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Authors: Abdul Malik *, Rasmus Fensholt, Ole Mertz
Received: 19 June 2015
E-mails: malik@ign.ku.dk, rf@ign.ku.dk, om@ign.ku.dk

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Qinglin Li <nathan.li@mdpi.com>

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Type of manuscript: Article
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Authors: Abdul Malik *, Rasmus Fensholt, Ole Mertz
Received: 20 June 2015
E-mails: malik@ign.ku.dk, rf@ign.ku.dk, om@ign.ku.dk

It has been reviewed by experts in the field and we request that you make major revisions before it is processed further. Please find your manuscript and the review reports at the following link:
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Abdul Malik

Tue 7/21/2015 1:08 PM

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Dear Nathan Li
Assistant Editor

Thanks for your information that our manuscript has been reviewed and also thank to the reviewers for their excellent comments. We will revise the manuscript according to the reviewer's comments. However, if possible we need more than 2 weeks for the revision, because currently my co-authors in their summer holiday, so it certainly difficult to discuss. They will be back to the office on 3 and 10 Aug, respectively.

Kind regards,
Abdul Malik

From: nathan.li@mdpi.com [nathan.li@mdpi.com]
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Reviewer 1:

English Language and Style

( ) English language and style are fine
(x) Minor spell check required
( ) Extensive editing of English language and style required
( ) I don't feel qualified to judge about the English Language and Style

Comments and Suggestions for Authors

Dear authors,

thank your for you interesting contribution on a highly topical subject. This especially since Indonesia is home to much of the remaining mongrove forest and, in the meantime, are planning to expand their aquaculture production drastically over the coming decade. You here have made a good job highlighting this, but several improvements are still needed to make this manuscript publishable.

Major comments:

- The title and manuscript suggests that this is comparison between shrimp farming and mangrove forests. However, on line 327-331 it turns out that only 12 out of 23 ponds produce shrimp. In the meantime you treat them as an average.
- While you treat a diverse set of farms as averages, you fail to acknowledge uncertainties and variability in data. Likewise for your monetary values for ecosystem services you only cite individual sources, without looking at ranges of numbers. Valuating ecosystem services is highly objective and can therefore result in a wide range of outcomes. Now you simply pick values randomly across papers therefore easily becomes like comparing apples and pears. For instance the Coastline prevention value (CPV) was calculated based on one single figure for the cost of artificial coastline protection, which was based on solely one reference (in Bahasa Indonesia). In the meantime Rönnbäck 1999 write "Estimates of the annual market value of capture fisheries supported by mangroves ranges from US$750 to 16 750 per hectare, which illustrates the potential support value of mangroves".
- As for your own selection of you have limited yourself to four different services. However, you miss out on some ecosystem services that are strongly linked to mangrove forests, such as carbon sequestration. Moreover, you never motivate your selection of ecosystem services.
- Some values seem counter-productive or double counting. For example, the supply of nutrients from mangroves to seaweed farming. I don't see the link here and I don't understand why mangroves would provide nutrients when they are nutrient sinks? Moreover, mangrove litter is greatly different from inorganic fertilizers.
- Key references missing:

  Rönnbäck et al. 1999 The ecological basis for economic value of seafood production supported by mangrove ecosystems

  Barbier et al. 2008 Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values

Minor comments:

- How representative is the study area for South Sulawesi – title suitable
- Lack of references in several places
- Value of shrimp lower than for both milkfish and Gracillaria – how was this considered in the calculations (if it was…)?
- L206: how did they use mangrove for fish capture? As fishing grounds?
- L238: …to a decrease in fish…
- L251: Please write out references. Pirzanet et al. (1999) and Gunarto et al (2004).
- L327: Please delete an "of"

<u>Reviewer 2:</u>

English Language and Style

( ) English language and style are fine
( ) Minor spell check required
(x) Extensive editing of English language and style required
( ) I don't feel qualified to judge about the English Language and Style

Comments and Suggestions for Authors

Many aspects of methods used are not mentioned in the Method chapter; e.g. the household surveys (line 206), the method of extrapolation from survey data to total and per ha benefits (survey 23 * 3 ha; total area close to 2600 ha of ponds); the environmental cost of shrimp ponds (line 348 to).

