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Chapter 15

Economic Valuation of Mangroves for Improved Usage and Management in Thailand

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Abstract. The role of mangrove ecosystem and its importance for management is examined. A dynamic simulation model to assess the cost and benefit of mangrove reforestation is developed and applied to a site in Thailand to test the applicability of the model. The model contains three main components: the natural mangrove ecosystem function, the interaction of human economic activity on the mangrove ecosystem and the economic model for the optimal utilization of the mangrove. The application of the model to the Bandon Bay area in Suratthani Province, southern Thailand, is discussed.

15.1. Introduction

This chapter looks at how valuation of mangrove ecosystem can be used to assess the cost and benefit of mangrove reforestation. The ecological role of mangroves in the coastal ecosystem is briefly reviewed. The economic evaluation of these functions as reported in the literature is reviewed in Section 15.2. A model, written with STELLA, is proposed in Section 15.3, with reference to a case study located in Bandon Bay, Suratthani Province, in Thailand. The simulation results with the model are reported in Section 15.4. Section 15.5 discusses the results and concludes with direction for future work.

15.1.1. The Ecological Role of Mangroves in Coastal Ecosystems

Mangroves are plants that grow in the tidal area between fresh and seawaters. Identification of plant species and explanation of how these plants can survive in the particular conditions of the tidal region show a high degree of adaptation of the plant community.

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Box 1

- *regulation functions* — protection against harmful cosmic influences; protection of the local and global energy balance; regulation of the chemical composition of the atmosphere; regulation of the chemical composition of the oceans; regulation of the local and global climate; regulation of runoff and flood prevention; water catchment and groundwater recharge; prevention of soil erosion and sediment control; formation of topsoil and maintenance of soil fertility; fixation of solar energy and biomass production; storage and recycling of organic matter; storage and recycling of nutrients; storage and recycling of human waste; regulation of biological control mechanisms; maintenance of migration and nursery habitats; and maintenance of biological (and genetic) diversity.
- *carrier functions* — human habitation and (indigenous) settlements; cultivation; energy conversion; recreation and tourism; and nature protection.
- *production functions* — oxygen; water; food and nutritious drinks; genetic resources; medicinal resources; raw materials for clothing and household fabrics; raw materials for building, construction, and industrial use; biochemicals (other than fuel and medicines); fuel and energy; fodder (animal feed) and fertilizer; and ornamental resources.
- *information functions* — providing esthetic information; providing spiritual and religious information; providing historic information; providing cultural and artistic inspiration; and providing scientific and educational information.

de Groot R. S. (1992). Functions of Nature: in Environmental Planning, Management and Decision-Making. Wolters-Noordhoff BV, Groningen, The Netherlands.

Several functions have been identified for mangroves, ranging from the ecological to the human uses, according to de Groot's classification, as shown in Box 1. Of particular interest are the ecological roles such as nutrient recycling, the nursery functions, in addition to the direct use of mangroves as a timber source and for harvesting fishery products on-site. The ecological roles are often externalized to the off-site area outside the mangrove, and therefore liable to be ignored when a decision is taken to convert mangroves to other uses. In particular, mangroves in Thailand have been converted to other uses, such as shrimp farms, construction sites or other non-mangrove uses. However, awareness of the external impacts of loss of mangrove areas has increased in recent times, and there is now an active movement to replant mangroves in many areas along the country's coastline. What is the cost and benefit of such mangrove reforestation activities? To address this question, it is necessary to be able to quantify the benefits, external and internal, of mangrove reforestation.

15.2. Problem Statement

The problem of economic evaluation of mangrove for management is one of addressing the many ecological functions of mangrove in a framework of cost–benefit analysis. How much would an increase of 1 m^2 of mangrove contribute to human welfare and hence would justify the cost?

15.3. Review of the Literature

Many attempts have been made in the literature to address the economic valuation issue. A good review is Spaninks & van Beukering (1997) (S&B). The study examines various mangrove functions and methods to assess their economic values, and finds that "most studies limit valuation to use values: the availability of market prices or market prices for substitutes means that the valuation of use values is relatively easy."

On indirect use values, based on ecological functions, the study finds the following:

"Most studies limit indirect use values to the nursery function." As stated in the chapter, "the value of this function… depends heavily on the ecological linkage between mangrove area and fish stocks." The chapter comments "in most cases, valuation of the impacts of a management alternative on catches in off-site fisheries is based on somewhat arbitrary assumptions, rather than on detailed scientific information."

In addition, studies also "ignore price changes and other economic reactions, and use simple multiplication by market price to value catches."

As noted by S&B, access conditions also are important in determining catches, as shown by Freeman's extension of the Ellis and Fisher model with a production function. This has been demonstrated in Aniyar (2002). Investigating the effect of a decline in the mangrove area by 50% from an equilibrium situation, under open access, there is no change in the rent of fisherman, whereas under regulated access, a change in the mangrove area will reduce rent, or to keep rent constant, the number of fishermen must be reduced. Thus, it is shown that the economic value of mangrove depends not only on the ecological linkage between mangrove and fish catch, but also the effort used for obtaining the catch, as well as the access condition which determines the level of such effort.

The examination of the mangrove–fishery linkage has been carried out with a variety of approaches, as already noted in our summary of S&B. In their own study, S&B takes the approach of estimating a "maximum allowable sustainable catch per year" based on cohort analysis of juveniles and an assumed optimal exploitation rate, to obtain the value of fish catch for the analysis. Different management regimes produce different nutrient productivity of the area, which translates to fish productivity. Unfortunately, in their paper, no specific mathematical expressions are given for the derivation.

In Aniyar, the approach of using a dynamic simulation model is adopted. The different relationships are modeled with the STELLA program, which allows for a dynamic simulation of the model until equilibrium values are reached. However, the parameter values used are assumed, based on "hypothetical (but well informed) interactions between mangrove forest, a single species of fish and fishery activities. The carrying capacity is assumed to be proportional to mangrove biomass."

15.3.1. On Bandon Bay, Suratthani

The Bandon Bay area of Suratthani province lies to the west of the Gulf of Thailand. The area receives the inflow of freshwater from the Tapi river. The estuary area is fringed with mangrove forest, which has been reduced by conversion to shrimp farming and urban development. In the bay area, mariculture is practiced, particularly the farming of oysters, mussels and clams.

