural capital


Food, fuel, fiber
Pollination
Climate regulation
Coastal protection
Clean water
Spiritual Fulfilment

Spatially-Explicit Ecological Production Functions

Ecological Production Function - an equation that relates the physical outputs of a production process to physical inputs

InVEST
integrated valuation of environmental services and tradeoffs

Links between biodiversity and…

- …ecosystem functions
  - Biomass production
  - Decomposition
  - Nutrient recycling
- …ecosystem services
  - Positive: crop yields, fisheries, timber yields, carbon sequestration
  - Negative/equivocal: water purification, disease regulation

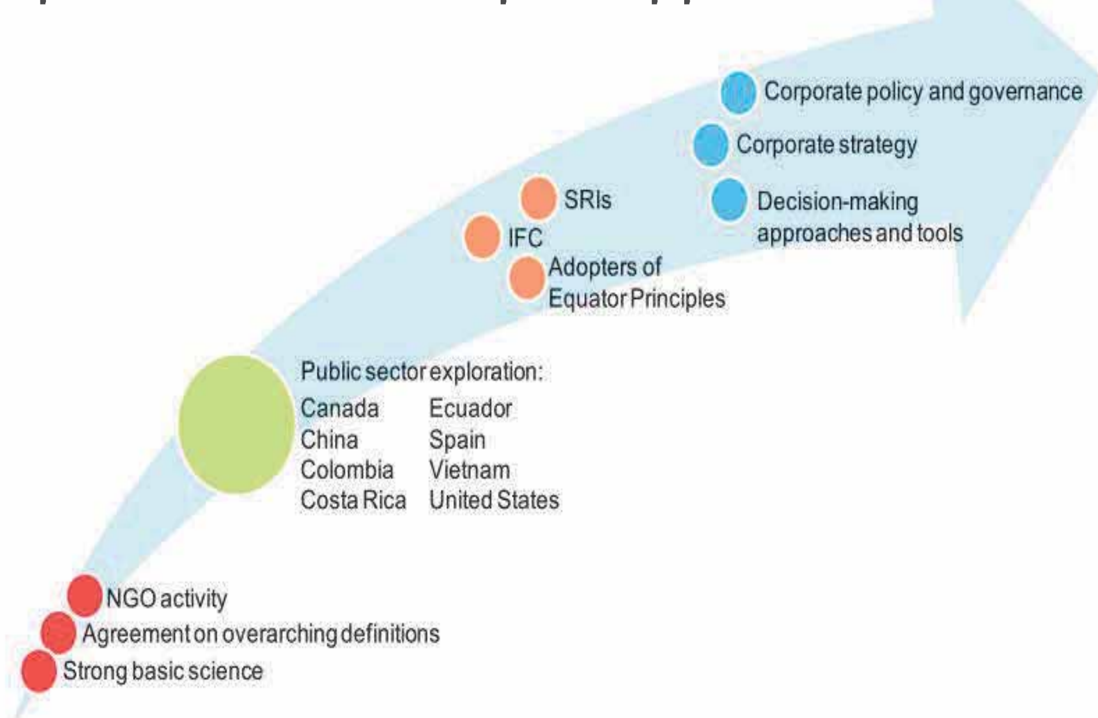
Cardinale et al. 2013 *Nature*

Timeline

2005	2008 – 2010	2012	2013
MILLENNIUM ECOSYSTEM ASSESSMENT	Ecosystem Services Partnership	RIO+20	The B Team
natural capital PROJECT	US National Ecosystem Services Partnership	ipbes	Natural Capital Business Hub
	A Conference on Ecosystem Services (ACES)	Natural Capital Coalition	Natural Capital Leaders index
	The Economics of Ecosystem and Biodiversity (TEEB)	GLOBE Natural Capital initiative	World Forum on Natural Capital
	Wealth Accounting and Valuation of Ecosystem Services (WAVES)	Natural Capital Declaration	
	ProEcoServ	Natural Capital Leadership Compact	
		UK Natural Capital Committee	

Private Sector projects

Uptake of natural capital approaches

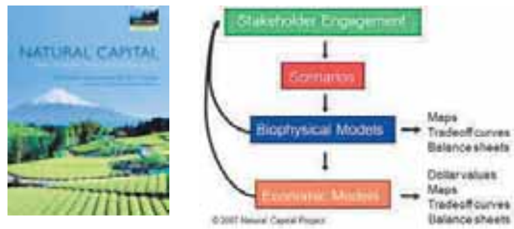


Business for Social Responsibility. 2012

Ecosystem Service Assessment Tools

ARIES (**AR**tificial **I**ntelligence for **E**cosystem **S**ervices)

InVEST
(**I**ntegrated **V**aluation of **E**cosystem **S**ervices and **T**radeoffs)

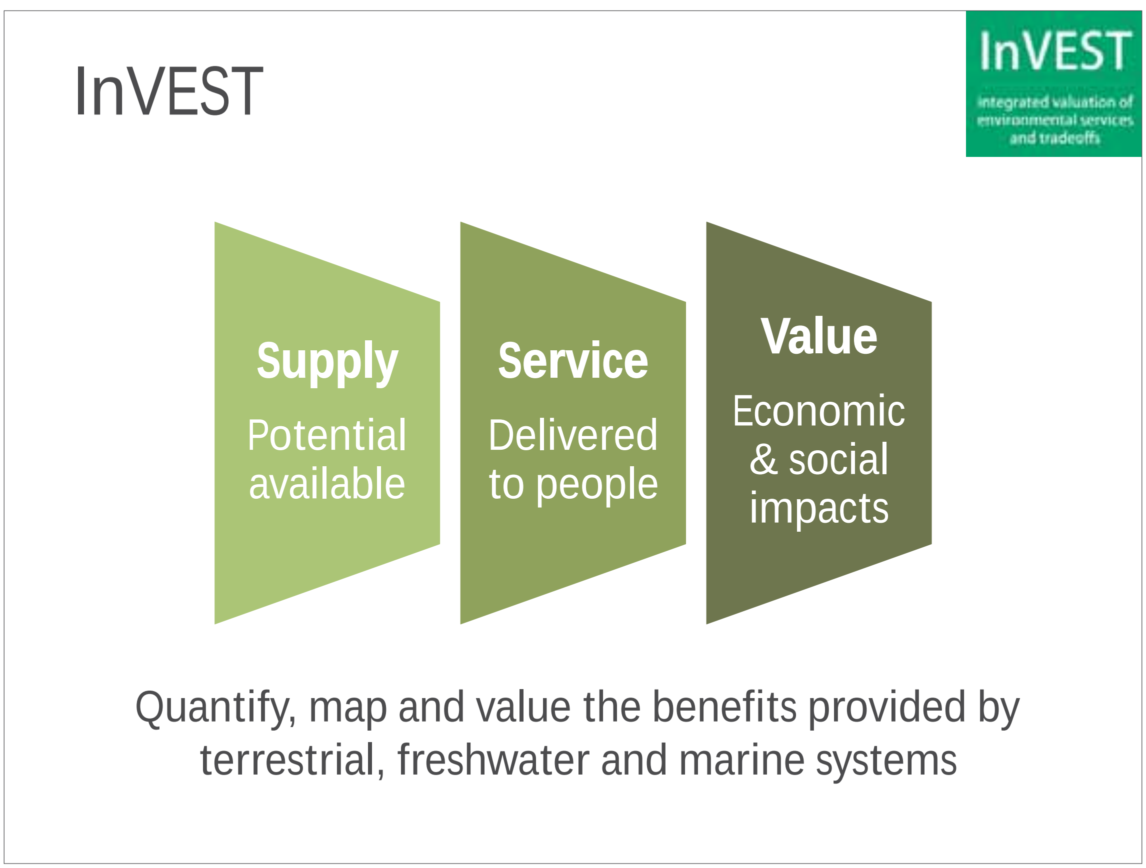


ESValue

EcoMetrix

A common vision to create a world where business conserves and enhances natural capital

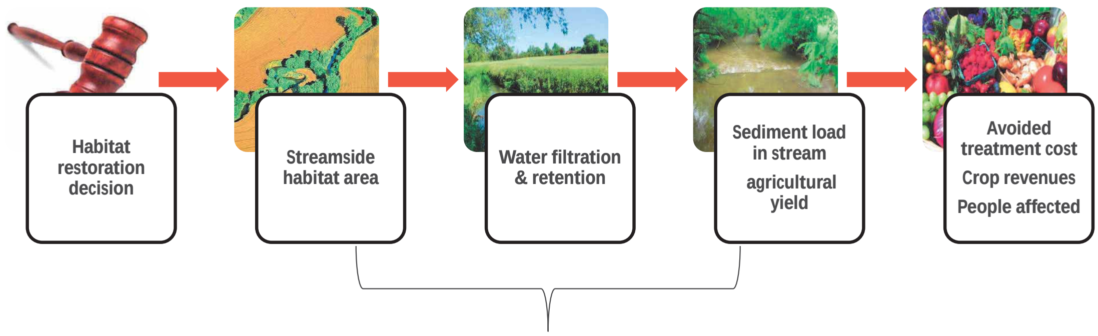

InVEST
integrated valuation of environmental services and tradeoffs
Free. Open source.
http://www.naturalcapitalproject.org
natural capital PROJECT


InVEST
InVEST
integrated valuation of environmental services and tradeoffs
Supply
Potential available
Service
Delivered to people
Value
Economic & social impacts
Quantify, map and value the benefits provided by terrestrial, freshwater and marine systems

Production Functions and Ecosystem Services

InVEST
integrated valuation of environmental services and tradeoffs

Alternative management, policy → Δ Ecosystem structure → Δ Ecosystem function → Δ Ecosystem service → Δ Ecosystem service value



Change in environment → Change in benefits
(production function)

InVEST Models

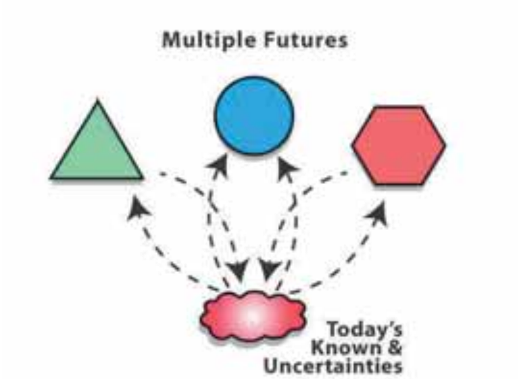
InVEST
integrated valuation of environmental services and tradeoffs

Scenarios

natural capital PROJECT

Plausible, simplified, descriptions of the future

- **Useful for examining how actions taken today play out into the future**
- **InVEST requires scenarios of maps of land/ocean cover**



Vancouver Island

Future?

Guerry et al. 2012

Terrestrial / FW Models

InVEST
integrated valuation of environmental services and tradeoffs

Biodiversity: Habitat Quality

Water yield for hydropower production

Erosion control: reservoirs and WQ

Water purification: nutrient retention

Carbon sequestration & storage

Managed timber production

Crop pollination

Coastal & Marine Models

InVEST
integrated valuation of environmental services and tradeoffs

Recreation*

Aquaculture

Fisheries*

Coastal Protection*

Renewable Energy (wave and wind)

Scenic Quality

Water Quality

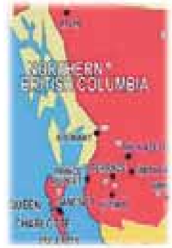
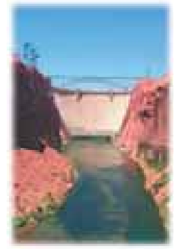
Habitat Risk Assessment*

Carbon Sequestration

Data Input Examples

InVEST
integrated valuation of environmental services and tradeoffs

Spatial data

Land use/ Land cover	Soil type	Topography	Cities	Infrastructure
				

Associated data

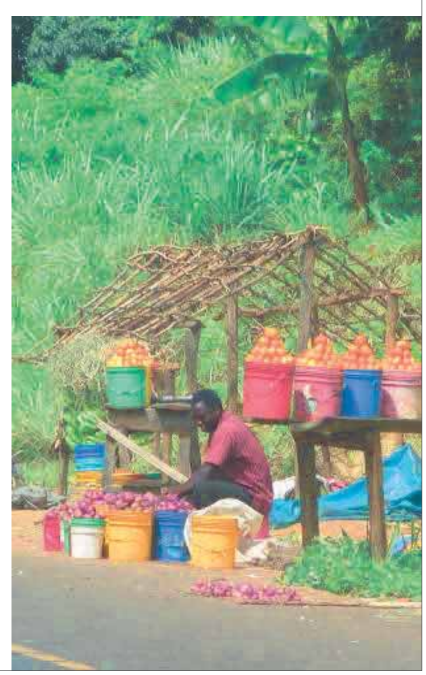
<u>Examples</u>:

- Carbon pools by land use/land cover and soil
- Habitat suitability by land use/land cover
- Market value of timber or carbon

Economic valuation methods

InVEST
integrated valuation of environmental services and tradeoffs

- Market valuation
  - Carbon
  - Timber
  - Non-timber forest products
- Avoided damage costs
  - Water purification
  - Flood mitigation
  - Avoided reservoir sedimentation
- Production Economics
  - Water for irrigation
  - Pollination of agricultural crops



