An operational and theoretically sound sustainability assessment framework for integrated coastal zone management: Satoumi, ecosystem services approach, and inclusive wealth

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Contents

1.1 Introduction

- Integrated coastal zone management (ICZM) has been adopted worldwide, including Europe and Japan
- Proper assessment framework and indicators are important for implementation and monitoring process of ICZM[1]
- Several shortcomings remain on existing ICZM indicators[1]
  - lacking reflection of the socio-ecological interactions
  - poor coordination between research outcome and practice
  - weak connection between the indicators and ICZM objectives
- Our aim is to develop practical and theoretically sound assessment framework for ICZM

- 1) Hoffman (2009), Maccarrone et al, (2014)

1.2 *Satoumi* creation as a policy target

- In Japanese ICZM, creation of “Satoumi”, a coastal zone where productivity and biodiversity are enriched with human-nature interaction, is set as a policy target in recent Japan[2]
  - Shift of social needs and political awareness from **“clean ocean”** to **“rich ocean”**[3]
- This phenomena can be generalized using concepts of Environmental Kuznets Curve and Socio-Ecological Production Landscapes[4] (SEPLs)

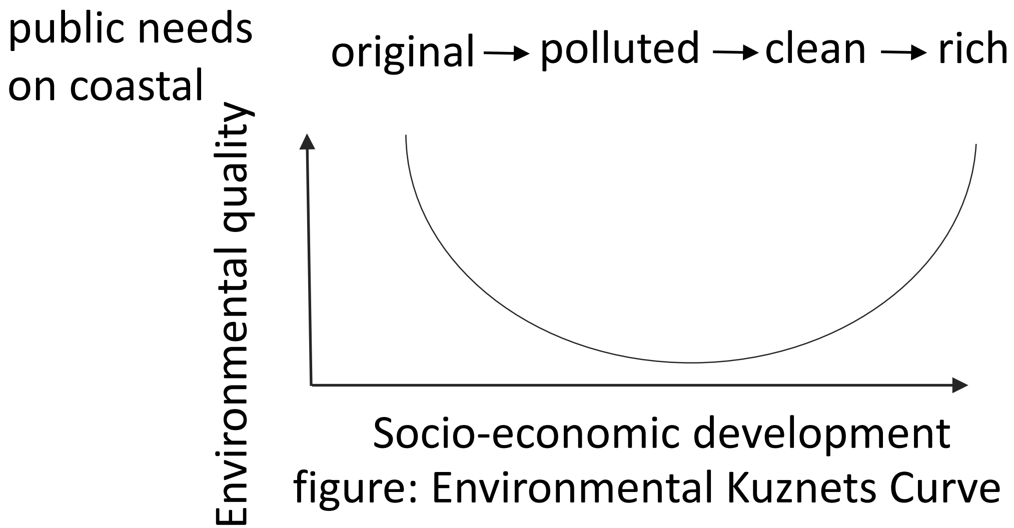
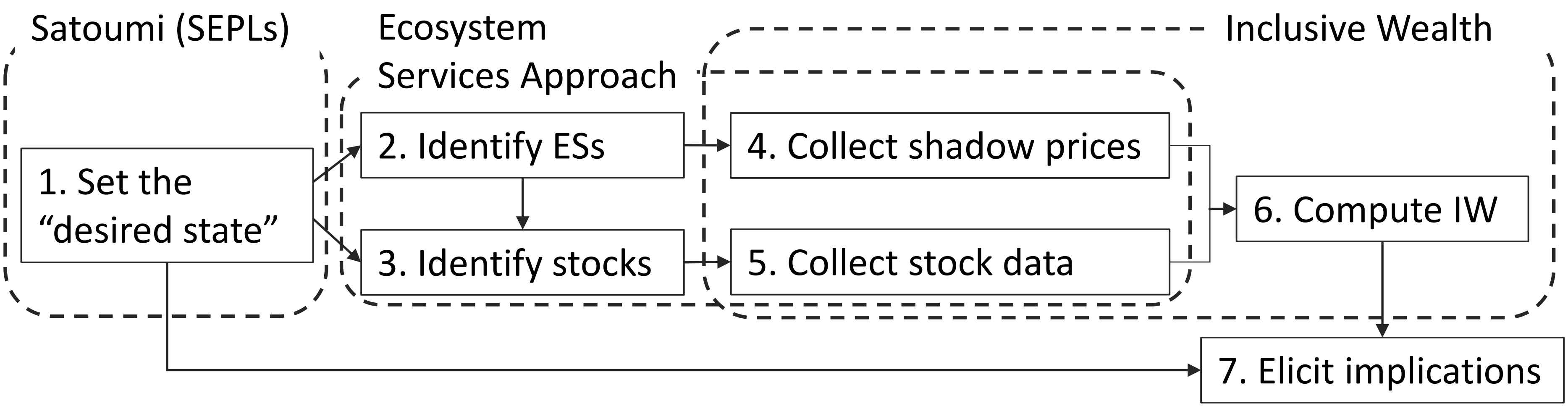