The nutrient status of the bay depends on the inflow of the nutrients with the natural river flows, as well as the human-induced nutrient discharge from the upstream urban settlements and industrial developments, as well as farming activities including shrimp farms. The conversion of mangrove to shrimp farms also has a bearing on the amount of nutrients entering the bay. A number of studies were carried out under the Thailand country study component, reported in the SARC/WOTRO/LOICZ 2001 study and Suthawan Sathirathai 1998 study for EEPSEA. The studies show that: (1) the nutrient status of the bay area is affected significantly by human activities, (2) the change in the nutrient status affects the biological productivity of the bay area and (3) shrimp farming imposes an economic cost in terms of loss of biological productivity which can be approximated by the foregone values of oyster production in the bay area.

Suthawan's case study of a village located in the mangrove area shows that there is significant direct use value of the mangrove forest, and that the economic value of the mangrove–fishery linkage can be estimated with the Ellis–Fisher–Freeman (EFF) model depending on the assumed demand elasticity and the cost function.

However, the above-mentioned studies are not integrated into a single quantitatively defined model, so the conclusions derived are at best qualitative, partial, and in terms of time sequence, ambiguous.

This chapter attempts to bring together these separate elements of the ecosystem in an integrated and quantitative way. This is done with the help of the STELLA software, which permits a dynamic specification of the individual relationships, as well as the integration of the separate relationships into a linked model. STELLA also allows the user to trace the dynamic evolution of the solution through time, rather than deriving a comparative static solution, as would be the case with the EFF model.

15.4. Scope of the Chapter

The model to be presented will be defined in more detail in Section 15.5. The overall approach is that the ecological linkage between mangrove and fishery will be elaborated, the nutrient status of the bay area and the biological productivity will be quantified, and the economic conditions relating to the level of effort, and the value of the catch, will also be elaborated. This will be done with the use of the STELLA software.

15.5. Definition of the Model

The model can be divided into three sectors: carbon stock, fish biomass, and fishery sector. The first two sectors, carbon stock and fish biomass, can be considered as the ecological part while the latter, fishery sector, is used to explain the impacts of ecological disturbance on the economic aspect.

15.5.1. Carbon Stock Sector

Three different sources of carbon discharge can be considered to be the key factor to determine the carbon stock in bay area: carbon discharge from economic activities, from mangrove area, and from shrimp farm area.

The dynamics of carbon stock is the determined by its initial value and changes during the time

$$C(t) = C(t - \mathrm{d}t) + \mathrm{CG}\,\mathrm{d}t$$

where C is the carbon stock and CG, the change in carbon stock in dt period.

$$\mathrm{CG} = \mathrm{CGE} + \mathrm{CGM} + \mathrm{CGS}$$

where CGE is the change in carbon stock from economic activities; CGM, the change in carbon stock from mangrove area; and CGS, the change in carbon stock from shrimp farm area.

$$\mathrm{CGE} = \sum_i (\mathrm{output}_i \times \mathrm{emission\ coefficient}_i)$$

$$\mathrm{CGM} = \mathrm{change\ in\ mangrove\ area} \times \mathrm{mangrove\ emission\ rate}$$

$$\mathrm{CGS} = \mathrm{change\ in\ shrimp\ farm\ area} \times \mathrm{shrimp\ farm\ emission\ rate}$$

From Fig. 1 above, land use change (i.e. mangrove reforestation, shrimp farm conversion, etc.), and change in economic activities can cause a change in carbon stock in the bay area.

15.5.2. Fish Biomass Sector

Like the carbon stock sector, fish biomass depends on its initial value and changes:

$$F(t) = F(t - \mathrm{d}t) + \mathrm{FG}\,\mathrm{d}t$$

where F is the fish biomass and FG, the change in fish biomass (Fig. 2).

Change in fish biomass is equal to change in natural growth minus the catch. The change in natural growth is explained by a natural carrying capacity function.

$$\mathrm{FG} = (F \times \mathrm{rF})(\mathrm{CC} - F)/\mathrm{CC} - \mathrm{catch}$$

where rF is the intrinsic growth rate (assumed to be 0.5) and CC, the carrying capacity.

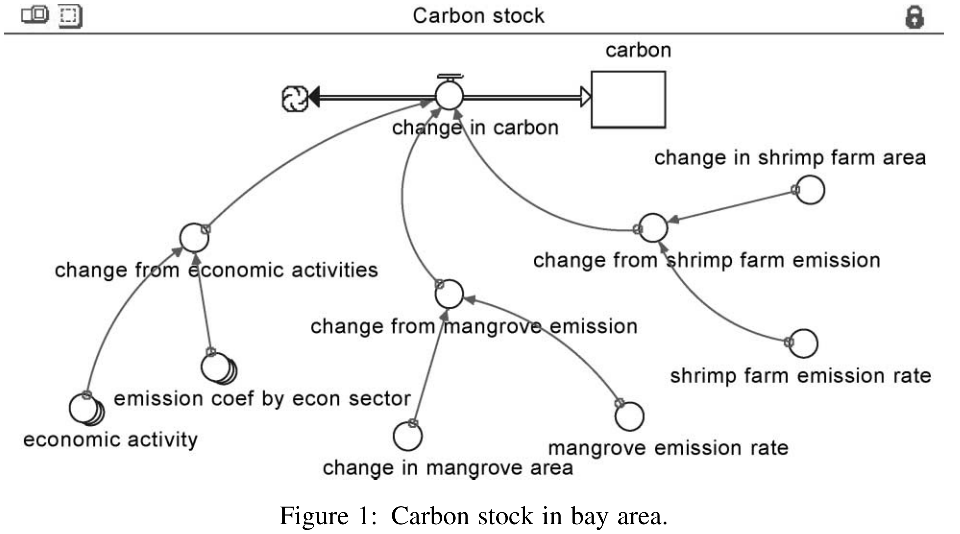

Figure 1: Carbon stock in bay area.