Recreation & Tourism: example

InVEST
integrated valuation of environmental services and tradeoffs

Recreation is:

- A service provided by nature
- Important for health and well-being of people
- Important to local economies

Recreation

InVEST
integrated valuation of environmental services and tradeoffs

Supply
Potential available

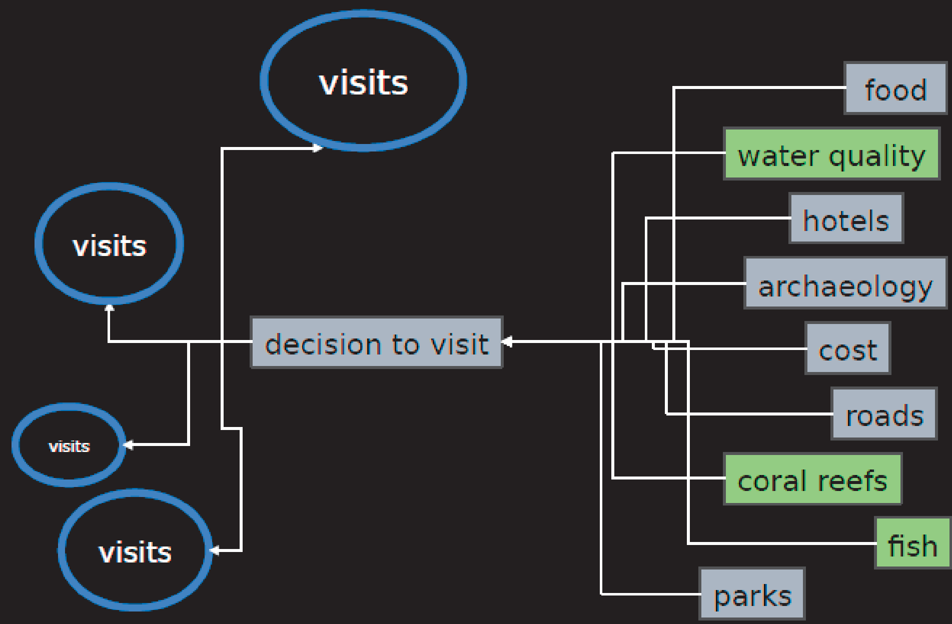
Service
Delivered to people

Value
Economic & social impacts

Coral reefs

background

visitation rate = predictor + predictor + predictor +



background

visitation rate = predictor + predictor + predictor +

shellfish collectors = **development** + water quality + abundance + area + access + substi

refuge visitors = **ocean** + park area + income + population

wildlife viewers = area + income + population

park visitors = **water activities** + park age + camping + distance to city + distance to tow

park visitors = **income** + park age + year

national park visitors = **area** + **fees** + population + substitutes + income + fame

park visitors = **recreational activities** + distance to city + habitats (#) + trails

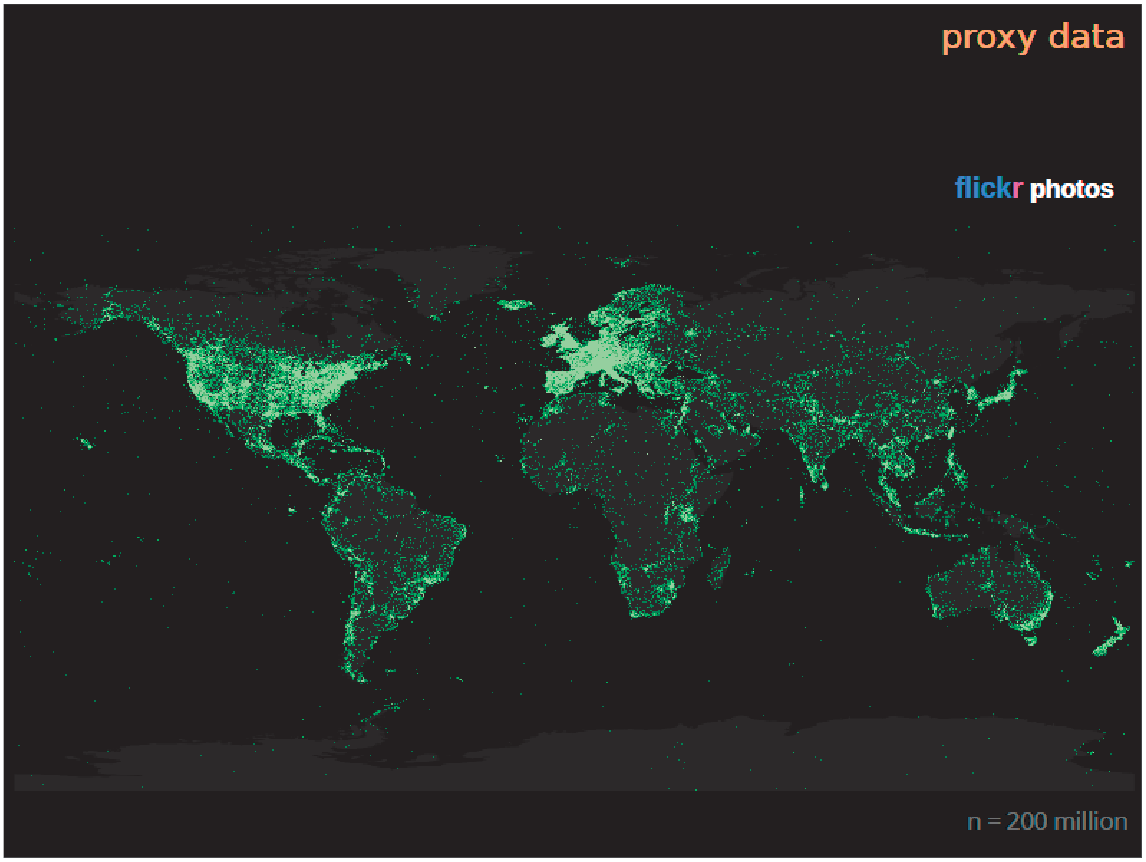
park visitors = **canyons** + **historic sites** + area + population + boating + wildlife viewing

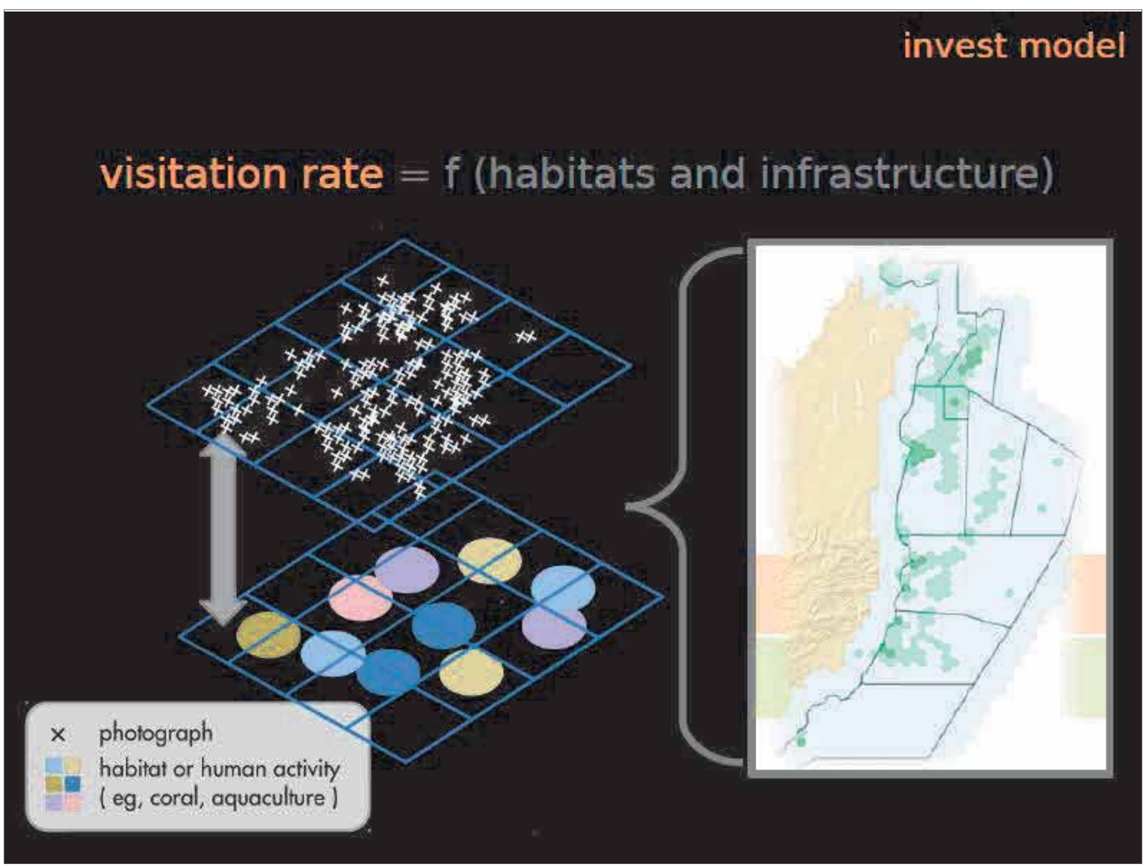
park visitors = **campsites** + **Lake Superior** + distance to city + population + habitats (#) +
+ trails + bird habitat + bird species + development + built capital + park area

woodland visitors = **population** + **forest attributes** + ownership + parking spaces

etc …

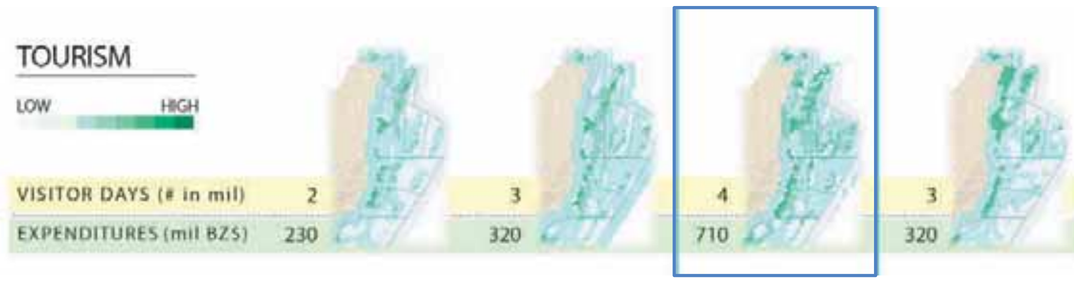
$R^2 = 0.26 – 0.78$


proxy data
flickr photos
n = 200 million


invest model
visitation rate = f (habitats and infrastructure)
× photograph
habitat or human activity
(eg, coral, aquaculture)

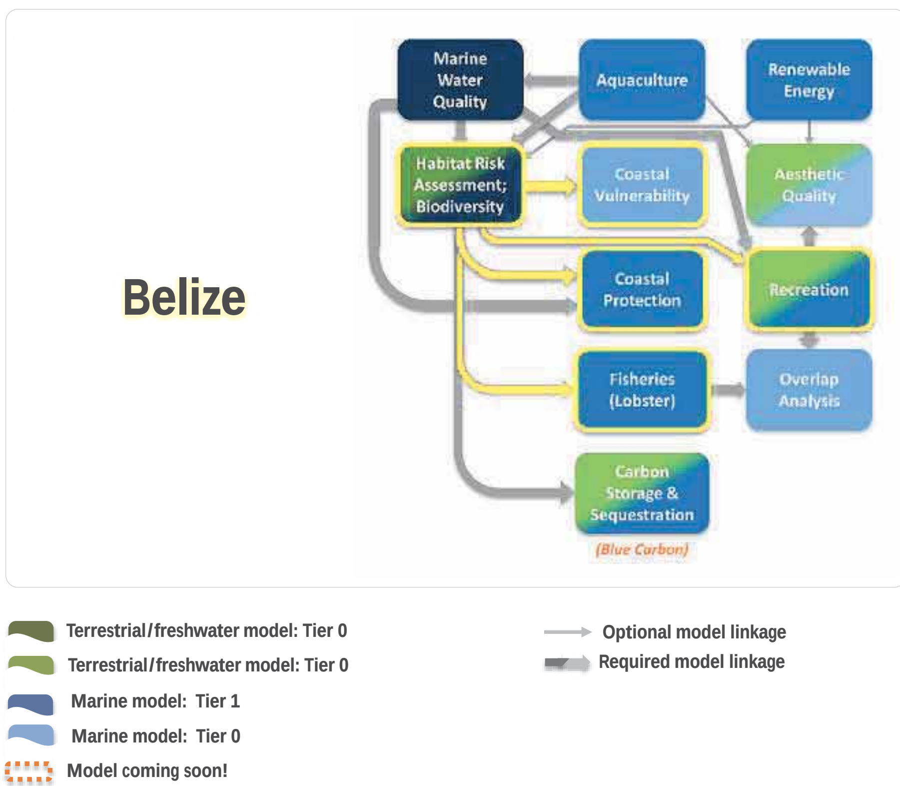
Recreation example: Output

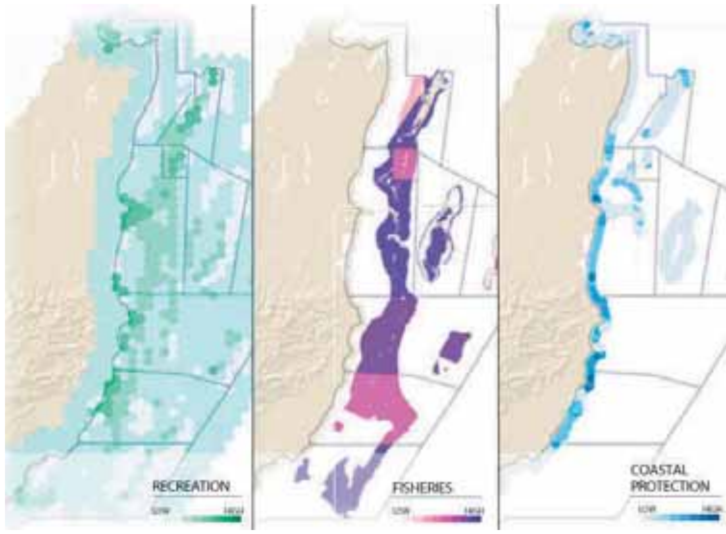
InVEST
integrated valuation of environmental services and tradeoffs



- Where are people visiting?
- What factors are positively or negatively correlated with visitation?
- What is the value provided by tourism?
- How might visitation and expenditures differ in the future?