figure: Environmental Kuznets Curve

2) Japanese Basic Plan on Ocean Policy, 2013 3) Matsuda (2013)
4)Duraiappa et al. 2012

2.1 Overview of the framework



- Inclusive Wealth: robust and realistic sustainability assessment framework; the computation basis of this framework
- Satoumi: Japanese concept of SEPLs; the guide for the “desired state” of coastal zones
- Ecosystem Services Approach: a scientific field for relationships between ecosystems and human well-being; the bridge between IW and satoumi to “translate” the desired state into scientific terms

- Source: authors

2.2.1 Inclusive Wealth

1. Sustainable development path

$$\frac{dV_t}{dt} = \sum_i p_{it} \frac{dK_{it}}{dt} + \frac{\partial V_t}{\partial t} \geq 0 \qquad (1)$$

- Where V_t is value function of social welfare,
- P_{it} is shadow price of i th stock at time t,
- $\frac{\partial V_t}{\partial t}$ is a drift term which reflects external influences

2. Desired state

$$\begin{cases} \frac{dV_t}{dt} > 0 \; if \; V_t < \underline{V} \\ \frac{dV_t}{dt} \leq 0 \; otherwise \end{cases} \qquad (2)$$

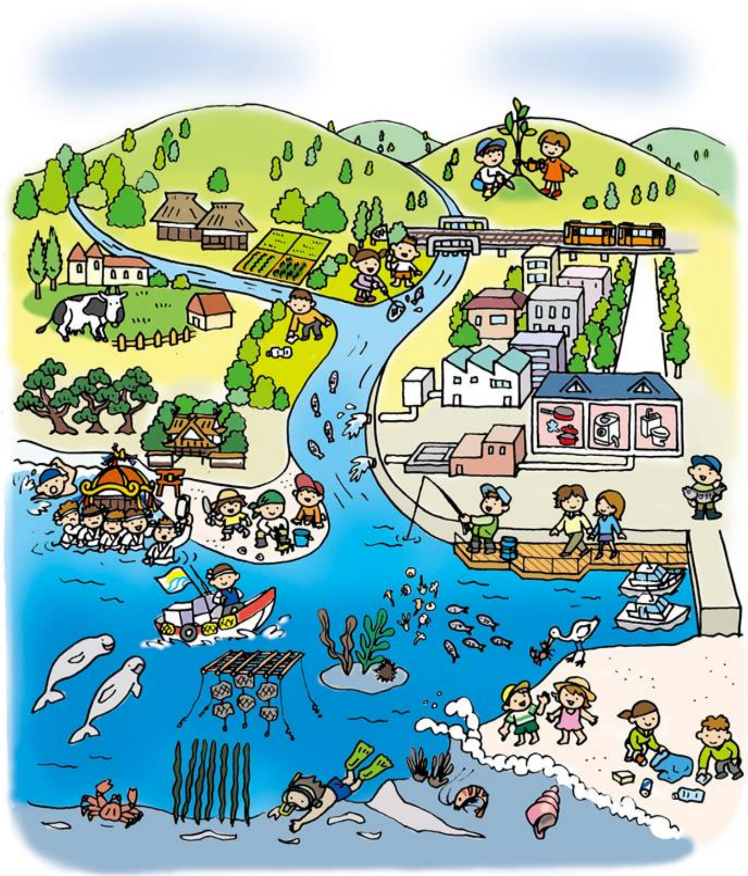
3. Strong sustainability

$$p_{jt}K_{jt} \geq \underline{v_j} \;\; j \in (1, \dots, m), \quad (3)$$

where $\underline{v_j}$ is the threshold of a stock valued with its shadow price

2.2.2 Satoumi

- Satoumi is a Japanese concept of coastal SEPLs, where human-nature interaction enhance ecosystem services
  - *Sato*: rural residential area
  - *Umi*: ocean
- Satoumi is also considered as "ideal relationships which should be created between human beings and the sea[5]"
- Recently, it is considered as one of the key concepts in Japanese ICZM to revitalize coastal zone[6]