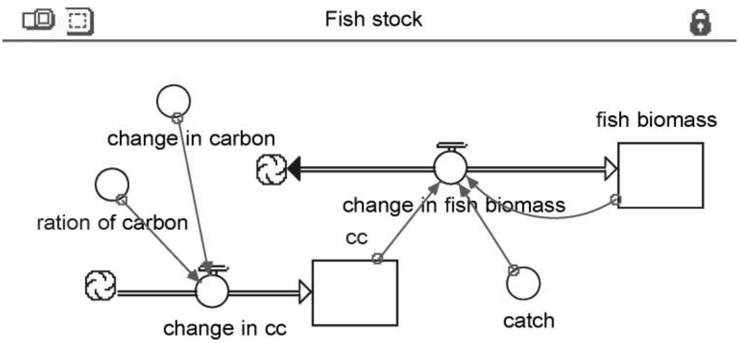

Figure 2: Fish biomass.

In this chapter, the carrying capacity for fish is not treated as a constant but is determined by the carbon stock in the area.

$$\mathrm{CC}(t) = \mathrm{CC}(t - \mathrm{d}t) + \mathrm{CCG}\,\mathrm{d}t$$

$$\mathrm{CCG} = \mathrm{CG} \times \mathrm{rC}$$

where CCG is the change in carrying capacity and RC, the carbon content in fish.

15.5.3. Fishery Sector

Fish catch is assumed to be a function of effort and the total fish biomass. The Cobb–Douglas function is used to explain the relationship in this case.

$$C = 0.35E^{0.5}F^{0.5}$$

where C is the catch and E, the effort (hours used in fishing) (Fig. 3).

Revenue from fishery is equal to the price of fish (in this chapter, assumed to be constant) times catch.

$$\mathrm{TR} = pC$$

where TR is the total revenue and p, the fish price.

Total cost of fishery in this case is equal to the cost of effort which can be estimated by wage of labor.

$$\mathrm{TC} = wE$$

where TC is the total cost and w, the wage of labor.

From the total revenue and total cost, the net revenue can be calculated from

$$\text{Net revenue} = \mathrm{TR} - \mathrm{TC}$$

$$\text{Net revenue per effort} = \text{Net revenue}/E$$

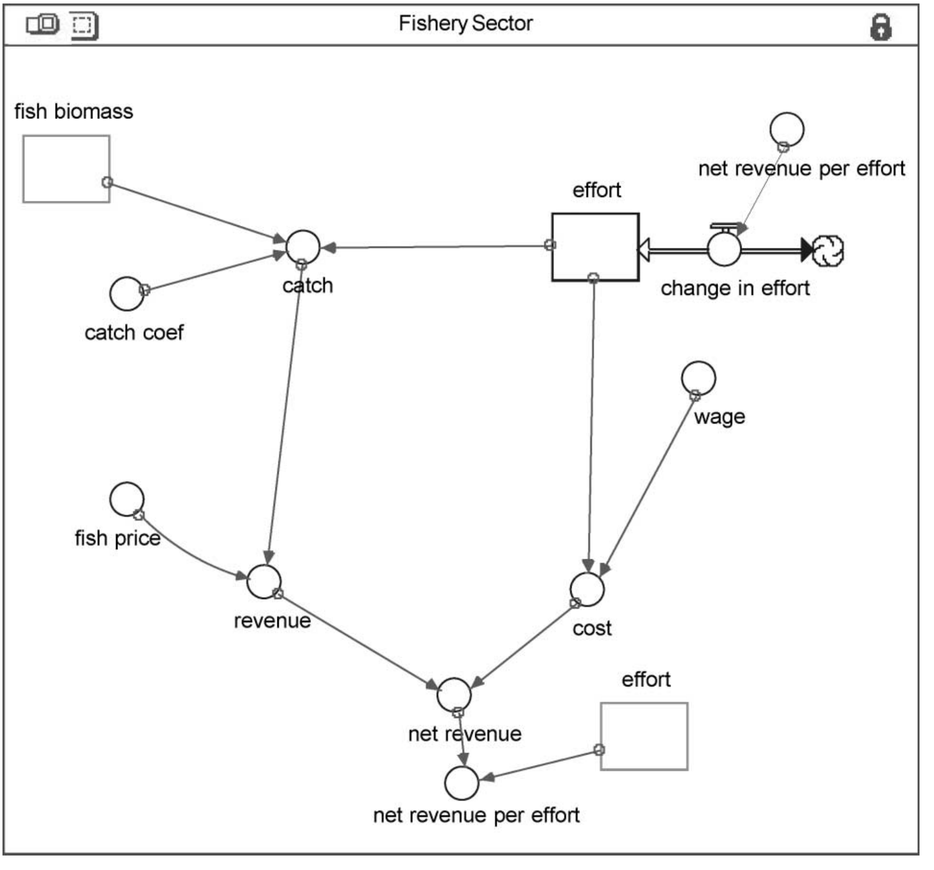

Figure 3: Fishery sector.

In the case of open access, with no barrier to entry or exit, the number of effort depends directly on the net revenue per effort. Positive net revenue per effort will encourage fishermen to increase their efforts which, instead, will gradually decrease the net revenue per effort. The increase in effort will go on until net revenue reaches zero.

The change in effort is assumed to be a linear function of net revenue per effort as follows:

$$\text{Change in effort} = a \times \text{Net revenue per effort}$$

where a is the open access coefficient which shows the relationship between new effort according to the net revenue per effort.

The coefficients, parameters, and initial values used in this chapter are shown in Appendix A.

15.6. Simulation Results

The model is simulated twice: with the baseline scenario, and the mangrove reforestation scenario, to compare the impacts of an increase in mangrove area.

15.6.1. Baseline Scenario

In the baseline scenario, the model is simulated without any change in exogenous variables, which affect carbon stock in the bay area. The outputs of key variables are shown in Figs. 4–6 (see Table B1 in Appendix B for the value of the variables).

From Fig. 4, at the beginning point, there is positive net revenue which encourage the fishermen to increase their effort in fishery. This will cause an increase in effort (as shown in Fig. 5) which will induce an increase in catch, therefore, decrease in fish biomass (Fig. 6).

