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Comparative economic analysis between commercial aquaculture and selected mangrove ecosystems along Macajalar Bay, Philippines

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Abstract

This paper aims to compare the cost and benefit values of commercial aquaculture and mangrove ecosystems situated in three municipalities namely; Laguindingan, Alubijid, and El Salvador, Northern Mindanao, Philippines. Cost-Benefit Analysis (CBA) has been used for value determination and comparison of mangrove forests and commercial aquaculture farm. The results revealed that the annual total economic values of the three selected mangrove study areas are estimated to be Php 1,496,345.55 (Laguindingan) Php 1,448,160.19 (Alubijid) and Php 1,444,172.53 (El Salvador per hectare, respectively). The highest value contribution is derived from the direct use value, 90.54 %, 90.40 % & 89.31%, respectively. Findings suggest that all households in all study sites are dependent on the direct benefits provided by mangroves in terms of their fishery products. In Cost-Benefit Analysis (CBA), the results revealed that at 10% discount rate mangrove restoration provides a better outcome as the net present value of mangroves is relatively three times higher than that of the commercial aquaculture project. Moreover, the outcomes at 15% discount rate showed a negative net present value for the aquaculture project (Laguindingan: Php -7,382,064.07, Alubijid: Php -7,357,714.64, El Salvador: Php -7,504,192.52) while the mangroves remained to have a positive net present value. This means that the conversion of mangrove forests into commercial aquaculture is not economically efficient. Mangrove restoration investment draws more equity (better social welfare) for communities than aquaculture as aquaculture development benefits accrue mainly to private operators with much higher incremental social costs than intact mangrove ecosystems.

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Introduction

Mangrove ecosystems are considered important sources of natural resources for socio-economic development and essential buffers against climate change impacts. Communities along coastlines rely heavily on mangrove products for their livelihoods (Acharya, 2002). Most of the mangrove resources are harvested and used by local communities for subsistence such as fuel wood, shellfish species and fish species, poles and posts for fences, collection of timber, fuel wood and production of handicrafts (Gunawardena & Rowan, 2005).

Furthermore, mangroves provide multiple ecosystem services such as: nursery grounds for fish, crabs; and shellfish; maintenance of biodiversity; coastline protection; absorption of pollutants; carbon sequestration and saltwater intrusion prevention (Dierberg & Kiattisimkul, 1996). Despite the importance and the great value of the goods and services they provide, mangroves have been relentlessly subjected to intense pressure, increased degradation, and decline over time.

In the Philippines, mangrove ecosystems along Macajalar Bay, Misamis Oriental play an important role in the economies and livelihoods of coastal municipalities which, among others, serve as habitat and nursery grounds for various marine species. The Macajalar Bay area is an important fishing ground in Misamis Oriental and one of the busiest areas in the region, boasting world-class commercial and industrial facilities and booming tourism activities. However, it presently faces a serious dilemma in striking a balance between economic development through resource use on the one hand and environmental protection on the other (Canoy & Quiaoit, 2011). The rapid economic development in the area poses a major threat to its vital resources if not managed appropriately and sustainably.

One of the major threats in this fishing ground is the conversion of mangroves into other alternative uses which has adversely affected the marine ecosystems over the decades. Mangrove trees were cut down and the resulting barren areas were converted into aquaculture farms. High profitability and the opportunity to generate foreign exchange have been used to justify the conversion of mangroves to aquaculture development (Gunawardena & Rowan, 2005). According to Ronnback (1999), the undervaluation of natural products and ecological services generated by mangrove ecosystems is a major driving force behind the conversion of this system into their alternative uses.

Within the Association of Southeast Asian Nations (ASEAN) only a few countries conducted an economic analysis of mangroves threatened by commercial aquaculture development. The value of mangrove forest ecosystems needs to be evaluated to determine the benefits that would be lost and the potential negative impacts to human life and welfare if the mangrove ecosystems are degraded (UNEP, 2011). Hence, this study aims to compare two different kinds of land uses, the mangrove ecosystems in Laguindingan, Alubijid, and El Salvador and the commercial milkfish aquaculture farm using Cost-Benefit Analysis (CBA) method and assess whether or not converting mangrove into commercial aquaculture is economically efficient.