InVEST Models & Linkages





Why InVEST?

InVEST
integrated valuation of environmental services and tradeoffs

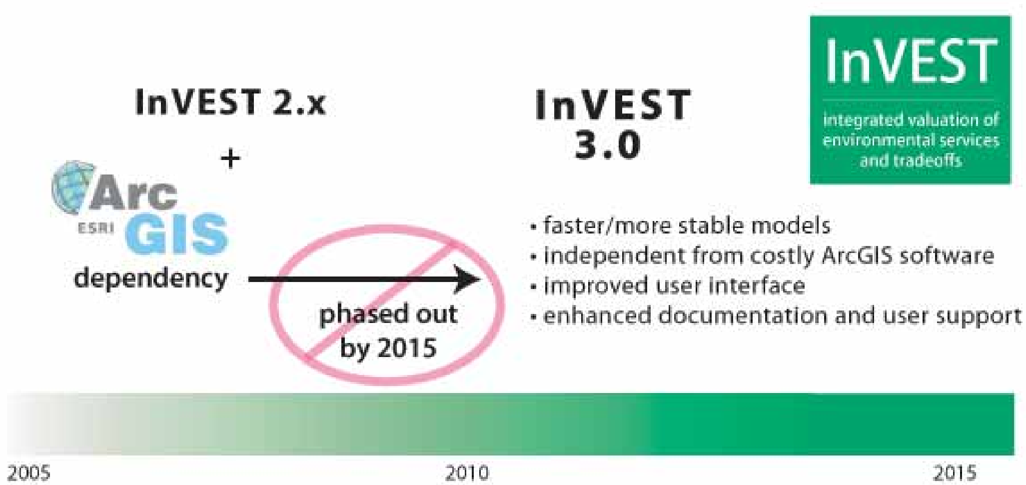
- Applicable anywhere on the globe
- With minimal data
- Flexible scale
- Scenario based
- Relevant to many kinds of decisions
- Biophysical and economic
- Multi-services comparisons (synergies and tradeoffs)

Preparing & Visualizing Data

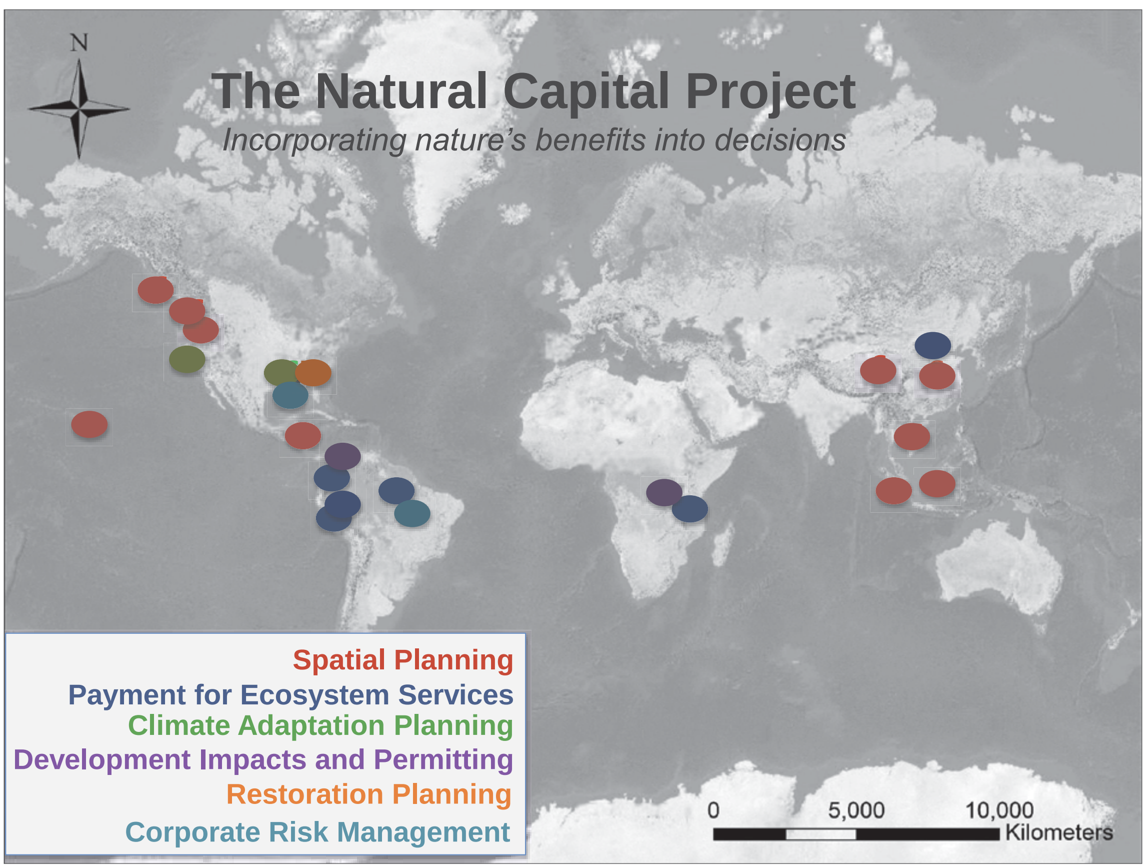
InVEST
integrated valuation of environmental services and tradeoffs

www.arcgis.com
License required

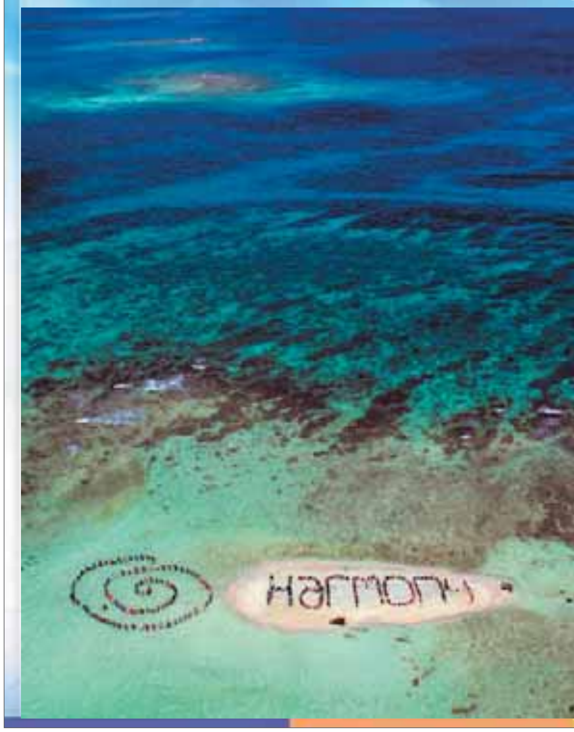
www.qgis.org
Free



Marine Spatial Planning using InVEST Models



1. Integrated coastal zone management plan in Belize



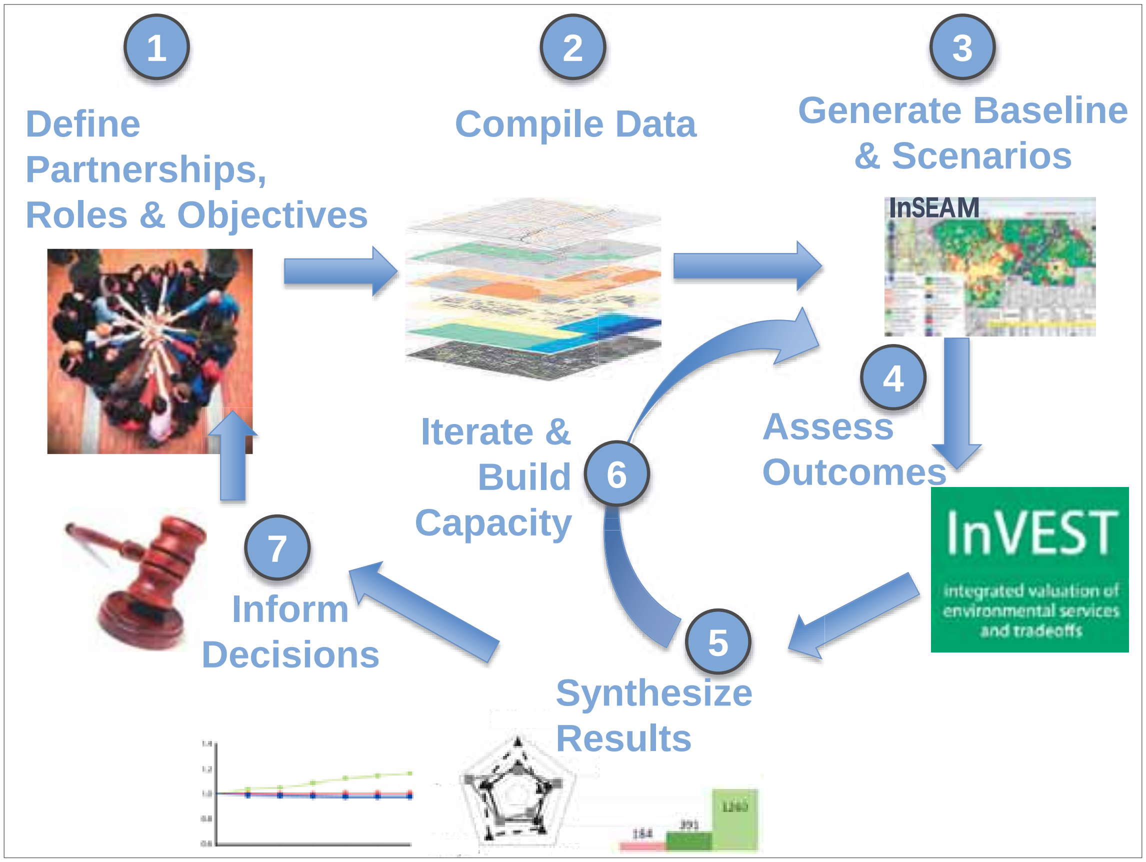
Facilitate the balanced and sustainable use of the coastal and marine environment for the benefit of Belizeans and the global community

BELIZE COASTAL ZONE MANAGEMENT AUTHORITY & INSTITUTE

natural capital PROJECT

WWF

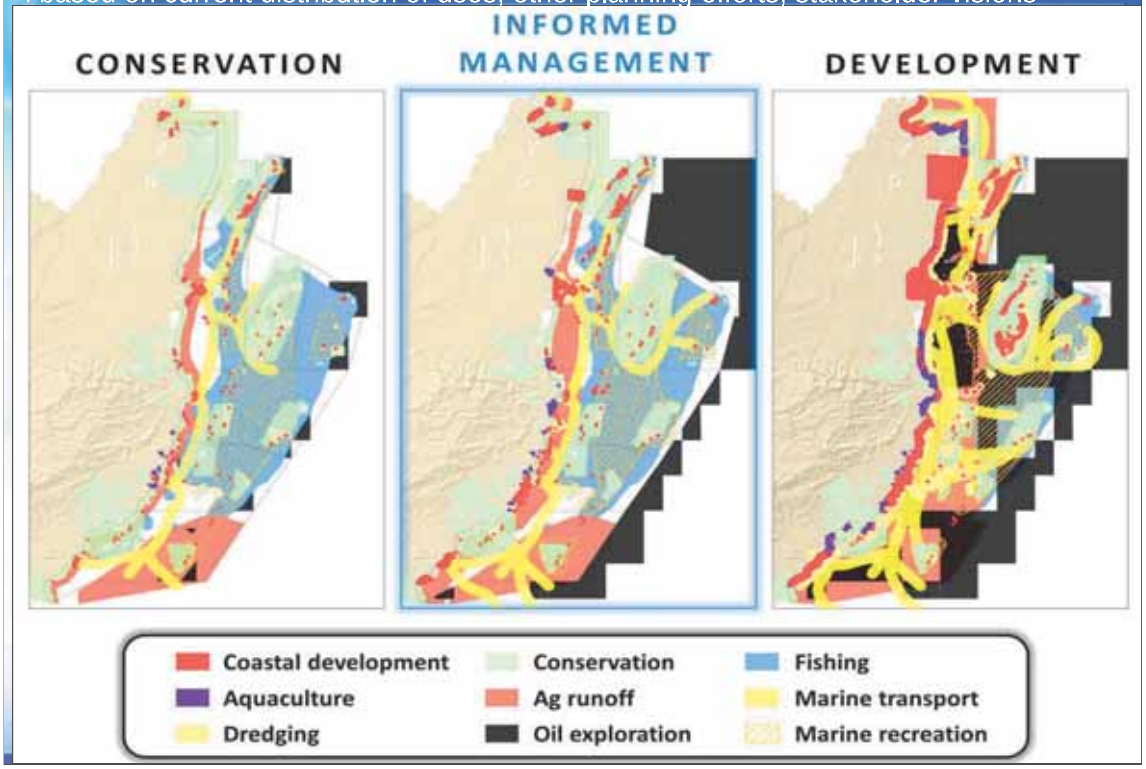
Coastal and marine ecosystems provide important benefits to the Belizean people