15.6.2. Mangrove Reforestation Scenario

Suppose that there is an 100 km^2 increase in mangrove area, the output of key variables will be as follows (Figs. 7–9) (see Table B2 in Appendix B for the value of the variables):

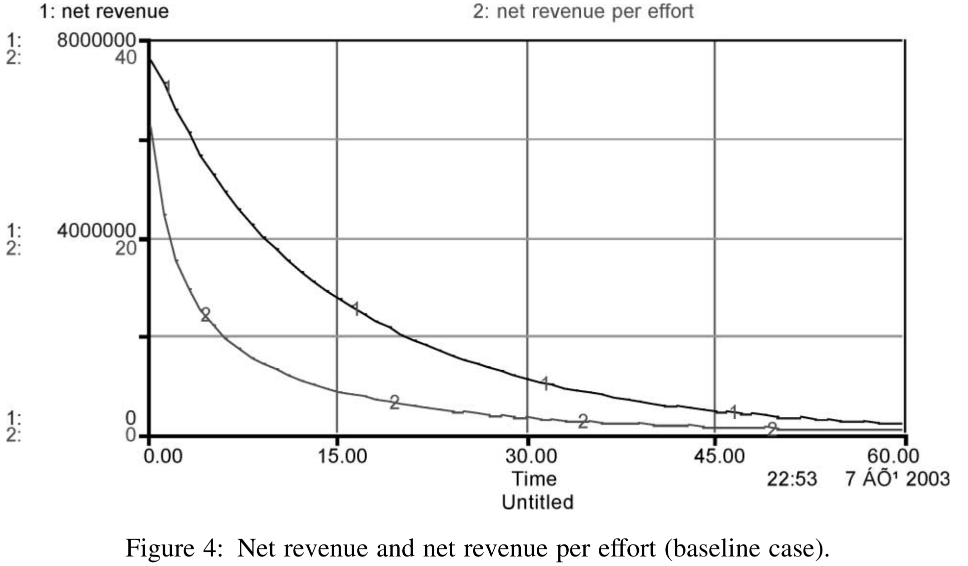

Figure 4: Net revenue and net revenue per effort (baseline case).

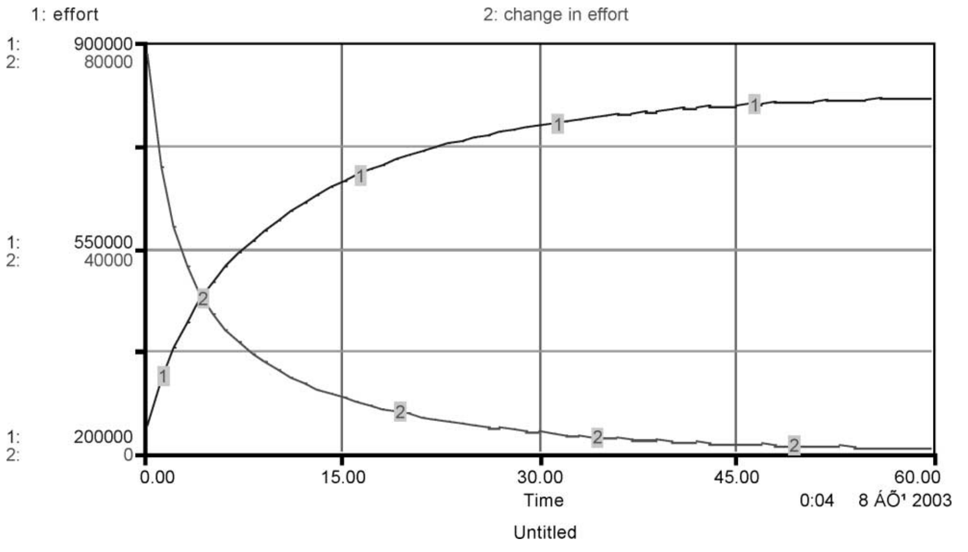

Figure 5: The effort of fishery (baseline case).

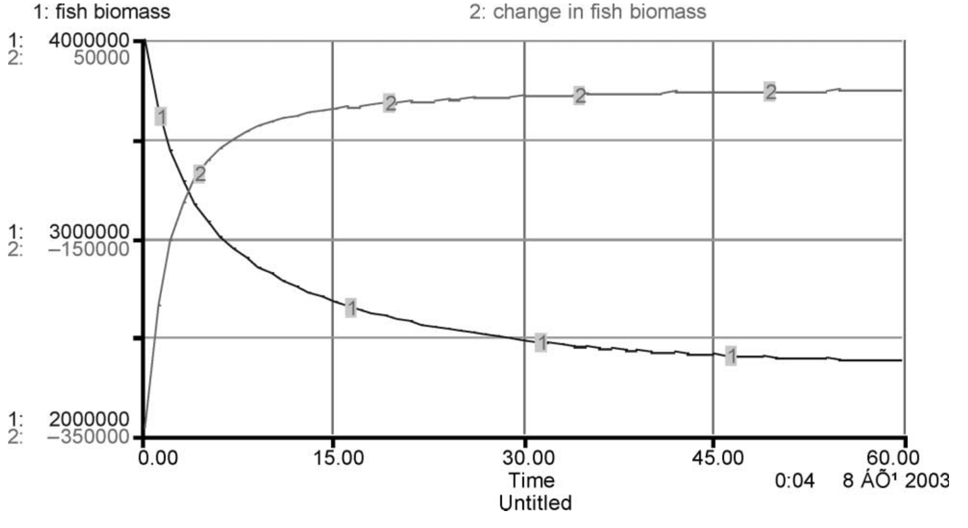

Figure 6: Fish biomass and change in fish biomass (baseline case).

Like the baseline case, positive net revenue will cause an increase in effort, catch and so decrease in fish biomass. But due to an increase in carbon stock discharged from mangrove area, fish biomass increases during that period which will lead to higher net revenue.

15.6.3. Comparison Between Baseline and Reforestation Scenario

Because of an increase in carbon stock (from mangrove area), the net revenue curve in the reforestation case will shift higher than in baseline case. The total net revenue of fishery can be presented by the area under the curve. The difference between areas under the curve is the surplus of mangrove reforestation reflecting through the net revenue of fishery sector.

From net revenue in each year, the net present value of net revenue in the baseline case is equal to 45,149,222.61 Baht, while in the reforestation case, the net present value is equal to 103,931,991.04 Baht. The surplus according to 100 km^2 reforestation will be equal to 58,782,768.44 Baht (in 60 years with 10% discount rate) (Figs. 10–12).