Materials and methods

Location of the Study

Macajalar Bay is a 470 square kilometer (sq km) embayment of Mindanao Sea that stretches from the Municipalities of Laguindingan to Kinoguitan in the province of Misamis Oriental (Canoy & Quiaoit, 2011). The Bay has an extensive intertidal coastal area, occupied by mangroves, coral reefs, seagrasses, sandy, and rocky beaches, estuaries, aquaculture farms, tourism, industries and settlement areas.

The study was conducted on three selected mangrove ecosystems along Macajalar Bay situated specifically at Tubajon, Laguindingan; Baybay, Alubijid; and Taytay El Salvador (Fig. 1). The areas are declared protected under Barangay Ordinance No. 94, Municipal Ordinance No. 45-2006 and City Fishery Code of 2012 for the three study areas, respectively.

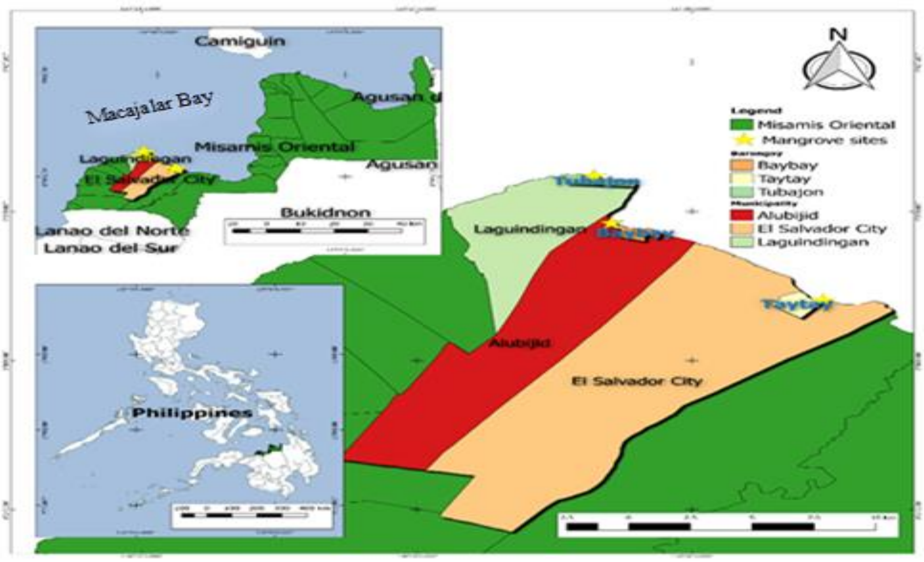

Fig. 1. Map of Macajalar Bay and the three selected mangrove study areas (Tubajon, Laguindingan; Baybay, Alubijid; and Taytay, El Salvador).

Data Collection

The Total Economic Values (benefit value) of the mangrove forest sites were taken from the unpublished thesis of Consolacion *et al.* (2018), and the data on the mangrove restoration costs were obtained from the DENR Mangrove Plantation Development Project and the Local Government Units (LGUs) of Laguindingan, Alubijid and El Salvador. On the other hand, the aquaculture farm operation and production costs were collected from a private investor of milkfish aquaculture in Balingasag, Misamis Oriental.

Data Analyses

The data on the total cost of commercial milkfish aquaculture were taken from the leading commercial aquaculture in Balingasag, Misamis Oriental, the Julmar Milkfish Commercial Aquaculture, identified as having the highest revenues among other aquaculture investors in the area. The value of aquaculture (AV) was calculated using the following formulas (Malik *et al.*, 2015):

Investment cost = cost of construction + fish cage materials (Php/ha/year)

Production cost = fixed cost (Php/ha/year) + variable cost (fry, feed, fertilizer, fuel, etc) (Php/ha/year)

Benefit of AV = production (kg/ha/year) × price (Php/kg)

In commercial aquaculture, the cost of aquaculture farming is in a market-based measurement, and the benefit value was measured by multiplying the fish production and price. On the other hand, the mangrove restoration cost is the sum of planting and maintenance costs of the mangrove (market-based approach was used to estimate the total cost) and the benefit value of mangrove is the sum of direct use value, indirect use value, and non-use value (Dixon, 2012).