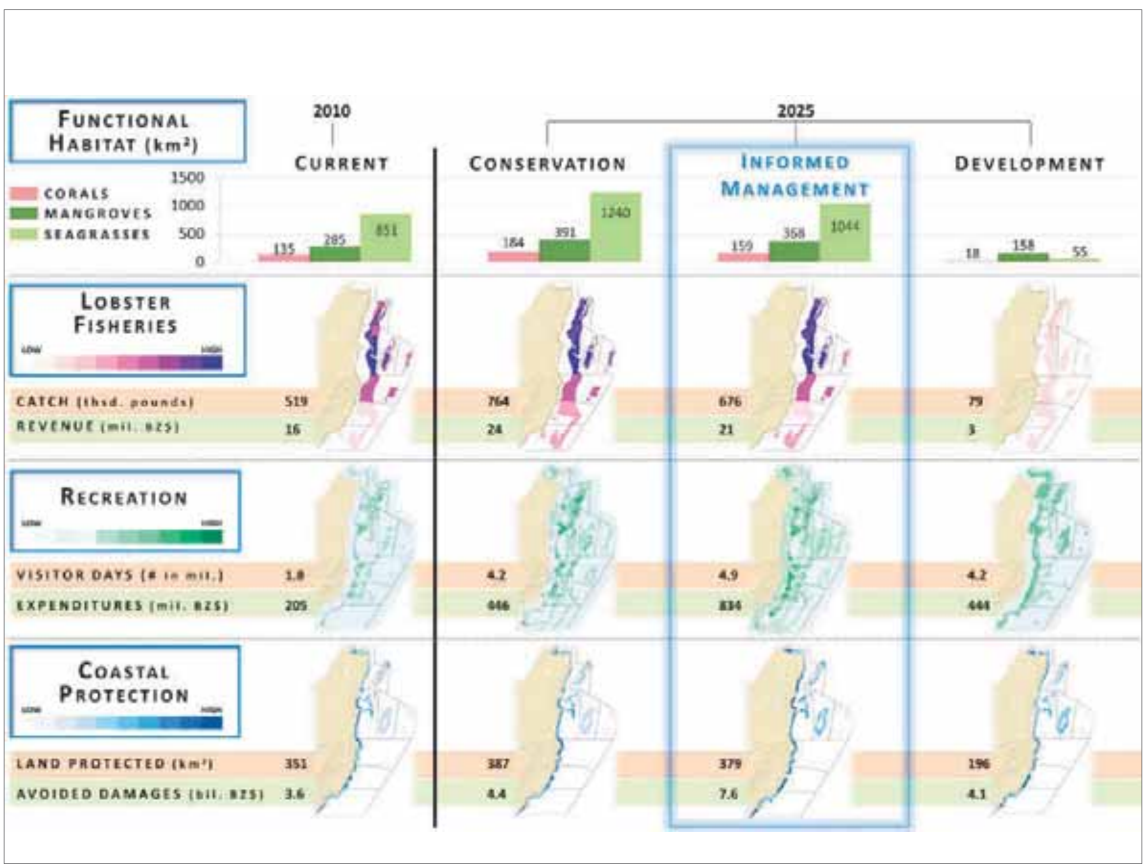

1
Define
Partnerships,
Roles & Objectives
2
Compile Data
3
Generate Baseline
& Scenarios
InSEAM
4
Assess
Outcomes
InVEST
integrated valuation of
environmental services
and tradeoffs
5
Synthesize
Results
6
Iterate &
Build
Capacity
7
Inform
Decisions


Stakeholder engagement
Models
InVEST
Integrated Valuation of
Ecosystem Services & Tradeoffs
COASTAL PLANNING REGIONS
Northern Belize
Central Belize
Southern Belize
Belize

Possible future scenarios (2025)

: based on current distribution of uses, other planning efforts, stakeholder visions





Informed first ICZM Plan in Belize
- Vote in the House of Representatives

Trained professionals in InVEST Software
- Contributed their perspectives on zoning options
- The CMAI expects to continue using InVEST in future environmental impact assessments for the coastal zone

Summary

Ecological Economics (Ruckelshaus et al. 2013)

- ✓ Applying a BES approach is most effective in leading to policy changes
- ✓ Simple ecological production function models have been useful in a diverse set of decision contexts
- ✓ Training local experts in the approaches and tools is important for building local capacity, ownership, trust, and long-term success
- ✓ Decision makers and stakeholders prefer to use a variety of BES value metrics
- ✓ An important science gap exists in linking changes in BES to changes in livelihoods, health, cultural values, and other metrics of human wellbeing
- ✓ Communicating uncertainty in useful and transparent ways remain challenging

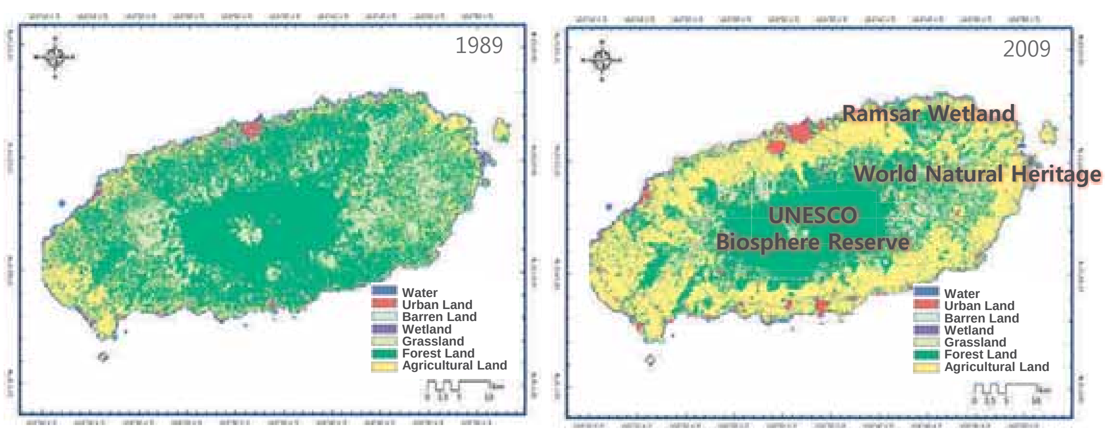
Ecosystem Service Model Applications for Decision Making

1. Jeju Island, Korea: Sustainable development

1

Main Issue of Natural Capital Management in Jeju

- **Conservation Efforts vs. Development Pressure**



		Agri. L.	Barren L.	Urban L.	Forest L.	Grassland	Water	Wetland
1989	Area(㎢)	379.32	7.83	69.39	924.93	466.55	37.12	0.59
1998	Area(㎢)	394.12	15.10	88.86	1035.46	322.08	29.16	0.39
2009	Area(㎢)	819.76	15.34	98.89	649.29	271.38	30.50	0.38
Increase & Decrease	Ratio(%)	+116	+96	+43	-30	-42	-18	-36

2

Objectives for the Jeju Applications

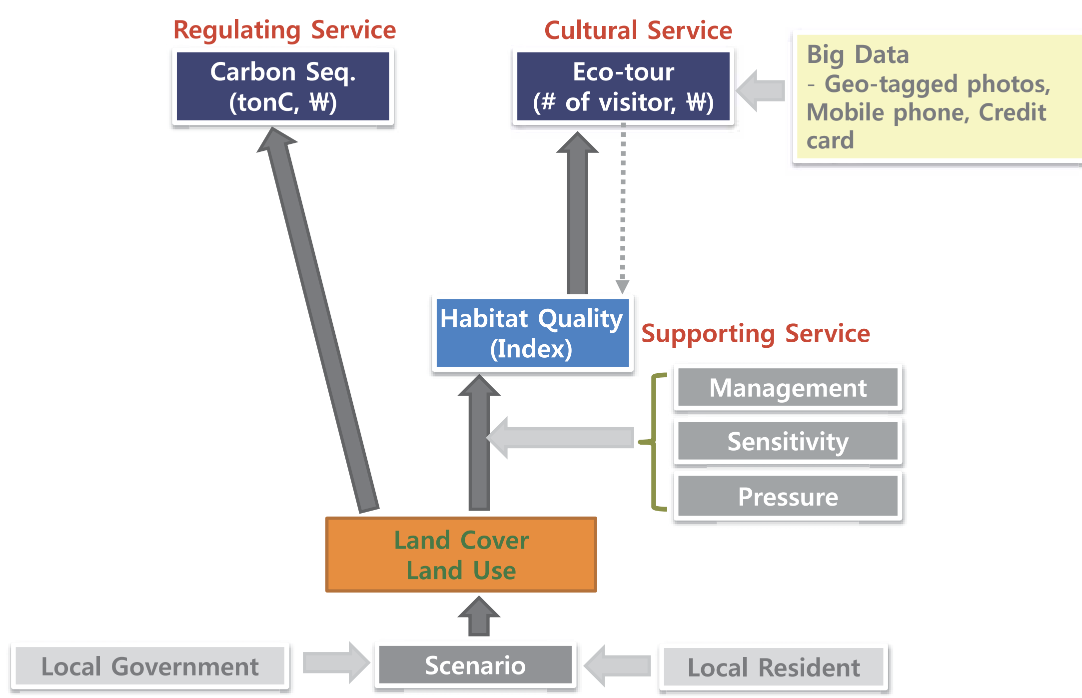
- **Background**

[PRESSURE]	[STATUS]	[IMPACT]
Changes in Pressures	Change of Ecosystem Structure	Changes in provision of Ecosystem Service
• Urban and Agricultural Land ↑ • Release of Protected Areas • International Free City • Development in Middle Mountainous Area	• Damage of Natural Habitat	• Decrease of Biodiversity

- **Main Objectives**

1. **Apply integrated ES modeling approaches to JeJu Island**
2. **Explore changes in ES in response to changes in LULC by time**
3. **Explore changes in ES under alternative scenarios**
4. **Use this information to inform decisions for SD for Jeju**

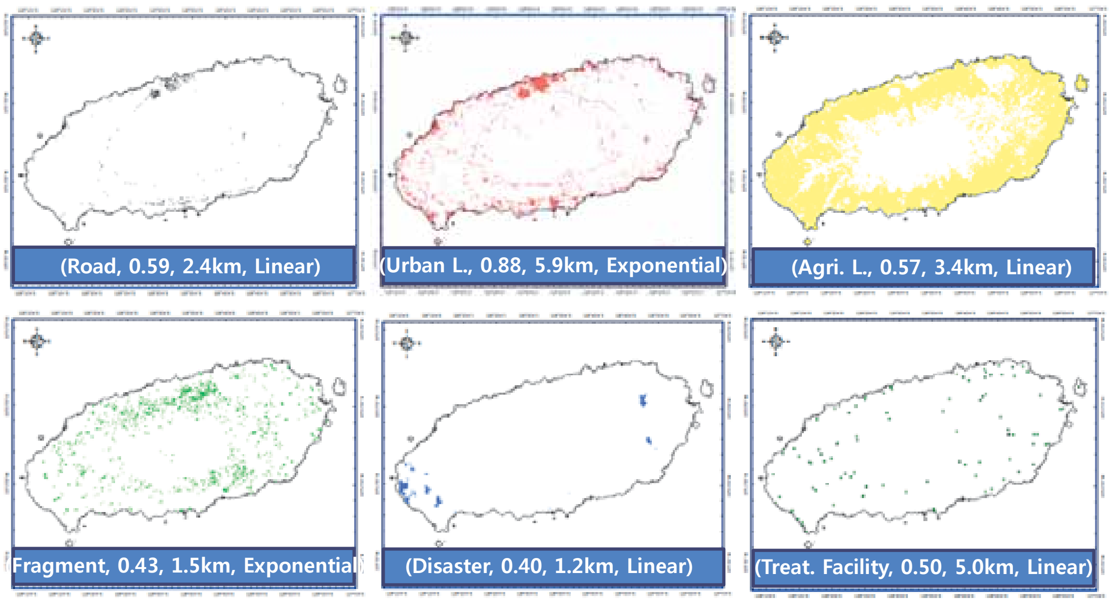
Evaluation System of Ecosystem Service in Jeju



4

Evaluation of Habitat Quality in Jeju

● **Input Data : Threat Factors(Factor, Weighting, Maximum Impact Distance, Impact Trend)**