Moreover, at least four aspects of the method are highly questionable:

1. The N and P captured by mangrove will be transformed to wood, nypah etcetera, and can be marketed as e.g. nypah craft and timber which are the final use value. Mangrove have a value as converter of waste from e.g. shrimp ponds, i.e. mangrove reduces pollution in case of excess nutrients. But I would not value this as fertiliser (line 158) because this N and P are not extracted as a product. Please use other TEV studies to identify a better method.

2. The replacement value of nursery by construction (and management) of ponds (line 156) because for many species of shrimp, crab, bivalves and fish the nursery is not yet possible. Moreover the method misses the foregone benefit from fishery, which I would suggest to use.

3. It is not clear how the assumptions (line 173 & 184) are related to the survey data. Regarding the forest: age of the present forest and duration of exploitation by the population should be considered.

4. Regarding the assumption on line 184-18xx: if the farms are already older than the 5 years, one may assume their production level is already low; however if they manage well their ponds

the production will not decline. And if they indeed harvest 7600 kg /ha/yr, we may assume they manage well their ponds.

Furthermore, reporting of results is not precise: units are often missing or not well specified.The authors don't interprete well the acidification problem (line 357). Please see the annotated pdf

Please use a native English scientific editor (see the annotated pdf for some problems).

Success with the revision

Forests **2015**, *6*, 1-x manuscripts; doi:10.3390/f60x000x

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Article

Economic Valuation of Mangroves for Comparison with Commercial Shrimp Farming in South Sulawesi

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Academic Editor:

Received: / Accepted: / Published:

Abstract: Mangroves are recognized as a provider of a variety of products and essential ecosystem services that contribute significantly to the livelihood of local communities. However, over the past decades, mangroves in many tropical areas including the Takalar district, South Sulawesi have degraded and decreased mainly due to conversion to shrimp ponds. Currently, little is known about the economic benefits of commercialization of shrimp ponds as compared to those derived from mangroves in the form of products and services. Here, we estimate the Total Economic Value (TEV) of mangrove benefits in order to compare it with the benefit value of commercial shrimp ponds. Market prices, replacement costs, benefit transfer value and Cost-Benefit Analyses (CBA) have been used for value determination and comparison. The results show that the per year TEV of mangroves during the study period was IDR 41,464,146,576 (USD 4,364,647) or IDR 24,121,086 (USD 2,539) per hectare, (the highest value contribution derived from the indirect use value (91%)), whereas the commercial shrimp ponds had a benefit value of IDR 1,373,250,500 (USD 144,553) or IDR 19,902,181 (USD 2,095) per hectare. In addition, the comparison of Net Present Value (NPV) between the benefit value of mangroves and that of commercial shrimp ponds revealed that conversion of mangroves into commercial shrimp ponds was not economically beneficial when the analysis was expanded to cover the costs of environmental and forest rehabilitation.

Keywords: Economic valuation; mangroves; commercial shrimp farming; Indonesia; South Sulawesi.

1. Introduction

One of the crucial issues in development based on the use of natural resources is how to integrate economic development on the one hand with natural resources and environmental sustainability on the other in order to mitigate negative impacts and problems in future [1]. In principle, development should take place by utilizing the natural resources optimally [2]. In many countries, development is considered inevitable as a way to improve the welfare of communities. Unfortunately, failure to take into account the costs and benefits of the use of natural resources, which leads to negligence in decision-making, is still common and currently, we are facing an increasing scarcity of the resources necessary to support local livelihoods [3].

Mangroves, which are considered an important natural resource, occupy coastal and estuarine areas in many tropical places, provide goods and services for both direct use (e.g. timber, firewood, charcoal, Nypa palm leaves for crafting, wood chips, fisheries, food, medicines, material construction and tourism and recreational areas) and indirect use (e.g. coastline protection, prevention of seawater intrusion, provision of nursery and breeding grounds for fish, supply of nutrients for marine life, biodiversity maintenance and carbon sequestration) that have contributed significantly to community livelihoods [4].