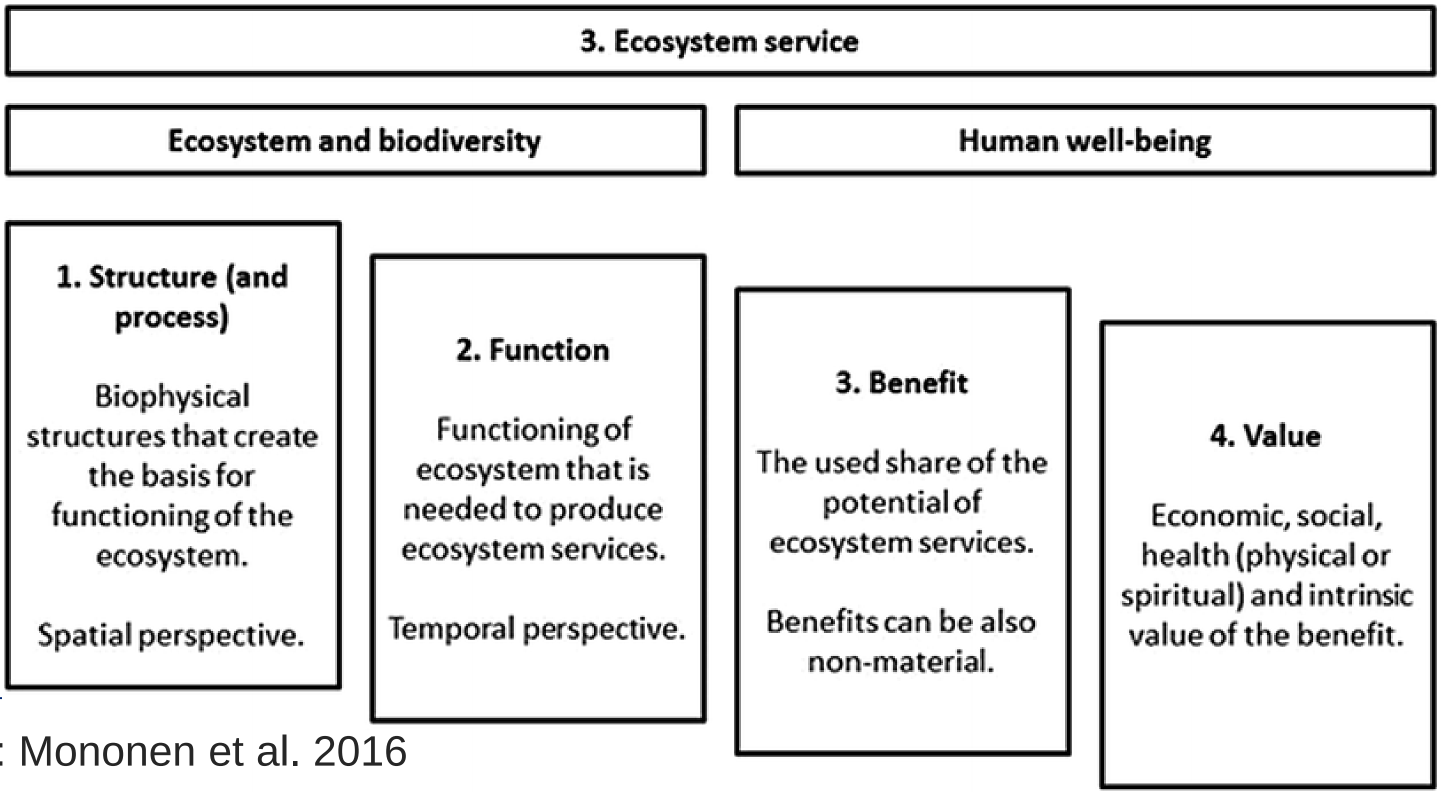


Source: Ministry of Environment, Japan

5) Saito et al (2012)
6) Japanese Basic Plan on Ocean Policy, 2013

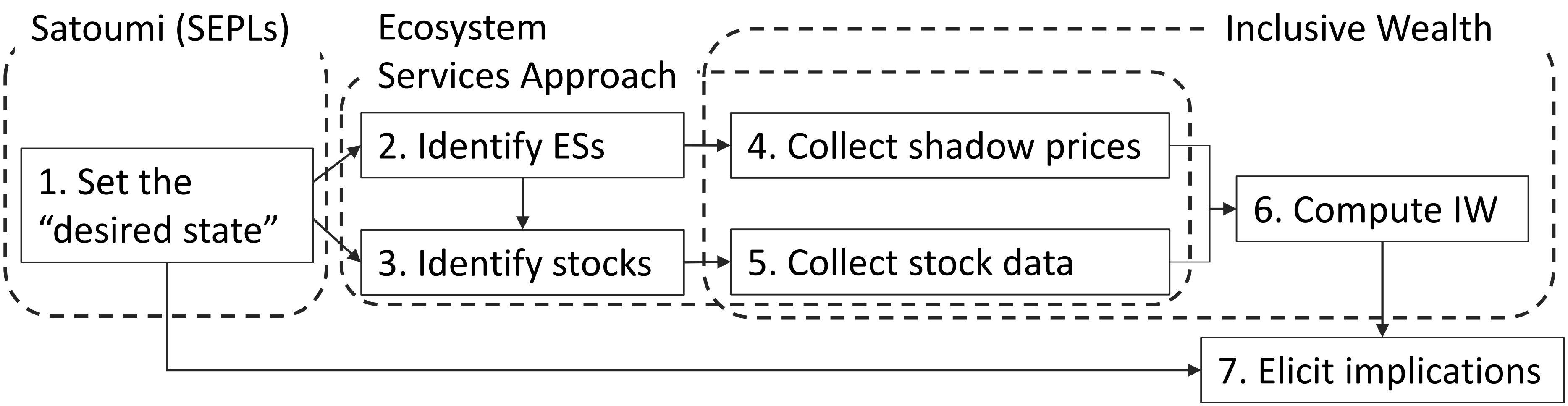
2.2.3 Ecosystem Services Approach

- Ecosystem service science is a field to study relationship between ecosystem and biodiversity (structure, function) and human well-being (benefit and value)
- Exponential research outcomes and the effort to “mainstreaming”



Source: Mononen et al. 2016

2.3 Assessment steps



I. Setting the "desired state"
   1. Set the "desired state" with the Satoumi concept

II. "Translation"
   2. Identify ecosystem services in the "desired state"
   3. Identify stocks in the "desired state"

III. IWI computation
   4. Collect shadow prices