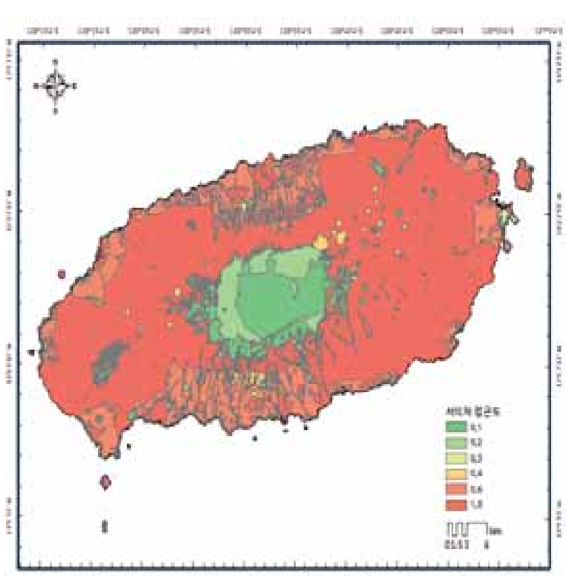


※ Reference to Natural Capital Project, Terrado et al.(2015, Model development for the assessment of terrestrial and aquatic habitat quality in conservation planning)

5

Evaluation of Habitat Quality in Jeju

● **Input Data : Accessibility**



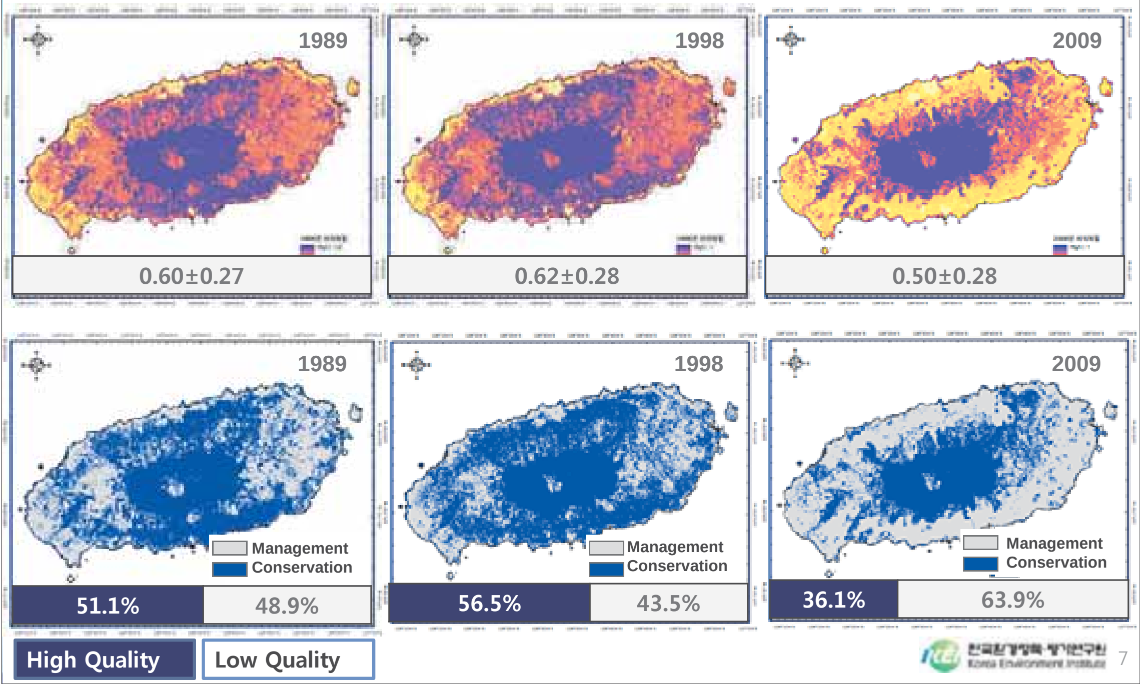
- 12 Protected Areas + Non-Protected Area
- Utility Strength(Prohibition, Limit, Permission) based on Related Law

	Protected Area	Accessibility	
1	Wetland Protected Area	I	0.10
2	Specific Conservation Island	V	0.50
3	Nature Park(Nature Conservation)	I	0.10
4	Nature Park(Nature Environment)	II	0.20
5	Natural Reserve Area	III	0.30
6	Absolute Preservation Area	III	0.30
7	Ecosystem Conservation Area	I	0.10
8	River District	I	0.10
9	Water Source Protection Area	I	0.10
10	Green Area(Conservation)	IV	0.40
11	Green Area(Nature)	VI	0.60
12	Reserve Forest(Public)	IV	0.40
13	Non-Protected Area	VII	1.00

6

Evaluation of Habitat Quality in Jeju

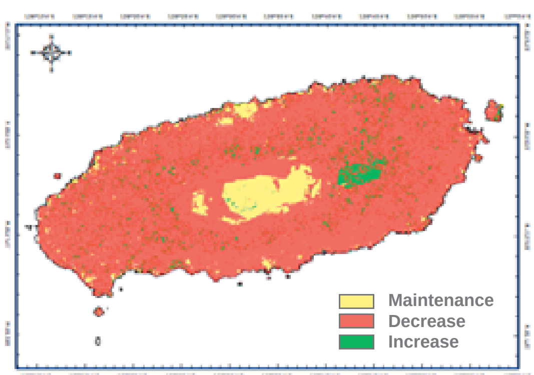
● Result : Evaluation

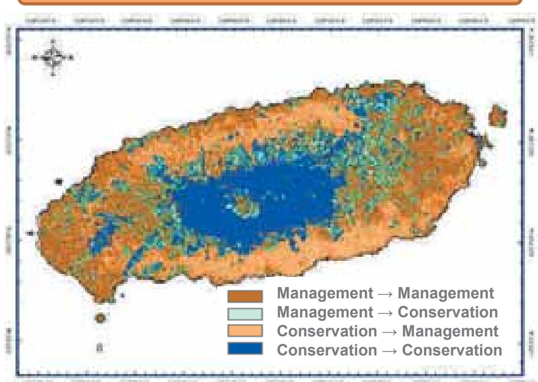


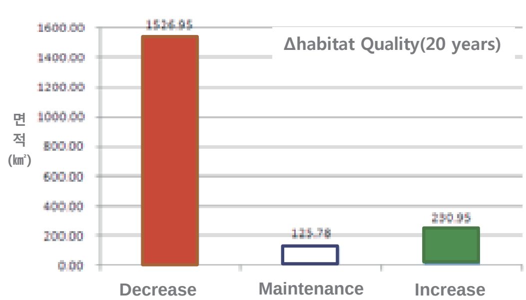
Evaluation of Habitat Quality in Jeju

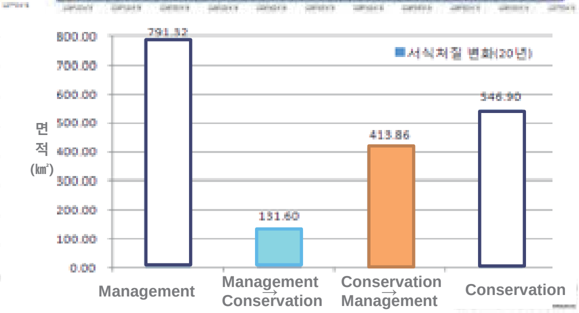
● Result : Δhabitat Quality(2009-1989)

Changes in Habitat Quality : High → Low



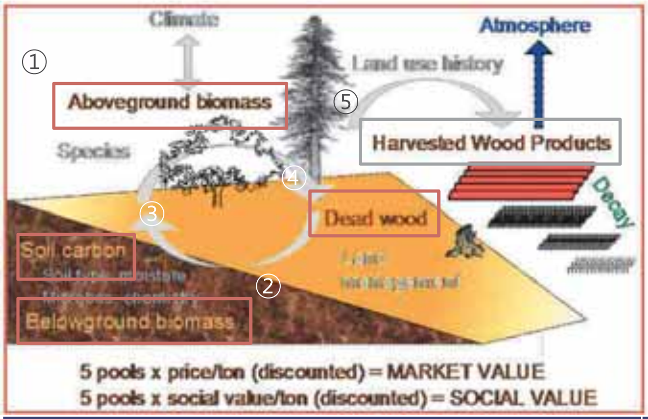






Assessment of carbon sequestration capacity in Jeju

- **Conceptual model of carbon storage and sequestration**



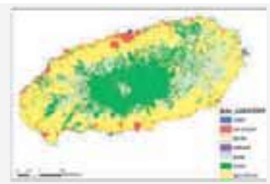
Carbon pool composition

① Aboveground biomass
② Belowground biomass
③ Soil carbon
④ Dead wood
⑤ Harvested wood products

Input data 1 : Carbon pool table

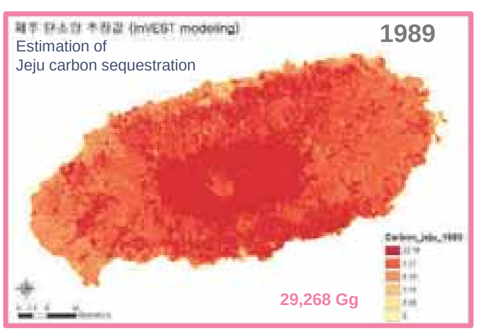
lucode	LULC_name	C_above	C_below	C_soil	C_dead
1	Forest	140	70	35	12
2	Coffee	65	40	25	6
3	Pasture/grass	15	35	30	4
4	Shrub/undergrowth	30	30	30	13
5	Open/urban	5	5	15	2

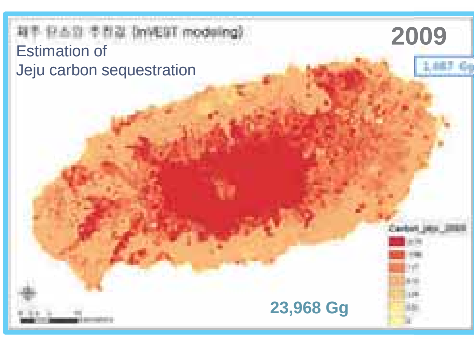
Input data 2 : Land cover map



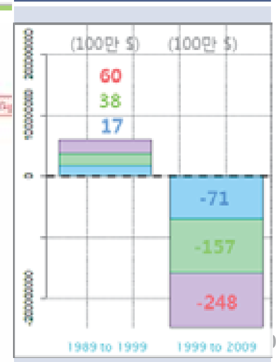
Assessment of carbon sequestration capacity in Jeju

- **Results**



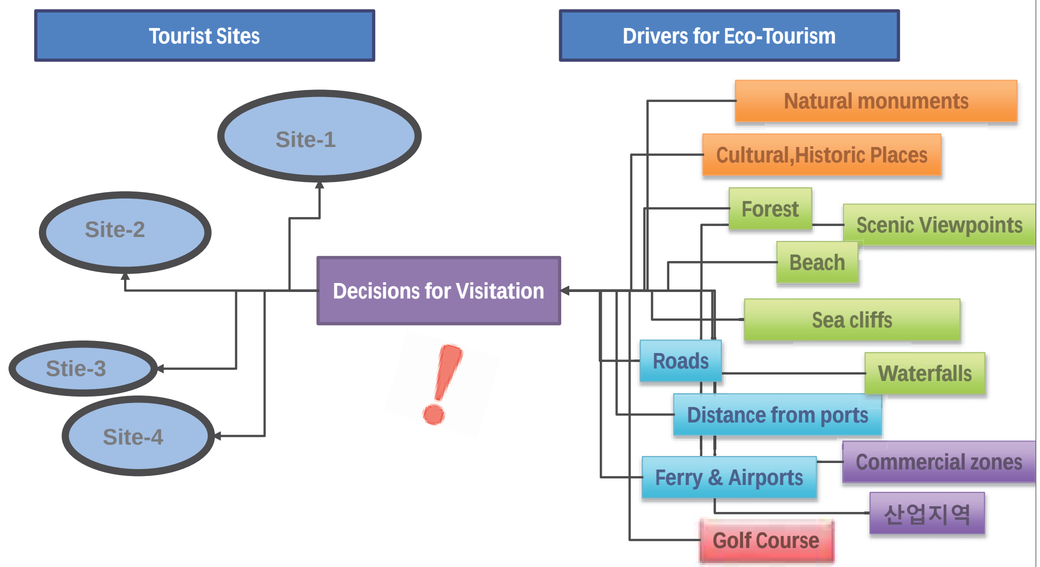


Carbon sequestration values (Discount rate: 5%)



Mapping and Valuing Nature-Based Recreation and Tourism in Jeju Island, Korea

- 평가방법 2. Quantitative relationships between visitation rates and attributes of the landscape



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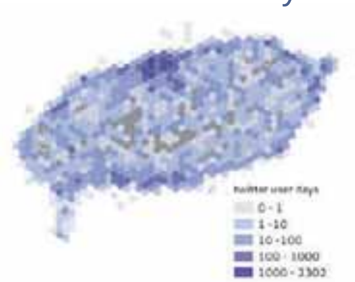
Mapping and Valuing Nature-Based Recreation and Tourism in Jeju Island, Korea