Mangrove Restoration cost = seed provision cost (Php/ha) + planting cost (Php/ha) + maintenance cost (Php/ha)

Benefit Value of mangrove = Direct Use Value + Indirect Use Value (CPV & CSV) + Option Value.

Cost-Benefit Analysis (CBA) is an economic evaluation technique that analyzes the generation of economic benefits and costs from a project by comparing the discounted flows of benefits and costs over a prescribed time horizon (Dixon, 2012). The flows of benefits and costs are usually compared using one of three evaluation measures: Net Present Value (NPV), Benefit-Cost Ratio (B/CR), or the Internal Rate of Return (IRR).

However, in this study, the three measures were applied to provide meaningful comparisons. The formulas for these three measures are as follows:

Net Present Value (NPV): $NPV = \sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t}$

Benefit-Cost Ratio (B/CR): $B/C\ ratio = \frac{\sum_{t=1}^{n} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{C_t}{(1+r)^t}}$

Internal Rate of Return (IRR): $\sum_{t=1}^{n} \frac{B_t - C_t}{(1+r)^t} = 0$

Where: B = Annual gross benefit; C = Annual gross cost; r = discount rate;
t = period of time

In this study, an assumption from Sathirathai (1998) was considered to allow the comparison of NPV and BCR mangroves (per hectare) with that of milkfish aquaculture. The assumption was that, after a mangrove forest has been converted into a milkfish farm for five years, the area will have to be re-established as a forest.

This will take an additional 15 years to restore it to its original state, making it a 20 years' project plan. Discount rates of 10% and 15% were compared for the sensitivity analysis.

The discount rate of 10% is the common base for CBA study, which is widely used in the existing literature (Tuan et al., 2009; Malik et al., 2015).

The discount rate of 15% was used to describe the current context of economic crisis (Tuan & Tinh, 2013).

The social costs include both the private costs and any other environmental costs to society arising from the production or consumption of a good or service. In this study, the environmental cost is the sum of the Indirect Use Value and the Option Value.

These mangrove benefits are the opportunity cost lost by the community in converting mangrove forests to aquaculture farms.

Environmental Cost = Indirect Use Value + Option Value

Results and discussion

Economic Benefit Value of Mangroves

Table 1 shows the Total Economic Value of the selected mangrove forest sites. The economic benefit value of mangroves is the sum of the direct use, indirect use, and option values of the mangroves. The annual benefit value (per hectare) of the mangroves in Laguindingan, Alubijid, and El Salvador are Php 1,496,345.55, Php 1,448,160.19, and Php 1,444,172.53, respectively. The largest benefit value of mangroves was derived from the Direct Use Value (Laguindingan: 90.54%, Alubijid: 90.40% & El Salvador: 89.31%, per year). It is evident that all households in each study sites are dependent on mangrove products (Direct Use Value).

Table 1. Total Economic Value of selected mangrove sites per hectare per year.

Total economic value	Laguindingan		Alubijid		El salvador	
	Php/ha/yr	(%)	Php/ha/yr	(%)	Php/ha/yr	(%)
Direct Use Value	1,354,790.36	90.54	1,309,085.41	90.40	1,289,859.32	89.31
Indirect Use Value	136,216.99	9.10	134,807.30	9.31	142,970.39	9.90
Option Value	5,338.20	0.36	4,267.48	0.29	11,342.82	0.79
TOTAL	1,496,345.55	100	1,448,160.19	100	1,444,172.53	100

Source: Consolacion (2018). Economic Valuation of Selected Mangrove Ecosystems along Macajalar Bay, Misamis Oriental, Philippines. Chapter 1 & 2. Mindanao State University-Iligan Institute of Technology.

Restoration Cost of a 1ha Mangrove Forest

Table 2 shows the estimated planting and maintenance costs of the mangrove forest restoration project. Cost estimates on the establishment of the mangroves were based primarily on the procurement/production of mangrove seedlings (Php 60,000.00) and plantation establishment (Php 70,000.00) that includes site preparation, labor cost, planting materials, seedlings collection, and transportation.

The local government allocation for the maintenance and protection of the mangroves per year is Php 120,000.00.

Table 2. Mangrove Restoration Costs.