   5. Collect stock data
   6. Compute inclusive wealth

- Source: authors

4.1 test in the Seto Inland Sea

- The framework was tested in the Seto Inland Sea, Japan, to demonstrate the computation and to explore research direction
  - an semi-enclosed coastal area which is economically, culturally, and ecologically important to Japan

- Source: authors, http://grand-touring-japan.travel.coocan.jp/roadofjapan/chushikoku/washuzan/DSC_7991washu-s_thumb.jpg, http://blogs.yahoo.co.jp/south3paradisecafe/GALLERY/show_image.html?id=33168459&no=0 https://www.env.go.jp/water/heisa/heisa_net/setouchiNet/seto/setonaikai/figs/sunameri-1.gif, http://ikilog.biodic.go.jp/Rdb/zukan/?_action=rn066,

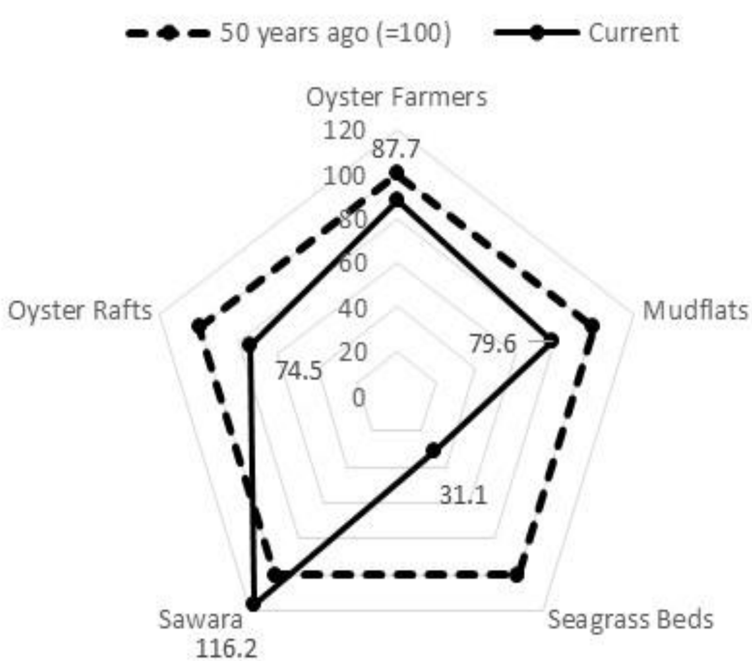
4.2 Stocks selection and computation method