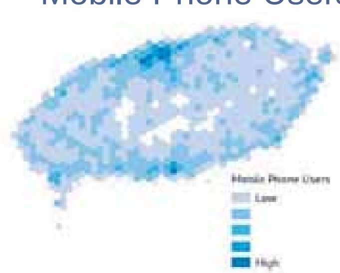
Patterns of visitation based on Big Data

Flickr Photo user-days

Twitter user-days

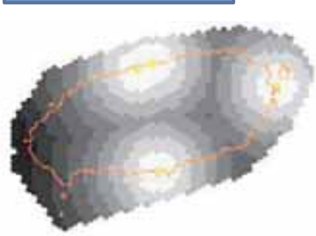


Mobile Phone Users



Drivers of Visitation

Accessibility:



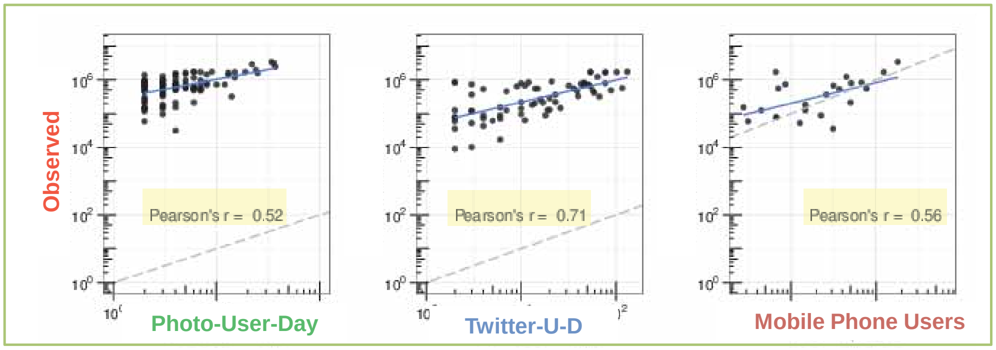
Natural Attractions:

Built Infrastructure:

12

Mapping and Valuing Nature-Based Recreation and Tourism in Jeju Island, Korea

● 평가결과 1. 관광지별 방문 비율 비교



Jeju City
(20 Tourist Sites)

SuKyPho City
(27 Tourist Sites)

47 Tourist Sites

13

Mapping and Valuing Nature-Based Recreation and Tourism in Jeju Island, Korea

Quantitative relationships between visitation rates and attributes of the landscape

Visitation = f

- Commercial Zones
- Cultural/Historic places
- Natural monuments
- Roads
- Sandy Beaches
- Waterfalls
- Scenic viewpoints
- Distance form ports
- Land area
- Forest
- Golf Course
- industrial Area
- Orle Trail
- Distance from loads

: Positive Relationship
요소가 증가할수록
방문객수도 증가

: Negative Relatiohship
요소가 증가할수록
방문객수는 감소

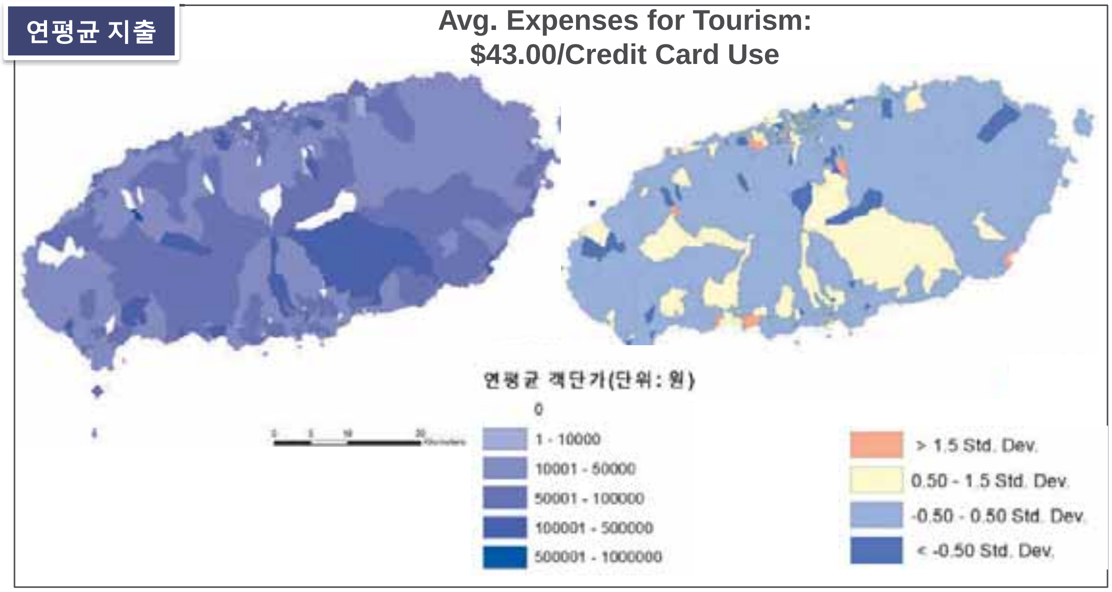
: No. Sig. Relationsip

Spatial variation of visitors can be explained by accessibility, natural and build attractions
(R^2 = 0.56)

14

Mapping and Valuing Nature-Based Recreation and Tourism in Jeju Island, Korea

● 평가 결과 3. 지출 정보(객단가)



※ 객단가: 1회 평균 결제 금액

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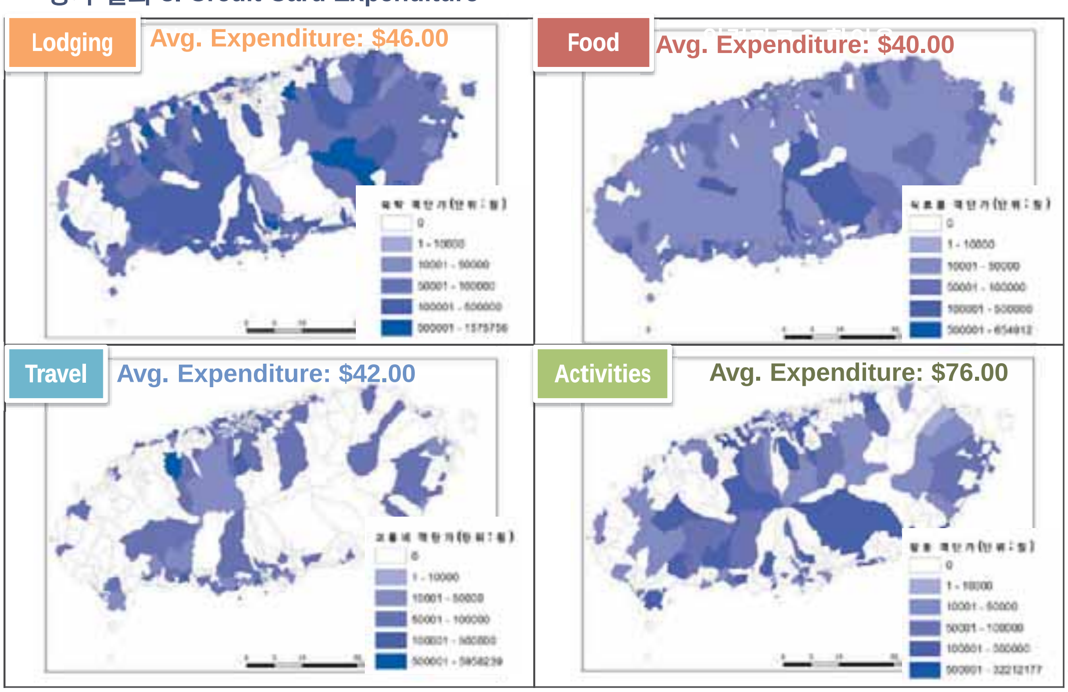
Mapping and Valuing Nature-Based Recreation and Tourism in Jeju Island, Korea

● 평가 결과 3. Credit Card Expenditure



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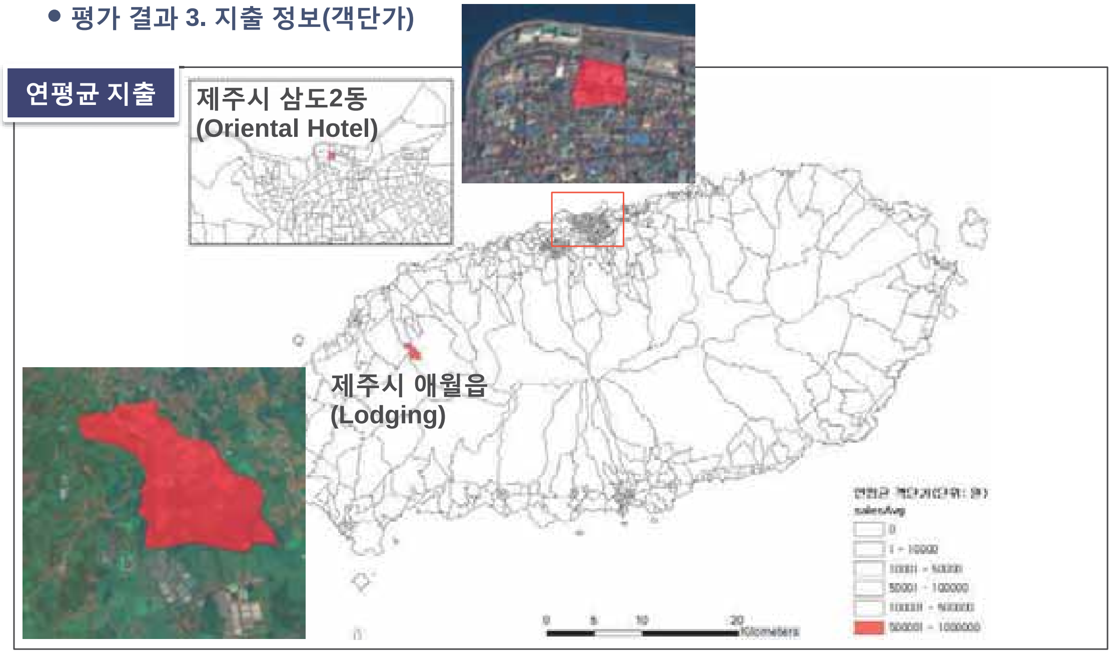
Mapping and Valuing Nature-Based Recreation and Tourism in Jeju Island, Korea

● 평가 결과 3. 지출 정보(객단가)



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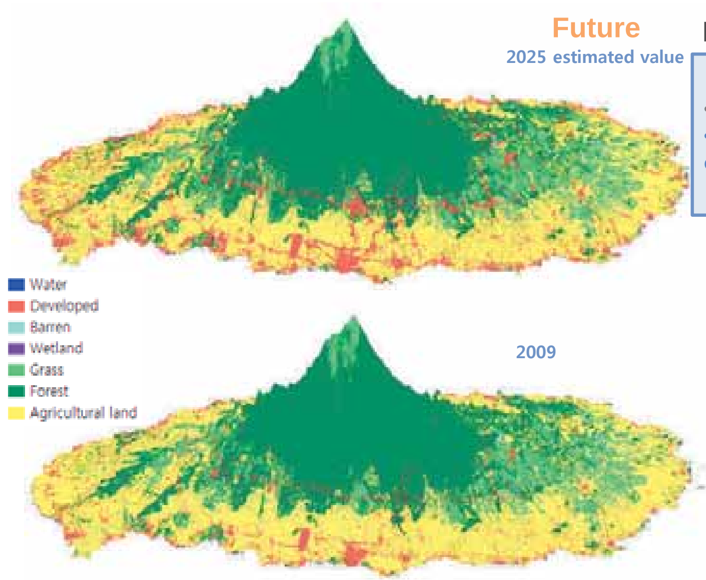
Mapping and Valuing Nature-Based Recreation and Tourism

- The places people visit reveal their preferences about natural environments.

- Quantitative relationships between visitation rates and attributes of the landscape show which attributes are most valued by tourists.

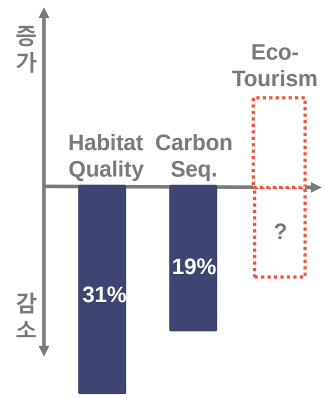
- These relationships can be applied to future scenarios of development or conservation to understand how tourism patterns may change.