Although mangroves provide a variety of products and services, they have been under great pressure due to decision making commonly based on assumptions of larger net benefits without considering the loss of wider mangrove services [5] and natural capital stocks [6]. Mangrove products and services are often undervalued or even ignored in the economy and by industry and local inhabitants [7]. Consequently, nearly half of the total mangrove areas in the world have been lost over the past decades, with the largest areas of decline in Asia [8,9,10]. In Indonesia (which has the largest mangrove areas in the world), mangroves are threatened primarily by aquaculture but also by overharvesting of timber, firewood collection, charcoal production and conversion to other land uses such as agriculture, urbanization, mining and salt ponds [10,11,12,13]. Mangrove areas are characterized by some of the most rapid loss rates of coastal ecosystems in Indonesia; from 1980 to 2003, at least 1.1 million hectares of mangrove were lost, with 75 % of these areas being converted to shrimp ponds [10,14]. High economic revenues from the increase in exports and foreign trade in shrimp have become the main driving forces for the expansion of shrimp ponds by clearing mangroves [12]. In 2012, for instance, shrimp exports from Indonesia were valued at USD 1,304,149,000, of which 38 percent went to the United

States of America (USA), 29 percent to Japan, 9 percent to European countries and 24 percent to other countries [15]. In South Sulawesi, the value of shrimp exports in 2011 reached USD 42,407,000 [13]. Since the early 1990s, Indonesia has become one of the major shrimp producing and exporting countries in the world [16]. However, the expansion of shrimp export which mostly comes from aquaculture production has triggered a heated debate in Indonesia as well as in other exporting countries such as Thailand due to the significant consequences for coastal areas [17,18].

Evaluation of the value of mangrove products and services affected by shrimp pond expansion is therefore important as a vehicle to integrate both ecological perspectives and economic considerations [19]. Such an evaluation will support reliable instruments that can be used to shift focus towards a green economy and guide policy makers to make sustainable decisions about mangrove utilization [4,2,20]. In addition, it is away to increase knowledge and awareness among stakeholders of the importance of the mangrove ecosystem for sustainable and environmentally friendly economic development [21].

Economic valuations of mangroves have been conducted in many areas of the world [7]. However, little attention has been paid in the scientific literature to an economic valuation of mangroves in areas threatened by commercial shrimp farming development in Indonesia and other Asian countries and to the discussion of the economic benefits of shrimp farming as compared to mangroves as a provider of a variety of products and environmental services. This paper aims to estimate the TEV of mangrove, including estimations of Direct Use Value (DUV), Indirect Use Value (IUV) and Option Value (OV), to enable a direct comparison with the benefit value of commercial shrimp farming for a case study area in southern South Sulawesi, Indonesia using the CBA method. Given the threat of aquaculture expansion, information from such analyses is critical as the net benefit value generated from mangroves is currently not considered by policy makers dealing with sustainable management of mangroves.

2. Study Area

Takalar district is located in southern South Sulawesi, Indonesia (between latitude 5°12’ - 5°38’ and longitude 119°10’- 119°39’, see figure 1), 45 km from Makassar city (the capital of South Sulawesi). The district has a coastline of 74 km [22], occupied by mangroves, coral reefs, sea grass, sandy beaches, rocky beaches, estuaries, shrimp ponds, rice fields and tourism and residential areas. Most areas of Takalar are plain and coastal areas (including small islands) with an altitude of 0 - 100 metres above sea level and the rest are hilly areas [23]. The district covers 566.51 km^2 and is divided into nine subdistricts (Galesong, South Galesong, North Galesong, Mangarabombang, Mappakasunggu, Pattalassang, South Polongbangkeng, North Polongbangkeng and Sanrobone) Mappakasunggu consists of a mainland part and small islands (Tanakeke, Lantangpeo, Bauluang, Satangnga and DayangDayang). The population is 272,316 and the population density is 481 persons per km^2. Mean temperatures vary from 23˚C - 33˚C andthe monthly precipitation average over the past eight years (2004 – 2011) has been between

174 mm and 712 mm; the greatest amount of precipitation occurred in 2008 from November to March [24].