Activities	Target	Unit cost (Php)	Cost/ha/year (Php)
• Mangrove Planting			
a. Procurement/ Production of Mangrove seedlings	4,000 seed-lings	15	60,000.00
b. Plantation Establishment			70,000.00
Total			130,000.00
• Operation and Maintenance			120,000.00

Source: Mangrove Plantation Cost: DENR R10, Mangrove Plantation Development Project in Tudela, Misamis Occidental.

Mangrove Maintenance Cost: Laguindingan, Alubijid & El Salvador LGU.

According to Tuan & Tinh (2013), the restoration cost varies in the first four (4) years while the maintenance and protection costs will be the same for the rest of the project life.

The seedling survival rate until maturity (4 years) is 80% (Narayan *et al.*, 2017). After four (4) years, the mangrove planting is completed, the cost of restoration will be zero.

Cost and Benefit Values of 1ha Commercial Aquaculture Development

Table 3 shows the cost of one-hectare milkfish aquaculture farming with 26 units of fish cages (15m diameter). The aquaculture owner harvests twice a year based on the five months cropping periods.

The total investment cost, including construction cost and equipment, for 20 years was Php 46,800,000.00 (average cost per fish cage is Php 900,000.00). The total production cost, including fixed costs (equipment depreciation cost) and variable costs (fingerlings, cost of labor, feeds, and fuel) was approximately Php 100,480,000.00 (average per fish cage is Php 3,864,615.38).

In an annual harvest, milkfish production generated an average of Php 40,000 kg/ha/year. The market price of the milkfish for big, medium, small, and very small sizes are Php 105/kg, Php 100 /kg, Php 95/kg, and Php 90/kg, respectively. Thus, annually the returns from aquaculture production amount to Php 106,080,000.00/ha.

Table 3. Costs and Returns of a 1ha Commercial Milkfish Aquaculture Development.

Costs and Returns of Aquaculture	Cost/ha/year (Php)*
Investment Cost 10-year project period (Php23,400,000.00) 20-year project period (Php 46,800,000.00)	2,340,000.00
Production Cost (Private Cost) Fixed Cost (Php 2,340,000) Variable Cost (Php 98,140,000)	100,480,000.00
Ecological/Environmental Cost Laguindingan Alubijid El Salvador	141,555.19 139,074.78 154,313.21
Returns from Productions (Sales)/ Benefit Value	106,080,000.00

*Costing of 26 units of fish cage in 2 croppings

On the other hand, the total cost of aquaculture is the sum of private cost and environmental cost to society. The private cost includes the costs of the firm/stakeholder pays to purchase capital, hire labor, equipment, materials, and other inputs for aquaculture development while the environmental cost is the loss of the ecological services provided by the mangroves to the communities (Indirect use value and Option value) if mangroves converted into aquaculture. These costs are not paid directly by the producer. The environmental cost of aquaculture in Laguindingan, Alubijid, and El Salvador are Php 141,555.19, Php 139,074.78, and Php 154,313.21, respectively.

Comparison of Cost and Benefit Values of Commercial Aquaculture and Selected Mangrove Ecosystems

Table 4 presents the Net Present Value (NPV), Benefit-Cost Ratio (BCR), and Internal Rate of Return (IRR) of the selected mangrove forests and commercial aquaculture in 20 years. The results revealed that at 10% discount rate, the NPV of the commercial aquaculture and mangrove forests attained positive values until the next 20-years and the BCR values were greater than or equal to 1.0 which means all the projects produce positive net benefits. While the projects provide a net positive outcome at 10% discount rate, the NPV, BCR, and IRR methods of obtaining results provide slightly different outcomes at 15% discount rate. Using the NPV method, the results suggest that mangrove restoration provides a better outcome as the NPV of the former is greater than the NPV of commercial aquaculture where its value becomes negative.

Moreover, using the BCR method, mangroves would still be preferable since the ratio between discounted benefits and costs is greater than commercial aquaculture at both discount rates. This means that the mangroves' benefits outweigh most of its costs than the commercial aquaculture. The results indicate that the conservation and protection of the mangrove forests are more economically efficient than commercial aquaculture development.

Table 4. Cost-Benefit Analysis of mangroves and commercial aquaculture per hectare per year.