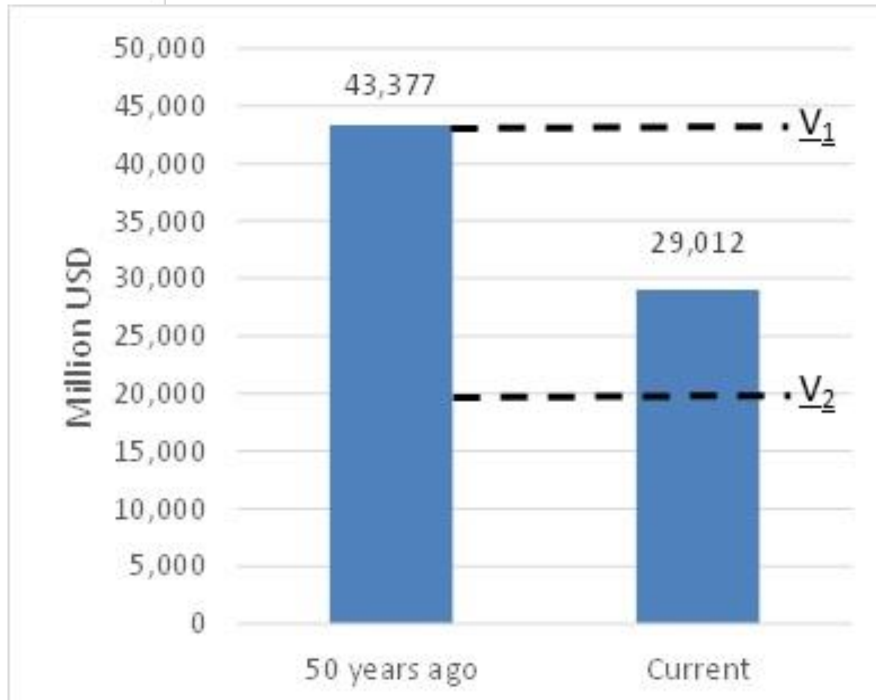
- General criteria
  - ✓ significance on satoumi, immobility, data availability
- Human capital: oyster farmers
  - ✓ importance of fishermen for satoumi maintenance, immobility
- Natural capital: mudflats, seagrass beds, and Japanese Spanish Mackerel
  - ✓ Mudflats and seagrass beds: importance for coastal ecosystem and as a policy target
  - ✓ Japanese Spanish Mackerel: cultural and religious importance, living near the Seto Inland Sea
- Manufactured capital: oyster raft areas
  - ✓ significance on satoumi, low possibility of outflow

- IW computation
  - UNU-IHDP and UNEP (2012), Pearson et al. (2013)
  - Statistic data of Ministry of Agriculture, Forestry and Fisheries, Japan and Ministry of the Environment, Japan etc.

4.3 test result

- The result shows the capitals' total values declined except for Japanese Spanish Mackerel from 1960 to 2010.
- We cannot say if Seto Inland Sea is on sustainable path because we did not set "desired state" here ($\underline{V}_1$ or $\underline{V}_2$?)





5. Discussion: research directions

1. Setting “desired state”
   - Field surveys (interview to local community and specialists, workshop) are needed
2. Shadow prices dynamics
   - Shadow prices estimation is a critical issue for IW computation (Pearson et al. 2013) and is dynamic (e.g. Costanza et al., 2014). However, such studies remain scant (Bennet et al., 2015)
3. External factors (drift term)
   - Drift term vanishes assuming a time-autonomous resource allocation mechanism (Arrow et al., 2003), however, it does not vanish in a open small region (e.g. export prices, exogenously led inflows and outflows of capital assets, participation of volunteers, and population changes)

6. Conclusion

- A novel sustainability assessment framework for ICZM focusing on revitalization of coastal zone in developed countries is proposed
- This framework integrates three independently developed concepts; inclusive wealth (IW), satoumi, and ecosystem services approach (ESA)
- The framework was tested in Seto Inland Sea, Japan, choosing five stocks to demonstrate computation and to explore research direction
- The test result showed declining trend on four capitals, and further researches are needed for rigorous computation on setting “desired state”, shadow prices dynamics, and drift term

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S1. Human capital (oyster farmers)

- We simply adopted the number of oyster farmers, assuming they cannot be differentiated regarding their skills and corresponding compensation.