Scenarios: Land cover change in Jeju (2025)



Based on

- Jeju Metropolitan City Plan 2025
- Logistic regression analysis based on historic trends



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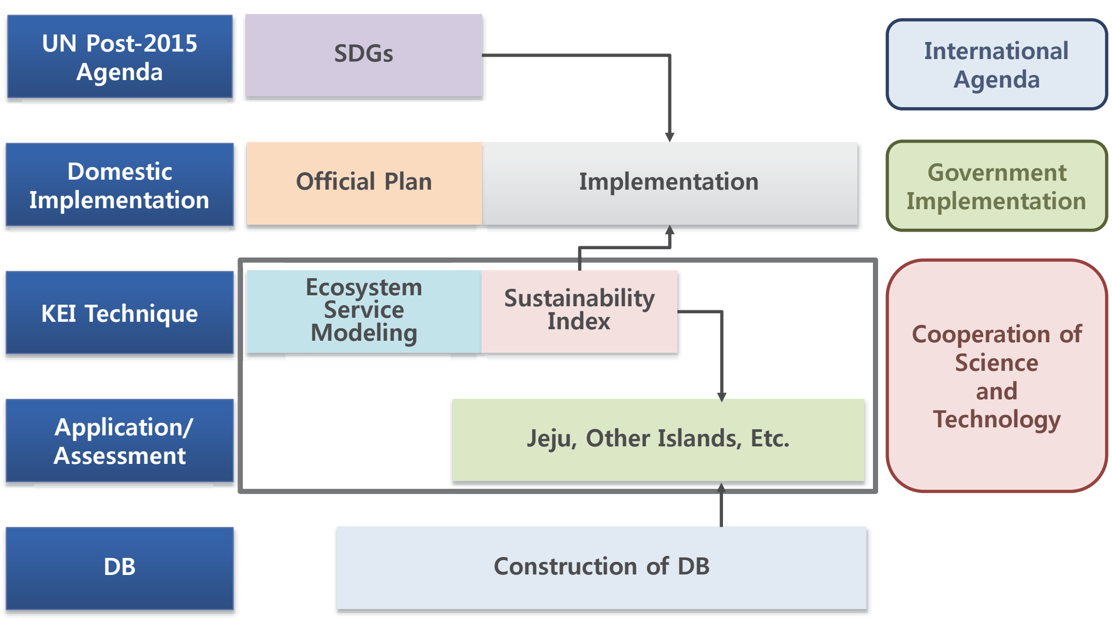
Use of Ecosystem Service Framework to Inform Decisions



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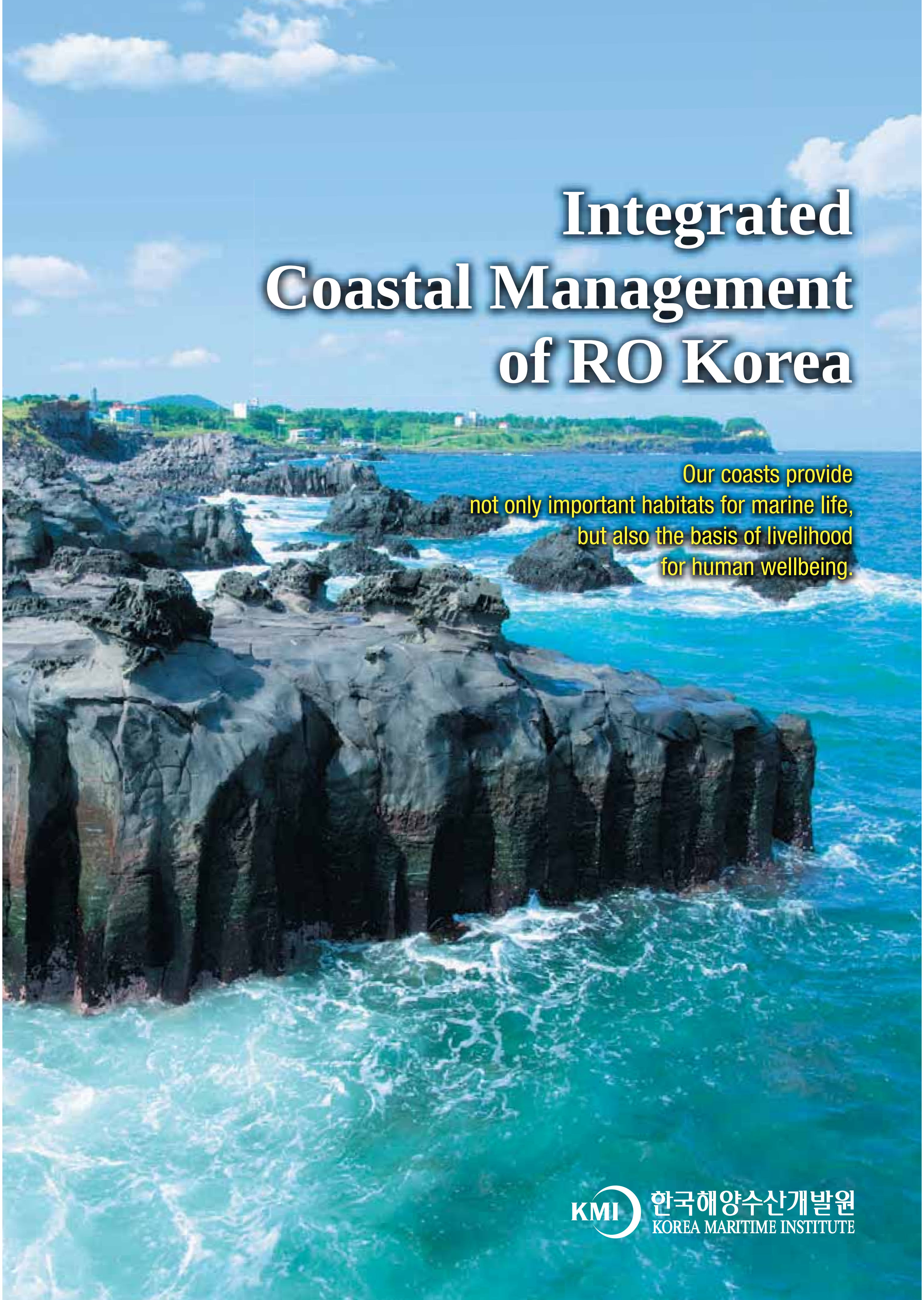
Appendix 1:
Integrated Coastal Management of RO KOREA



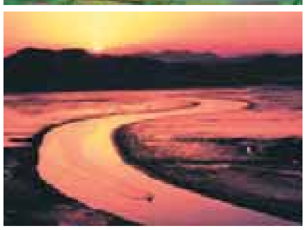
Integrated Coastal Management of RO Korea

Our coasts provide
not only important habitats for marine life,
but also the basis of livelihood
for human wellbeing.

KMI 한국해양수산개발원
KOREA MARITIME INSTITUTE

RO Korea’ Coast & Ocean Ecosystem and Landscape

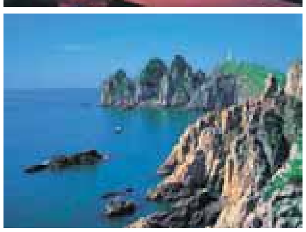
The west and the south coast, which consist of small and large bays, small peninsulas, and countless islands, have more than 90% of Korea’s ecologically invaluable coastal wetland, serving as a habitat for marine life. The east coast has beautiful beaches, sand bars, and lagoons scattered along the coastline.



←↙ *Suncheon* Bay (Ramsar site), one of Wetland Protected Area, is of great ecological value as a winter habitat for an internationally renowned rare species.

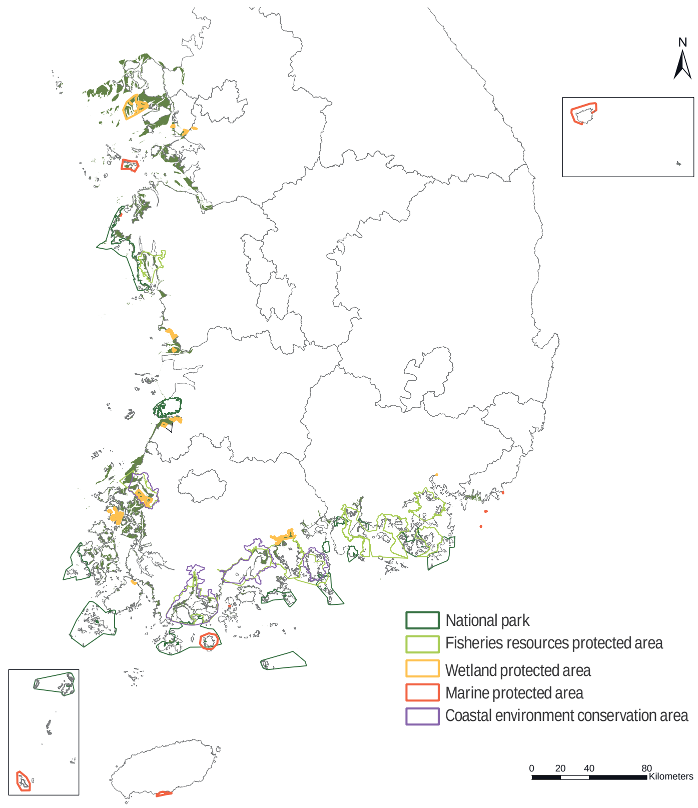
Sinduri Sand dune

Spotted seals, *Baengnyeong* Island



Haegeumgang Island

Protected Areas in Coastal and Marine Areas



Evolutionary Process of Integrated Coastal Management in RO Korea

As Chapter 17 of Agenda 21 had recommended ‘Integrated Coastal Management (ICM)’ in 1992 as a strategy to achieve the protection and sustainable use of coastal and marine resources, the Coastal Management Act that focused on ‘integration’ and ‘cooperation’ was enacted in 1999. Since it set the basic direction for national policies, the Integrated Coastal Management has produced numerous achievements, including the establishment of the National Integrated Coastal Management Plan, autonomous coastal management systems by municipalities, restriction on public water reclamation, the establishment of coastal management information systems, and raised public awareness. The government revamped the Coastal Management Act in 2008 and prepared coastal management tools, such as the Coastal Sea Area Zoning, the Coastal Sea Area Suitability Assessment, and the Target-based Natural Coast Management System.

1992
Agenda 21

1996
Ministry of Maritime Affairs and Fisheries

1999
Coastal Management Act

2000
1st National Integrated Coastal Management Plan

2000
Establishment of policies and bodies related coastal environment

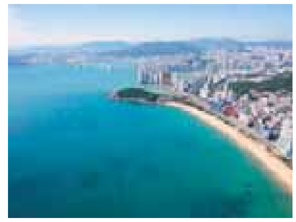
2002-2008
Local Coastal Management plans

2003-2004
1st Coastal Survey

2004~
Integrated Coastal Management Information System

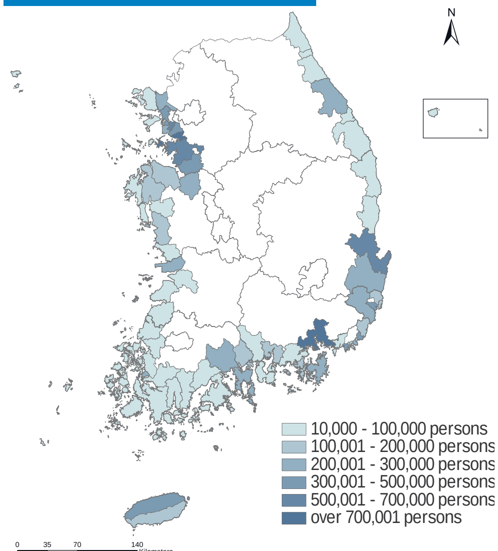
RO Korea's Coast & Marine Use and Development

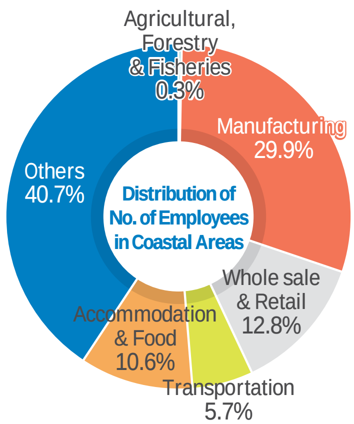
27% of population live in the coastal areas. There are 60 ports and 109 national fishery harbors along the coastline. RO Korea's marine economy has developed through the continuous use and development of the coast and ocean. RO Korea is recently focusing its efforts on developing new renewable energy such as wind and solar power as well as marine energy such as tidal power in order to tackle climate change.



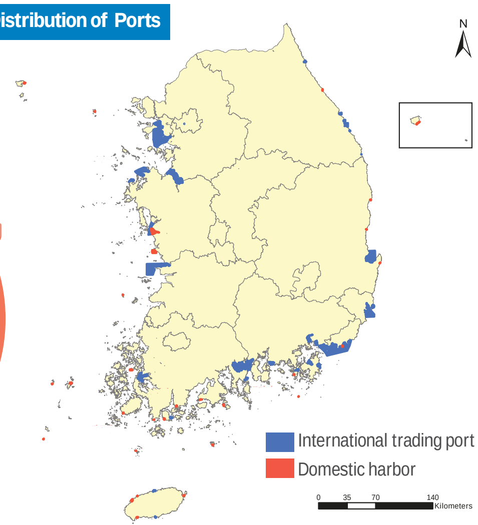
HaeUnDae is one of the most representative cities in RO Korea located in Busan. It is the most popular beach which 1 million people have visited in the summer season.

Distribution of Coastal Population





Distribution of Ports



The Coastal Management Act aims to conserve the coastal environment and seeks its sustainable development, for the purpose of making the coast into a better place for livelihood. The act stipulates the scope of coastal zones, basic principles of coastal management, coastal surveys, major content and procedures of national/local integrated coastal management plans, designation and management of coastal sea area zoning & coastal erosion areas, coastal enhancement projects, and the composition and operation of the coastal management deliberation committee.