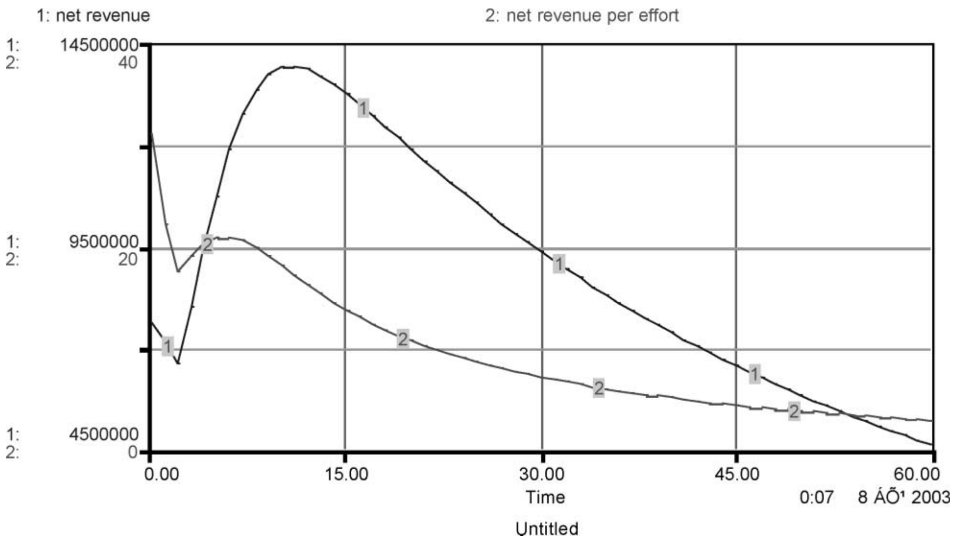

Figure 7: Net revenue and net revenue per effort (reforestation case).

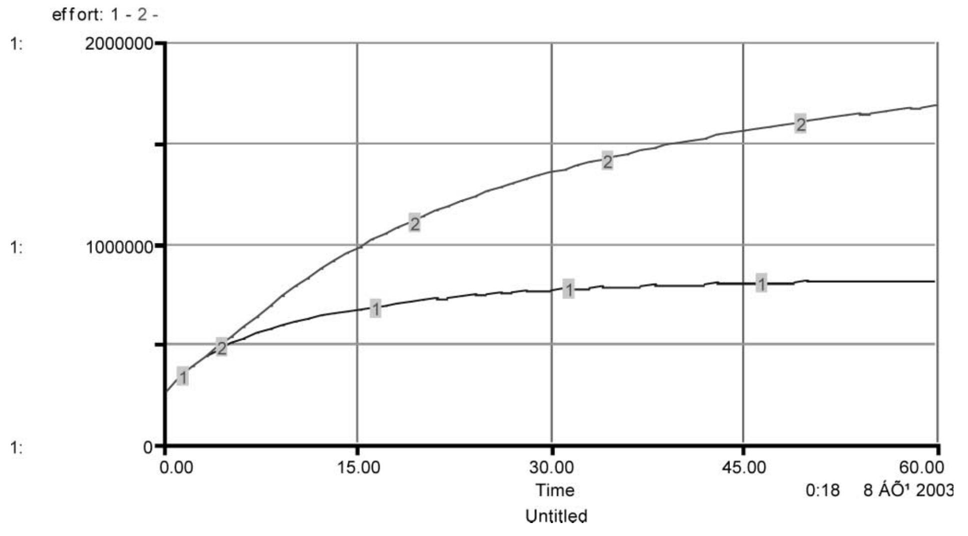

Figure 8: Effort of fishery (reforestation case).

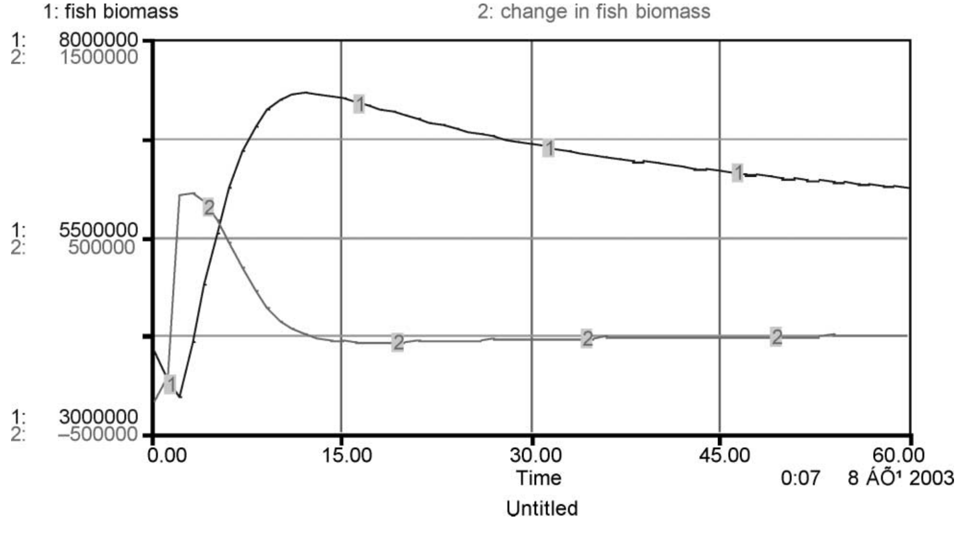

Figure 9: Fish biomass and change in fish biomass (reforestation case).