$$HCW_t = W_t \sum_{t=1}^{50} \frac{I_t}{(1+r)^t} \quad (5)$$

- W_t: number of oyster farmers in t
- I_t: income earned from oyster farming in t
- r:interest rate of 8.5% (UNU-IHDP, 2014)
- It was assumed that oyster farmers work 50 years on average

Time	HCW_t	W_t	$\sum_{t=1}^{50} \frac{I_t}{(1+r)^t}$
50 years ago	55,597,461 TJPY	2,769 farmers	20,079 TJPY
Current	48,781,927 TJPY	2,574 farmers	18,951 TJPY

S2.1 Natural Capital (Japanese Spanish Mackerel)

- We assumed that the stock commercially available at *t* is maintained

$$WS_t = \sum_{t=1}^{\infty} \frac{Stock\ commercially\ available_t \cdot Price_t \cdot Rental\ Rate_t}{(1+r)^t} \quad (6)$$

- *r*: discount rate = 5.0% (UNU-IHDP, 2014)
- In actual estimation, the same rental rate was applied to both times because of a lack of data.

Time	WS_t	$Rental\ Rate$	$\sum_{t=1}^{\infty} \frac{Stock\ commercially\ available_t \cdot Price_t}{(1+r)^t}$
50 years ago	10,529,662 TJPY	0.379	1,389,138 TJPY
Current	12,239,960 TJPY	0.379	1,614,770 TJPY

S2.2 Natural Capital (Seagrass bed)

- The present value of the total wealth obtained from seagrass bed areas (Seagrass bed Area Wealth, SAW) follows as:

$$SAW_t = A_t \times Wha_t = A_t \times \sum_{t=1}^{\infty} \frac{P_t}{(1+r)^t}$$

- A: seagrass bed area in interaction with population and contributing to social welfare at time *t*
- *Wha*: the value of total wealth per hectare
- *P*: marginal contribution of ecosystem service flows to inter-temporal social welfare
- *r*: discount rate of 5.0% (UNU-IHDP, 2014)

Time	$A_t \times Wha_t$	A_t	$\sum_{t=1}^{\infty} \frac{P_t}{(1+r)^t}$
50 years ago	3,700,397,219 TJPY	15,000 ha	246,693 TJPY
Current	2,946,256,266 TJPY	11,943 ha	246,693 TJPY

S2.3 Natural Capital (Mudflats)

- The present value of the total wealth obtained from mudflat areas (Mudflat Area Wealth, MAW) is estimated as:

$$MAW_t = A_t \times Wha_t = A_t \times \sum_{t=1}^{\infty} \frac{P_t}{(1+r)^t}$$

- *A*: mudflat area in interaction with population and contributing to social welfare at time *t*
- *Wha*: the value of total wealth per hectare
- *P*: marginal contribution of ecosystem service flows to inter-temporal social welfare
- *r*: discount rate of 5.0% (UNU-IHDP, 2014)

Time	$A_t \times Wha_t$	A_t	$\sum_{t=1}^{\infty} \frac{P_t}{(1+r)^t}$
50 years ago	1,403,007,660 TJPY	22,635 ha	61,984 TJPY
Current	436,087,805 TJPY	6,381 ha	68,342 TJPY

S3. Manufactured capital (Oyster raft)

- To compute the shadow price of oyster raft areas, we applied a similar methodology as the one used to compute cropland value in the IW report 2014 (UNU-IHDP, 2014). Conceptually, it computes the net present value (NPV) of future rental flows obtained from oyster farming.
- The present value of the total wealth obtained from oyster raft areas (Raft Areas Wealth, RAW) is computed as the product of the oyster raft areas and the total wealth per hectare as:

$$RAW_t = A_t \times Wha_t = A_t \times \sum_{t=1}^{\infty} \frac{RP_t}{(1+r)^t} = A_t \times \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \frac{R_t \times P_t \times Q_t}{A_t}$$

- *Wha*: present value of the total wealth per hectare
- *RP*: rental price per hectare
- *r*: discount rate of 5.0% (UNU-IHDP, 2014)
- *R*: rental rate
- *P*: price per amount of oysters
- *Q*: quantity of production of oysters
- *A*: total area harvested

Time	$A_t \times Wha_t$	R_t	$A_t \times \sum_{t=1}^{\infty} \frac{1}{(1+r)^t} \frac{P_t \times Q_t}{A_t}$
50 years ago	185,608,015 TJPY	0.582	15,951,672 TJPY
Current	138,343,170 TJPY	0.289	23,934,804 TJPY