2008
Ministry of Land, Transport and Maritime Affairs

2009
Revision of Coastal Management Act

2008-2009
2nd Coastal Survey

2011
2nd National Integrated Coastal Management Plan

2013
Ministry of Oceans and Fisheries

2014
Strengthening polices and bodies of coastal ocean

3rd Coastal Survey

2015
2nd National Integrated Coastal Management Plan (revising)

Reasonable Policy-Making to be able to balance and optimize the supply and demand of coastal ocean resources

Coastal Management Act

- Coastal survey & information system
- National ICM plan
- Local ICM plans
- Target-based natural coast management
- Coastal sea zoning
- Coastal enhancement project
- Coastal erosion management
- Coastal management deliberation committee

Sharing Experiences and Knowledge with Our Region

1st International Workshop on Spatial Management Tools toward Creative and Viable Coastal Societies

- 28-29 Nov. 2013, Seoul, Republic of Korea
- MOF, PEMSEA, China(SOA), Vietnam(VASI), Indonesia(Bogor Agricultural Univ.)
- Univ. of Aveiro (Portugal), Natural Capital Project, PacMARA, KOEM, KIOST, universities, etc.

1st International Training Program & 2nd Workshop on Marine Ecosystem Valuation and Spatial Management Tools

- 1-5 Sep. 2014, Seoul, Republic of Korea
- MOF, PEMSEA, Natural Capital Project, PacMARA
- China, Philippines, Cambodia, Indonesia, Japan. RO Korea
- Governmental sectors, research institutes, universities, private sectors, NGOs, etc.
- Marxan course / Marine InVEST / Emergy valuation and Marine spatial planning

Joint Workshop on Development and Application of Ocean Health Index for RO Korea and Asian Region

- 16-17 June 2015, Busan, Republic of Korea
- Prof. Benjamin S. Halpern (UCSB) and Erich J Pacheco (Conservation international)
- 40 RO Korean experts

Pilot project on the development of Ocean Health Index of RO Korea with Ocean Health Index team

Important Dates of KMI-PEMSEA Training and International Workshop 2016
(2016. 8.22 - 26, Busan, RO Korea)

- **3rd Training Program on Marine Ecosystem Services and Spatial Planning Tools**
  - Call for application : May 31, 2016
  - Inquiry and submission : Heejung CHOI, chj1013@kmi.re.kr
    - * The application form will be sent to potential applicants on their request.

- **4th International Workshop on Marine Ecosystem Services and Spatial Planning**
  - Call for abstracts : February 28, 2016 / abstract length : 300 words or less
    - * Focused theme : Challenges and perspectives in mainstreaming marine ecosystem services into marine spatial policy of coastal states
  - Acceptance Notice : March 31, 2016
  - Submission of a full paper : July 31, 2016 / paper length : 6,000 words or less
    - * Full papers will be published in a special edition of international journals.
  - Inquiry and submission : Jiyeon CHOI, jychoi@kmi.re.kr

KMI will cover all costs such as round-trip airfares traveling, domestic transportation, lodges and meals, except travel insurance. A small amount of honorarium will be paid to author(s) of papers.

Appendix 2:
Contributors of the Training Program

Acknowledgments

We thank the participants in the 2nd International Training Program on Marine Ecosystem Services Valuation listed below.

★ ***Course contributors***

Course	Name	Organizations
MAPS-MSA	*Jungho Nam*	Korea Maritime Institute
	Jongseo Yim	Seoul National University
	Hee-Jung Choi	Korea Maritime Institute
MAPS-SEV	*Daeseok Kang*	Pukyong National University
	Jungho Nam	Korea Maritime Institute
	Hyun-Woo Choi	Korea Institute of Ocean Science and Technology
	Kyuhee Son	Korea Marine Environment Management Corporation
Marine InVEST	*Choong-Ki Kim*	Korea Environment Institute
	Gregg Verutes	Natural Capital Project

★ ***The Training Program Organizers and Facilitators***

Name	Organizations
Jungho Nam	Korea Maritime Institute
Jiyeon Choi	Korea Maritime Institute
Woohyun Sophia Choi	Korea Maritime Institute
Belyn Rafael	Partnerships in Environmental Management for the Seas of East Asia
Natalie Degger	Partnerships in Environmental Management for the Seas of East Asia

Dr. Jungho NAM

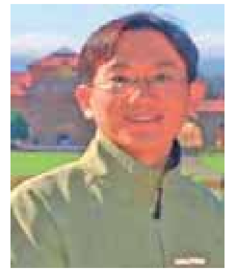
Korea Maritime Institute
#26, Haeyang-ro 301beon-gil, Yeongdo-gu, Busan, Republic of Korea
Email: jhnam@kmi.re.kr / jhnam007@gmail.com

Dr. Nam, Jungho has been working at Korea Maritime Institute (KMI) since 1996, which is a government-affiliated research entity under the Prime Minister's Office. His researches cover integrated coastal planning, climate change adaptation, marine environment management, marine ecosystem protection, coastal conflict resolution, transboundary marine environmental affairs, official development assistance, marine science and technology application etc. He has contributed to the formulation of marine policies for his government and establishment of legal and institutional mechanisms for sustainable ocean and coasts. He also has been involved in global and regional environmental issues and their related activities, including land-based activities control, marine debris management, coastal watershed management, transboundary protected areas etc. He contributed to activities of PEMSEA, COBSEA, NOWPAP, YSLME and World Ocean Forum. He served members of National Commission on Sustainable Development and National Commission on Maritime Affairs and Fisheries. He is serving members of National Committee on Coastal Management & National Committee on Land Use Regulation, and has been leading Marine Ecosystem Service Research Network of Korea (MESN Korea).

Prof. Daeseok KANG

Pukyong National University
45, Yongso-ro, Nam-gu, Busan, Republic of Korea
Email: dskang@me.com

Dr. Daeseok Kang is a faculty member of the Department of Ecological Engineering at the Pukyong National University in Busan, Korea. He teaches and does researches in the fields of systems ecology, ecosystem modeling, environmental accounting, ecological economics, and environmental policy. His current research focus is on management strategies and valuation of ecosystem services of marine and coastal ecosystem of Korea. He has served on various advisory committees for government ministries at the national and local levels and the Presidential Committee on Sustainable Development.



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Choong-Ki Kim is a research fellow for the division of natural resources conservation in Korea Environment Institute (KEI). His study area includes ecosystem service, nature based tourism, climate change adaptation, and ocean renewable energy. His previous work at Natural Capital Project, Stanford University, was to develop a decision supporting tool, InVEST, to value the benefits from nature. He applied the InVEST models to various decision contexts to inform decisions for sustainable development. He also worked in numerical modeling studies with scales ranging from an estuary to a regional ocean. The focus had been on hydrodynamics, marine water quality, thermal discharge effects, storm surge prediction, transport processes of marine organisms, coupled biological-physical processes, and land-sea interaction.

Experience:

Working Group Member, Group on Earth Observations-Biodiversity Observation Network (GEO-BON)

Author for Regional Assessment for the Asia-Pacific, Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)

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YIM, Jongseo is a PhD student at geography and a fellow of National Global PhD fellowship program. He is skillful with modeling based on Geographic Information System (GIS) and Remote Sensing (RS). Formerly he had worked one and half years as a researcher at Korea Maritime Institute (KMI). During that period, he assisted in researches related to development of marine/coastal environment management and planning. His current research interests lies in spatially explicit approaches that uses scientific and geospatial information to address conflicts and organize human activities in the marine/coastal area, while maintaining ecosystem health, function, and services.

Ms. Hee-Jung CHOI

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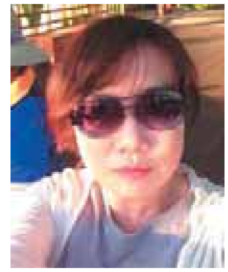
CHOI, Hee-Jung is the senior researcher of Marine Research Division of Korea Maritime Institute (KMI). Her background lies in geography (BSc) and geographical information system (MSc). She has been involved in development of national coastal and marine policies and formulation of various management plans at national and local levels. She is also participating in activities relevant to national coastal basic survey and coastal information system development. Recently, she has especially an interest in coastal and marine spatial management (or planning) and tools for ecosystem-based marine spatial management (such as spatial decision support systems etc.).

Dr. Gregg Verutes

Natural Capital Project

Gregg Verutes leads the training program which hosts various introductory sessions and technical workshops throughout the world. His current focus is developing innovative techniques that use maps, games, and problem-based exercises to teach students, scientists and practitioners about valuing nature. He also serves as a GIS specialist for the marine team working on coastal zone management in Belize and coastal hazard research throughout the United States. Mr. Verutes received his M.S. from San Diego State University and his B.S. in Policy Analysis and Management from Cornell University.



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Jiyeon CHOI is an associate research fellow of Marine Policy Research Dept. of Korea Maritime Institute (KMI). This institute is a government-affiliated research entity under the Prime Minister's Office. Her researches cover coastal and marine spatial planning, ocean zoning, coastline & landscape management, coastal survey & evaluation system, coastal information management etc. She has joined several international cooperation projects regarding integrated coastal management in East Asian Seas and Caribbean Sea. She has actively involved the process of the development of coastal management policies of the Ministry of Oceans and Fisheries and supported local governments developing and implementing coastal management plans and policies.

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Woohyun Sophia Choi is a researcher at the Marine Research Division of Korea Maritime Institute (KMI). She received her B.A. in International Development Studies from McGill University and her M.A. in Global Environmental Studies (MA) at Sophia University (Tokyo, Japan).

Ms. Belyn Rafael

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Ms. Belyn Rafael is currently coordinating the implementation of the SDS-SEA in Cambodia and Lao as well as the implementation of the Joint Communique between the UNDP GEF Small Grants Programme and PEMSEA. She has been working with the countries on the development and implementation of the national programs focusing on Integrated Coastal Management and Integrated Riverbasin Management. She has a degree in Journalism, with a Masters on International Studies and currently taking up her Doctoral in Public Administration at the University of the Philippines.

Dr. Natalie Degger

PEMSEA

Dr. Natalie Degger has provided consultancy and technical services to networks of national departments, universities, science institutions and industrial partners involved in marine pollution monitoring and earth observational science. During her time with MERIT, Natalie was involved with the Global Artificial Mussel Watch Program and delivered training to environmental managers and scientists from the International Atomic Energy Agency.

Natalie joined PEMSEA in 2015 on a one-year fellowship where she is involved in activities supporting the UNDP/GEF Scaling up SDS-SEA implementation project. She is also assisting with the GEF/World Bank Medium-sized Project on Applying Knowledge Management to Scale up Partnership Investments for Sustainable Development of Large Marine Ecosystems of East Asia and their Coasts.

Appendix 3:
Trainees of 2nd Training Program

Acknowledgments

We thank all trainees in the 2nd International Training Program on Marine Ecosystem Services Valuation listed below.

NAME	Organization	Nation
Lyna Khan	Royal University of Phnom Penh	Cambodia
Sophal Sreng	Ministry of Environment	Cambodia
Thay Chanta	Ministry of Environment	Cambodia
Peng Benrong	Coastal and Ocean Management Institute	China
Qinhua Fang	Coastal and Ocean Management Institute	China
Rudolf Wu	MERIT	China
Ye Guanqiong	OC ZU	China
Luky Adrianto	Bogor Agricultural University	Indonesia
Yudi Wahyudin	Bogor Agricultural University	Indonesia
Ario Damar	Bogor Agricultural University	Indonesia
Alan Koropitan	Bogor Agricultural University	Indonesia
Jo Yong Chol	N ICM	DPRK
Choe Ho Jong	KIISU	DPRK
Ri Kyong Su	MLEP	DPRK
Yun Kon San	MF	DPRK
Sengphasouk Xayavong	DWR	Lao PDR
Monique Sumampouw	World Wildlife Fund	Malaysia
Vivienne Rhea S. Padura	De Lasalle Lipa	Philippines
Regina Therese Bacalso	ECO-FISH	Philippines
Marie Nievales	University of the Philippines, Visayas	Philippines

NAME	Organization	Nation
Norman Emmanuel Ramirez	ASEAN Center for Biodiversity	Philippines
Porfirio M. Aliño	University of the Philippines, Marine Science Institute	Philippines
Changsu Lee	National Marine Biodiversity Institute of Korea	RO Korea
Seunghoon Yoo	Seoul National University of Science & Technology	RO Korea
Sejun Jin	Seoul National University of Science & Technology	RO Korea
Bong-Oh Kwon	Seoul National University	RO Korea
A-reum Han	Anyang University	RO Korea
Praparsiri Barnette	Burapha University	Thailand
Sakanan Plathong	Prince of Songkhla University	Thailand
Lince Dessey	UNITAL	Timor Leste
Mario Tilman	UNTL	Timor Leste
Mario Cabral	UNTL	Timor Leste
Peter Mumby	CCRES	The UK
Tobias Borger	PML	The UK
Nguyen Son	IET	Vietnam
Vu Thi Mai Lan	VASI	Vietnam
Nguyen Bich Ngoc	VASI	Vietnam
Tu Thi Lan Huong	VASI	Vietnam
Won Tae Shin	PEMSEA	
Belyn Rafael	PEMSEA	
Natalie Degger	PEMSEA	

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