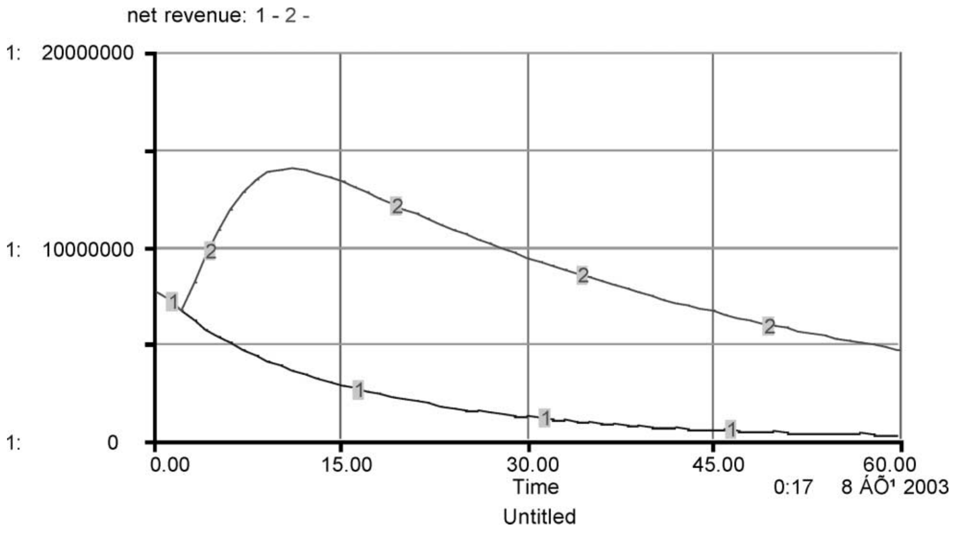

Figure 10: The comparison of net revenue between baseline and reforestation scenario.

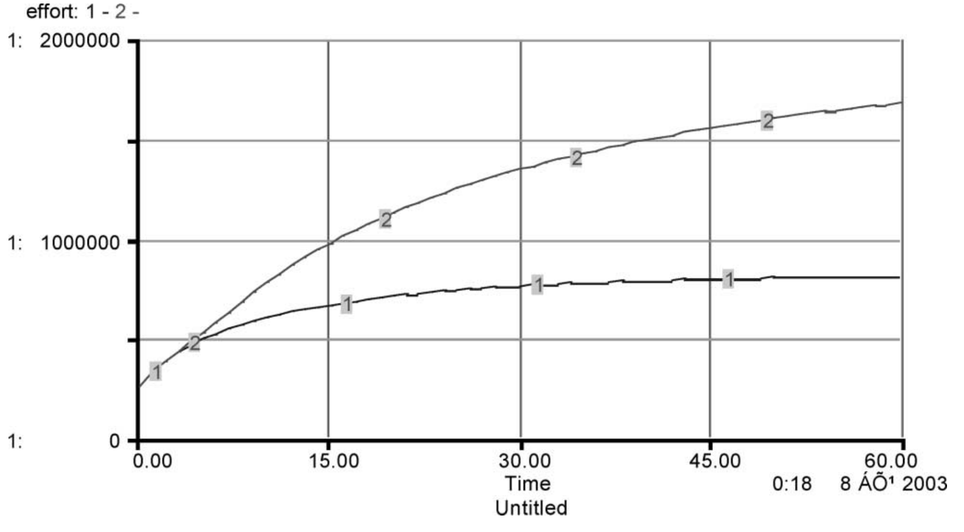

Figure 11: The comparison of effort between baseline and reforestation scenario.

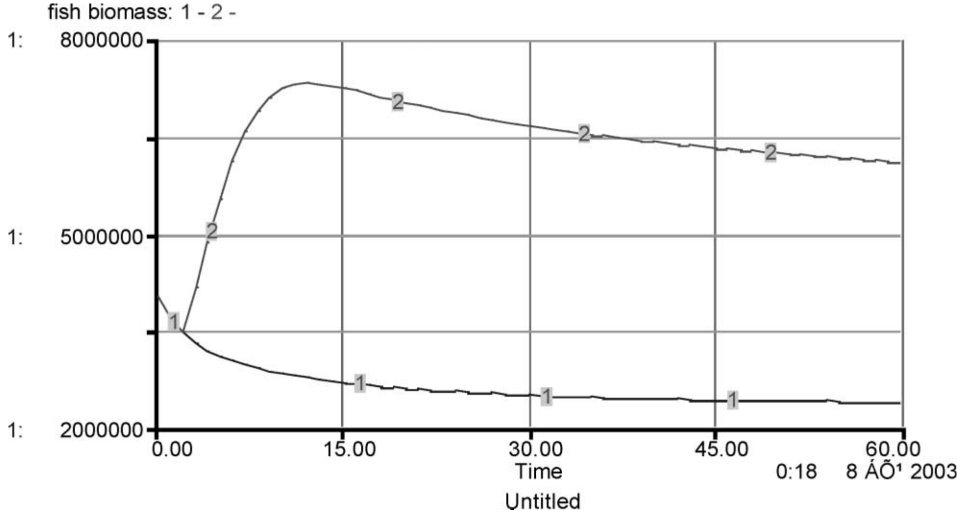

Figure 12: The comparison of fish biomass between baseline and reforestation scenario.

15.7. Discussion

The model is used to evaluate indirect use value (through fishery) of mangrove. It explores a new approach to measure the benefit by the difference between areas under net revenue curve after reforestation takes place. The simulation model incorporates the effects of interactions between the ecological factors, represented by the carbon and fish biomass relationship, and the economic factors, represented by the effort–net profit relationship. Reforestation produces a one-off gain in the yield of fish from the fishing effort, but the open access leads eventually to a position of zero net profit as before. However, there are some limitations for this study. The accuracy of the model is still questionable due to the accuracy of quantitative relationship. The value of parameters should be determined for the improvement of the model.

Appendix A

See Table A1.

Table A1: The coefficients, parameter, and initial values used in the model.

Name	Value	Source
Emission coefficient by economic sector (tonC/mB)		LOICZ (2001)
Agriculture	0.18275	
Fishery	0.09129	
Manufacturing I	0.36550	
Manufacturing II	0.18275	
Utilities	0.36550	
Construction	0.18275	
Trade	0.12036	
RestHotel	0.12036	
TransCom	0.18275	
Other services	0.12036	
Emission coefficient of mangrove area (tonC/km^2/year)	1,118	LOICZ (2001)
Emission coefficient of shrimp farm area (tonC/km^2/year)	39.44	LOICZ (2001)
Ratio of carbon in animal (%)	5.00	LOICZ (2001)
The intrinsic growth rate	0.5	Aniyar (2002)
Fish price (Baht/kg)	37.81	Sathirathai (1998)
Wage (Baht/h)	22.5	Sathirathai (1998)
Initial value of carbon (tonC)	32,837.91	LOICZ (2001)
Initial value of fish biomass (kg)	4,000,000	
Initial value of fish carrying capacity (kg)	4,000,000	
Initial value of effort (h)	243,672.2	LOICZ (2001)

Appendix B

See Tables B1 and B2.