In past decades, mangroves in this area have degraded and decreased mainly due to conversion to shrimp ponds. About 2,593 hectares (77.4%) of the total mangrove forest area has been changed to aquaculture (shrimp ponds), mainly on Tanakeke Island and in Banyuanyara village. Currently, the total extent of intact mangrove forest is 1,719 hectares and covers the subdistricts of Mappakasunggu, Mangarabombang, Pattallassang, Sanrobone, Galesong, South Galesong and North Galesong [13]. Mangroves in this region are dominated by saplings and seedlings and comprise 10 species (*Avicennia alba*, *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Excoecaria agallocha*, *Lumnitzera racemosa*, *Nypa fruticans*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhizophora stylosa* and *Sonneratia alba*). The most dominant species has been *Rhizophora mucronata*, followed by *Sonneratia alba*. The Diameter at Breast High (DBH) of mangrove trees is between 6.37 cm and 23.57 cm and the diameter size classes of 10-15 cm are dominant, followed by 15-20 cm [25].

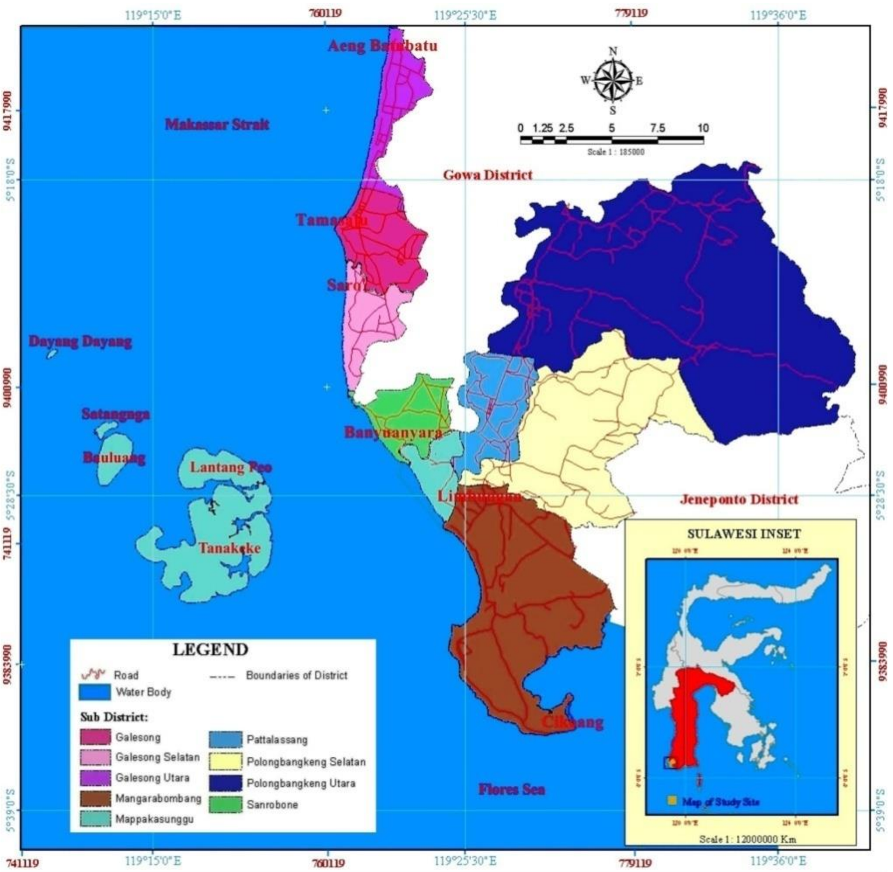

Figure 1. Map of the Takalar District Study Area, South Sulawesi, Indonesia

3. Materials and Methods

The TEV of mangroves was calculated from monetary values of the DUV, IUV and OV of mangroves [26,4,27]. The DUV of mangroves was derived from benefit values of fishery products (fish, crab and shrimp capture as well as seaweed farming) and forestry products (firewood collection, charcoal production and Nypa palm crafting), which have been estimated using market prices [4,27] and the following formulas:

- Fish, crab and shrimp capture and seaweed farming values (FV;CV; SV; SFV)

$$\text{FV; CV; SV; SFV} = \text{production (unit/yr)} \times \text{price (IDR/unit)} - \text{Production cost (IDR)} \qquad (1)$$

- Firewood value (FwV)

$$\text{FwV} = \text{Wood collection (unit/yr)} \times \text{price (IDR/unit)} - \text{production cost (IDR)} \qquad (2)$$

- Charcoal value (CcV)

$$\text{CcV} = \text{Production (unit/yr)} \times \text{Price (IDR/unit)} - \text{production cost (IDR)} \qquad (3)$$

- Nypa palm crafting value (NpcV)

$$\text{NpcV} = \text{Production (Unit/yr)} \times \text{Price (IDR/unit)} - \text{production cost (IDR)} \qquad (4)$$

The IUV of mangroves is derived from benefit values of mangrove services such as coastline protection, seawater intrusion prevention, provision of nursery grounds and supply of nutrients for marine organisms. These benefit values were estimated using replacement costs [4,27]. The coastline protection service was estimated by the cost of breakwater construction over a 10-year project lifespan; the seawater intrusion prevention service was assessed by the cost of the water supply needs of people if the availability of fresh water was reduced due to mangrove loss; the provision of nursery grounds service was estimated by the construction cost of ponds for nursery grounds for shrimp or fish. Finally, the supply of nutrients service was assessed by the value of nutrient production (nitrogen and phosphate) from mangrove litter converted to the fertilizer market price of Urea $(NH_2)_2CO$ and SP-36 (Superphosphate, 36 percent P_2O_5), using the following formulas:

- Coastline prevention value (CPV)

$$\text{CPV} = \text{Coastal length (m)} \times \text{Cost of breakwater construction (IDR)} \qquad (5)$$

Coastal length = 74,000 m; Cost of breakwater construction with specification of length (1m), width (11m) and height (2.5m) = IDR 1,530,880/m^3 (USD 158/m^3) [28].

- Seawater intrusion prevention value (SwIPV)

$$\text{SwIPV} = \text{household population} \times \text{number of water supply (gallon/day)} \times \text{Price (IDR /gallon)} \times 365 \text{ days} \qquad (6)$$

- Provision of nursery grounds value (PNGV)

$$\text{NGV} = \text{Total of mangrove area (Ha)} \times \text{Construction cost of the pond (IDR/Ha)} \qquad (7)$$

- Supply of nutrients value (SNV)

$$\text{SNV} = \text{Organic material Nitrogen and Phosphate (Kg/Ha/yr)} \times \text{total area of mangrove (Ha)} \times \text{Price of Urea \& SP-36 fertilizers (IDR/kg)} \qquad (8)$$

The OV of mangroves was calculated using the benefit transfer value method [4,27,21]. The benefit values of medicinal material from mangrove ecosystems was estimated by transferring the available value from Sribianti [29], who studied in East Luwu district, Indonesia. The annual benefit was IDR 1,500,000 (USD 157) per hectare [29].

The economic value of shrimp ponds (SpV) was calculated using the formula:

$$\text{SpV} = \text{Production (unit/yr)} \times \text{Price (IDR/unit)} - \text{Production cost (IDR)} \qquad (9)$$

The NPV of mangroves and commercial shrimp ponds was estimated using CBA with the following assumptions:

- The benefit value of fisheries and forestry, medicines and mangrove services over a 10-year project period will decrease 5% – 20% (the decrease will begin in the second year of the project) with a subsequent decrease in mangrove ecosystem functions that provide products and services due to the expansion of shrimp ponds. In contrast, the costs of production will increase by 2% - 20% during such a project period.
- Several studies (e.g. [30,4,31,32]) have observed that shrimp production decreases successively after the fifth year due to the lower survival rate of shrimp. Hence, the production of shrimp over a 10-year project period also decreases by 5 – 20% and investment and production costs increase to sustain shrimp production.
- In accordance with the loan interest rate prevailing at financial institutions such as banks when the survey was conducted, a discount rate of 10% was used in the CBA.
- The environmental cost (water pollution cost) of shrimp ponds was adopted from Lan [33], who reported that the production of 360,000 tons of shrimp generates an environmental cost of USD 280 million (1 kg shrimp produced = USD 1.28), whereas the forest rehabilitation cost was estimated from seed provision, planting and maintenance costs. The forest rehabilitation cost was estimated from year 6 to year 10 (assuming normal shrimp pond production during the first 5 years). The formula for calculating the NPV is as follows: [27]

$$\mathrm{NPV} = \sum_{i=1}^{n} \frac{\mathrm{Bit} - \mathrm{Cit}}{(1+r)^{t}} \text{(Ordinary CBA)}$$

$$\mathrm{NPV} = \sum_{i=1}^{n} \frac{(\mathrm{Bit} + \mathrm{EBit}) - (\mathrm{Cit} - \mathrm{ECit})}{(1+r)^{t}} \quad \text{(Extended CBA)} \qquad (10)$$

Where:

NPV = Net Present Value
B = annual gross benefit; EB = annual extended benefit
C = annual gross cost; EC = annual extended cost
r = discount rate
i = each benefit or cost
t = period of time

Criteria: NPV > 0: financially feasible; NPV = 0: impasse; and NPV <0: not financially feasible.

4. Results and Discussion

4.1. DUV of mangroves

In past decades, people who lived around mangroves in this area were highly dependent on mangroves for various fishery and forestry products for domestic and commercial purposes. In fisheries, mangrove forest has benefits for the capture of fish, crab and shrimp as well as seaweed and shrimp farming, whereas in forestry, benefits connected with the collection of firewood, charcoal production and Nypa palm leaf crafting are generated. The results of the household survey showed that 43 households have been directly using mangrove for fish capture, six for crab capture, six for shrimp capture and seven for seaweed farming. Eight households have been using mangrove for harvest firewood, four for charcoal production and three for Nypa palm leaf crafting. The production averages of fish, crab and shrimp capture and seaweed farming (*Eucheuma cottonii*) per household per year are 2,450 kg, 338 kg, 213 kg and 8,914 kg, respectively. The production of firewood, charcoal and handcrafts such as roofs, walls, floor mats, baskets and especially hats from Nypa palm leaves per household per year amounted to 60 bundles (1 bundle = 100 stems with a length of 1 m and a diameter of 4 cm to 8 cm), 720 sacks (1 sack = 25 kg) and 6,750 units, respectively. The total of fish, crab and shrimp production was 105,350 kg/year, 2,028 kg/year and 1,278 kg/year, respectively, whereas seaweed (*Eucheuma cottonii*) production was 62,398 kg per year. Harvested mangrove forests for firewood reached 480 bundles per year, charcoal production was 2,160 sacks per year and handcrafting produced 27,000 units per year. The highest benefit of DUV was obtained from fish production, earning IDR 498,850,000 (USD 52,511) per year, followed by seaweed farming for IDR 327,588,000 (USD 19,402) per year. Thus, the total benefit of the DUV of mangrove ecosystem is IDR 1,105,209,600 (USD 116,338) per year (Table 1).