Study Areas	Discount Rate	
	10%	15%
Laguindingan		
Mangroves		
NPV	7,589,498.21	4,852,042.70
BCR	7.33	6.30
IRR (%)	96.84	
Aquaculture		
NPV	2,765,671.13	(7,382,064.07)
BCR	1.00	0.99
IRR (%)	11.093	
Alubijid		
Mangroves		
NPV	7,306,503.98	4,666,306.99
BCR	7.10	6.10
IRR (%)	94.75	
Aquaculture		
NPV	2,798,789.75	(7,357,714.64)
BCR	1.00	0.99
IRR (%)	11.106	
El Salvador		
Mangroves		
NPV	7,283,084.34	4,650,936.13
BCR	7.08	6.1
IRR (%)	94.57	
Aquaculture		
NPV	2,599,559.41	(7,504,192.52)
BCR	1.00	0.99
IRR (%)	11.027	

Note: Values enclosed in parentheses are negative.

According to Sathirathai (1998), conversion of mangrove forest into commercial aquaculture farms is financially efficient only for those who can afford the venture (private operators). Large amount of capital is needed to invest in this project and those living along the coastline areas do not have the capacity to invest in such venture. Moreover, vast open access areas of mangrove forests have been rapidly diminishing over the past few years. Even though commercial aquaculture is financially efficient, the problem of income distribution is a big concern.

This strongly implies that conversion of important mangrove areas into commercial milkfish aquaculture is not economically efficient in social welfare and environmental perspectives. Economic efficiency indicates an economic state in which every resource is optimally allocated to serve each individual or entity in the best way possible. Commercial aquaculture development only creates enormous benefits for those who can only afford the project. The gainers are mainly outsiders who can afford the high initial investment requirement.

In addition, the study of Malik *et al.* (2015) demonstrated that the economic benefit value of mangroves exceeds the economic benefit value of commercial aquaculture in the Takalar District, South Sulawesi, Indonesia. The conversion of mangroves into commercial aquaculture was found to have a higher net present value than the Direct Use Value (benefit value of fisheries and forestry products) and Option Value of mangroves. At a first glance, commercial aquaculture seems to be economically viable but, when the Indirect Use Value of mangroves was included in the comparison, the value of mangroves was considerably higher. If the estimation of the NPV of aquaculture is extended to include external costs (costs of environmental and forest rehabilitation or social costs related to water pollution and loss of mangroves), the revenue of commercial aquaculture would become negative or is no longer economically beneficial. Extended or external costs and benefits of the project should also be considered, such as the cost of pollution from aquaculture which was not included and is beyond the scope of the study. According to Sathirathai (1998), there were problems of abandoned aquaculture ponds after private entrepreneurs leave the areas such as water pollution and soil degradation (lagoons). Yap (2001) reported that the potential of intensive milkfish farming in polluting the environment has been sufficiently demonstrated in fish pens and fish cages set in shallow waters where fish kills became a recurring problem. Khor (1995) reported as well that the results of Cost-Benefit Analysis in India, which concluded that aquaculture caused more economic harm, the costs (damage) outweighing the benefits by as much as 4 to 1 in Andhra Pradesh.

These illustrate the need for greater awareness of economic analysis within environmental impact assessment and appraisal. Extended cost and benefit analysis can be a useful tool for decision-makers in considering the nature of the costs and benefits, the number of individuals affected, and the user groups to which the costs and benefits accrue (Nickerson, 1999). Hence, these considerations are important in ensuring sustainable resource use and improvements in social welfare.

Conclusion

It is evident that all households in the study sites were dependent on the direct benefits provided by mangroves in terms of fishery products (Laguindingan: 90.54%, Alubijid: 90.40 % & El Salvador: 89.31% ha/yr, respectively). Moreover, the results of the Cost-Benefit Analysis revealed that mangrove restoration provides a better outcome as the net present value of mangroves is greater than the net present value of the commercial aquaculture project at the two discount rates considered in this study. Thus, the conversion of mangrove forests into commercial aquaculture is not economically efficient. Commercial aquaculture only creates enormous private benefits for those who can only afford the project. The gainers are mainly outsiders who can afford the high initial investment requirements. The local people tend to experience loss in terms of the net foregone benefits or ecological services of mangrove to the community such as coastline protection and carbon sequestration. It is thus reasonable to conclude that the mangrove restoration project would be a valuable investment, particularly in the context of economic crisis and climate change.

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