Table B1: The simulation results of baseline scenario.

Year	Carbon (tonC)	Fish biomass (kg)	Effort (h)	Catch (kg)	Net revenue (Baht)
0	32,837.91	4,000,000.00	243,672.20	345,542.15	7,582,324.22
1	32,837.91	3,654,457.85	321,464.46	379,355.17	7,110,468.58
2	32,837.91	3,432,948.83	376,761.93	398,047.79	6,573,043.49

(*continued*)

Table B1: Continued.

Year	Carbon (tonC)	Fish biomass (kg)	Effort (h)	Catch (kg)	Net revenue (Baht)
3	32,837.91	3,278,233.25	420,377.29	410,872.99	6,076,618.73
4	32,837.91	3,163,125.23	456,515.18	420,585.07	5,630,729.84
5	32,837.91	3,073,432.62	487,350.57	428,351.84	5,230,595.06
6	32,837.91	3,001,048.59	514,182.36	434,773.58	4,869,685.93
7	32,837.91	2,941,012.73	537,859.20	440,200.77	4,542,159.06
8	32,837.91	2,890,123.84	558,971.41	444,857.66	4,243,211.16
9	32,837.91	2,846,226.12	577,949.18	448,897.90	3,968,972.93
10	32,837.91	2,807,815.90	595,117.53	452,432.43	3,716,325.89
11	32,837.91	2,773,812.65	610,729.26	455,544.67	3,482,735.66
12	32,837.91	2,743,419.73	624,985.72	458,299.33	3,266,118.87
13	32,837.91	2,716,036.29	638,050.50	460,747.89	3,064,741.51
14	32,837.91	2,691,199.90	650,058.72	462,932.12	2,877,142.38
15	32,837.91	2,668,548.12	661,123.65	464,886.47	2,702,075.42
16	32,837.91	2,647,792.07	671,341.39	466,639.71	2,538,466.20
17	32,837.91	2,628,698.04	680,794.35	468,216.13	2,385,378.76
18	32,837.91	2,611,074.26	689,553.90	469,636.42	2,241,990.19
19	32,837.91	2,594,761.37	697,682.30	470,918.35	2,107,570.83
20	32,837.91	2,579,625.39	705,234.35	472,077.27	1,981,468.91
21	32,837.91	2,565,552.42	712,258.50	473,126.54	1,863,098.26
22	32,837.91	2,552,444.69	718,797.90	474,077.80	1,751,928.64
23	32,837.91	2,540,217.50	724,891.16	474,941.26	1,647,477.84
24	32,837.91	2,528,796.87	730,572.97	475,725.92	1,549,305.30
25	32,837.91	2,518,117.68	735,874.65	476,439.74	1,457,006.85
26	32,837.91	2,508,122.20	740,824.57	477,089.74	1,370,210.39
27	32,837.91	2,498,758.94	745,448.50	477,682.19	1,288,572.25
28	32,837.91	2,489,981.69	749,769.97	478,222.65	1,211,774.10
29	32,837.91	2,481,748.78	753,810.46	478,716.10	1,139,520.41
30	32,837.91	2,474,022.45	757,589.66	479,166.98	1,071,536.17
31	32,837.91	2,466,768.31	761,125.66	479,579.27	1,007,565.02
32	32,837.91	2,459,954.95	764,435.12	479,956.57	947,367.59
33	32,837.91	2,453,553.57	767,533.38	480,302.06	890,720.00
34	32,837.91	2,447,537.65	770,434.62	480,618.66	837,412.66
35	32,837.91	2,441,882.75	773,151.96	480,908.97	787,249.09
36	32,837.91	2,436,566.23	775,697.54	481,175.34	740,044.94
37	32,837.91	2,431,567.13	778,082.64	481,419.90	695,627.10
38	32,837.91	2,426,865.96	780,317.70	481,644.57	653,832.89
39	32,837.91	2,422,444.57	782,412.47	481,851.09	614,509.33
40	32,837.91	2,418,286.05	784,375.98	482,041.05	577,512.51
41	32,837.91	2,414,374.60	786,216.65	482,215.86	542,706.97

(*continued*)

Table B1: Continued.

Year	Carbon (tonC)	Fish biomass (kg)	Effort (h)	Catch (kg)	Net revenue (Baht)
42	32,837.91	2,410,695.45	787,942.34	482,376.83	509,965.16
43	32,837.91	2,407,234.78	789,560.37	482,525.13	479,166.95
44	32,837.91	2,403,979.62	791,077.57	482,661.85	450,199.14
45	32,837.91	2,400,917.83	792,500.31	482,787.94	422,955.08
46	32,837.91	2,398,038.00	793,834.55	482,904.30	397,334.24
47	32,837.91	2,395,329.42	795,085.86	483,011.74	373,241.87
48	32,837.91	2,392,782.01	796,259.45	483,110.99	350,588.65
49	32,837.91	2,390,386.32	797,360.19	483,202.71	329,290.37
50	32,837.91	2,388,133.42	798,392.63	483,287.54	309,267.65
51	32,837.91	2,386,014.93	799,361.04	483,366.01	290,445.65
52	32,837.91	2,384,022.98	800,269.40	483,438.65	272,753.81
53	32,837.91	2,382,150.12	801,121.47	483,505.92	256,125.62
54	32,837.91	2,380,389.36	801,920.75	483,568.24	240,498.38
55	32,837.91	2,378,734.12	802,670.50	483,626.01	225,813.00
56	32,837.91	2,377,178.17	803,373.82	483,679.58	212,013.78
57	32,837.91	2,375,715.67	804,033.58	483,729.27	199,048.23
58	32,837.91	2,374,341.12	804,652.49	483,775.40	186,866.89
59	32,837.91	2,373,049.31	805,233.07	483,818.23	175,423.15
Final	32,837.91	2,371,835.36	805,777.70	483,858.01	164,673.10

Table B2: The simulation results of reforestation scenario.

Year	Carbon (tonC)	Fish biomass (kg)	Effort (h)	Catch (kg)	Net revenue (Baht)
0	32,837.91	4,000,000.00	243,672.20	345,542.15	7,582,324.22
1	32,837.91	3,654,457.85	321,464.46	379,355.17	7,110,468.58
2	144,637.91	3,432,948.83	376,761.93	398,047.79	6,573,043.49
3	144,637.91	4,136,926.16	420,377.29	461,558.29	7,993,029.76
4	144,637.91	4,851,539.08	467,912.15	527,339.10	9,410,667.95
5	144,637.91	5,522,783.32	518,192.25	592,096.51	10,727,843.52
6	144,637.91	6,101,821.13	569,948.35	652,702.88	11,854,858.14
7	144,637.91	6,558,828.55	621,948.05	706,900.42	12,734,073.70
8	144,637.91	6,888,473.17	673,134.29	753,668.54	13,350,685.97
9	144,637.91	7,105,054.63	722,718.33	793,115.23	13,726,524.45
10	144,637.91	7,232,464.56	770,200.61	826,062.92	13,903,925.47
11	144,637.91	7,295,389.73	815,331.46	853,609.80	13,930,028.72

(*continued*)

Table B2: Continued.

Year	Carbon (tonC)	Fish biomass (kg)	Effort (h)	Catch (kg)	Net revenue (Baht)
12	144,637.91	7,314,568.05	858,044.24	876,833.69	13,847,086.31
13	144,637.91	7,305,502.96	898,389.15	896,654.96	13,688,768.08
14	144,637.91	7,278,993.99	936,481.68	913,804.66	13,480,116.31
15	144,637.91	7,242,238.28	972,467.75	928,842.44	13,239,008.46
16	144,637.91	7,199,894.78	1,006,502.32	942,190.04	12,977,903.25
17	144,637.91	7,154,915.69	1,038,737.47	954,164.39	12,705,362.44
18	144,637.91	7,109,136.23	1,069,316.33	965,005.00	12,427,221.50
19	144,637.91	7,063,672.34	1,098,370.46	974,894.77	12,147,435.80
20	144,637.91	7,019,181.68	1,126,019.23	983,975.28	11,868,672.84
21	144,637.91	6,976,032.30	1,152,370.18	992,357.81	11,592,719.69
22	144,637.91	6,934,410.84	1,177,519.91	1,000,131.16	11,320,761.15
23	144,637.91	6,894,391.58	1,201,555.09	1,007,367.33	11,053,569.13
24	144,637.91	6,855,980.45	1,224,553.56	1,014,125.54	10,791,631.77
25	144,637.91	6,819,142.95	1,246,585.33	1,020,455.21	10,535,241.61
26	144,637.91	6,783,821.75	1,267,713.53	1,026,398.05	10,284,556.13
27	144,637.91	6,749,947.84	1,287,995.23	1,031,989.74	10,039,639.44
28	144,637.91	6,717,447.35	1,307,482.18	1,037,261.05	9,800,491.18
29	144,637.91	6,686,245.80	1,326,221.42	1,042,238.79	9,567,066.66
30	144,637.91	6,656,270.53	1,344,255.87	1,046,946.52	9,339,290.85
31	144,637.91	6,627,452.12	1,361,624.75	1,051,405.06	9,117,068.35
32	144,637.91	6,599,725.07	1,378,364.07	1,055,632.95	8,900,290.29
33	144,637.91	6,573,028.11	1,394,506.92	1,059,646.79	8,688,839.32
34	144,637.91	6,547,304.21	1,410,083.83	1,063,461.50	8,482,593.05
35	144,637.91	6,522,500.43	1,425,122.99	1,067,090.55	8,281,426.57
36	144,637.91	6,498,567.71	1,439,650.56	1,070,546.20	8,085,214.21
37	144,637.91	6,475,460.62	1,453,690.79	1,073,839.56	7,893,830.76
38	144,637.91	6,453,137.07	1,467,266.29	1,076,980.80	7,707,152.37
39	144,637.91	6,431,558.07	1,480,398.11	1,079,979.23	7,525,057.15
40	144,637.91	6,410,687.43	1,493,105.94	1,082,843.41	7,347,425.60
41	144,637.91	6,390,491.52	1,505,408.19	1,085,581.20	7,174,140.83
42	144,637.91	6,370,939.09	1,517,322.14	1,088,199.87	7,005,088.83
43	144,637.91	6,352,001.01	1,528,864.00	1,090,706.12	6,840,158.48
44	144,637.91	6,333,650.09	1,540,049.03	1,093,106.19	6,679,241.64
45	144,637.91	6,315,860.95	1,550,891.61	1,095,405.83	6,522,233.14
46	144,637.91	6,298,609.81	1,561,405.30	1,097,610.42	6,369,030.79
47	144,637.91	6,281,874.39	1,571,602.89	1,099,724.95	6,219,535.30
48	144,637.91	6,265,633.78	1,581,496.51	1,101,754.08	6,073,650.25
49	144,637.91	6,249,868.30	1,591,097.62	1,103,702.15	5,931,282.00

(*continued*)

Table B2: Continued.

Year	Carbon (tonC)	Fish biomass (kg)	Effort (h)	Catch (kg)	Net revenue (Baht)
50	144,637.91	6,234,559.43	1,600,417.10	1,105,573.25	5,792,339.65
51	144,637.91	6,219,689.71	1,609,465.27	1,107,371.16	5,656,734.95
52	144,637.91	6,205,242.65	1,618,251.94	1,109,099.47	5,524,382.21
53	144,637.91	6,191,202.65	1,626,786.43	1,110,761.52	5,395,198.24
54	144,637.91	6,177,554.96	1,635,077.62	1,112,360.45	5,269,102.26
55	144,637.91	6,164,285.58	1,643,133.97	1,113,899.24	5,146,015.84
56	144,637.91	6,151,381.23	1,650,963.55	1,115,380.66	5,025,862.79
57	144,637.91	6,138,829.30	1,658,574.05	1,116,807.33	4,908,569.11
58	144,637.91	6,126,617.79	1,665,972.82	1,118,181.74	4,794,062.92
59	144,637.91	6,114,735.28	1,673,166.91	1,119,506.21	4,682,274.37
Final	144,637.91	6,103,170.87	1,680,163.04	1,120,782.97	4,573,135.59

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