Table 1. DUV of mangroves

No	Products	House-hold users (n=77)	Net use value (IDR/yr)	Net use value/ household (IDR/yr)	Net use value (USD/yr)	Net use value/ household (USD/yr)	Net use value (IDR/Ha/yr)	Net use value (USD/Ha/yr)	% use value/ year
Fishery products									
1	Fish capture	43	498,850,000	11,601,163	52,511	1,221	290,198	31	45
2	Crab capture	6	62,040,000	10,340,000	6,531	1,088	36,091	4	6
3	Shrimp capture	6	26,810,000	4,468,333	2,822	470	15,586	2	2
4	Seaweed farming (*Eucheuma cottonii*)	7	327,588,000	46,798,286	34,483	4,926	190,569	20	29
	Sub Total of DUV =		915,288,000		96,346		532,454	56	82
Forestry products									
1	Firewood	8	32,100,000	4,012,500	3,379	422	18,674	2	3
2	Charcoal	3	83,685,600	27,895,200	8,809	2,936	48,683	5	8
3	Nypa palm crafting	4	74,136,000	18,534,000	7,804	1,951	43,127	5	7
	Sub Total DUV =		189,921,600		19,992		110,484	12	18
	Total of DUV =		1,105,209,600		116,338		642,938	68	100

Exchange rate: USD 1 = IDR 9,500; Total area of mangrove = 1,719 Ha

A large number and variety of fish species and other marine species use the mangroves for nursery, spawning and feeding grounds and for migrating to the coral reef areas or offshore [34]. The main fish, shrimp and crab species available for fishery in the mangrove area include small pelagic fish, snapper (*lates calcarifer*), milkfish (*Chanos chanos*), white shrimp (*Pennaeus* *vannamei*) and mud crab (*Scylla sp*.). In seaweed farms on the seashore (near mangrove areas), cultures of *Eucheuma cottonii* are developed. Furthermore, the harvest of mangroves for home consumption and firewood and charcoal for commercial use are mostly derived from *Rhizophora sp*., whereas leaves of *Nypa fruticans* are used for handcrafts such as hats, floor mats, baskets, roofs and walls. Even though fish capture is the dominant source of revenue for the local population and the highest generator of net benefit per year (IDR 498,850,000 = USD 52,511), the highest net benefit value per household per year (IDR 46,798,286 = USD 4,926) is derived from seaweed farming. Over the last decades, clearing mangrove to expand shrimp ponds has been widespread in this area, causing mangrove areas to decrease and degrade rapidly, which in turn has led to a decrease infish production and fishermen's income. Consequently, seaweed farming has become an alternative livelihood strategy that has proven to be more profitable than fishing [13].

4.2. IUV of mangroves

Besides providing a variety of products, mangrove forest supports ecological services by protecting the coastline from exposure to waves, preventing seawater intrusion and providing nursery grounds and supplying nutrients for marine organisms [35]. [36] stated that the stand of *Kandelia candel* (six years old) can reduce waves with an offshore height of 1 m to 0.05 m when they reach the shore. [37] and [38] revealed that abrasion and seawater intrusion occurred in several places in the region where mangrove is absent. Abrasion was found along the coast in six subdistricts of Takalar district (Mappakasunggu, Mangarabombang, Sanrobone, South Galesong, Galesong and North Galesong), reaching 20-100 metres per year over the past five years. Moreover, seawater intrusion into inland areas has made growth conditions difficult for local crops such as banana. Furthermore, [39] and [40] found that 17 commercial fish species inhabit and use mangroves as nursery grounds in Lamuru Estuary, Bone district, South Sulawesi while 27 commercial fish species do so in the Tongke-tongke mangrove forest area and Sinjai district. In Selangor, Malaysia, [41] noted that many species of fish (119) and prawn (9) inhabit and use mangrove as nursery and feeding grounds. In addition, [42] reported that the average production of nitrogen and phosphate of mangrove litter in Sinjai district, South Sulawesi reached 497.98 kg/ha and 22.02 kg/ha, respectively. [43] report the availability of nutrients in the soil of the Bhitarkanika National Park, India to be2,907 kg/ha (nitrogen) and 28.11 kg/ha (phosphate).

In this case study area, the net benefit values of these mangrove services have been estimated using the replacement cost method. Annual values of prevention of coastline erosion and seawater intrusion provided by mangroves were estimated to be IDR 11,328,512,000 (USD 1,192,475) or IDR 6,590,176 (USD 694) per hectare and IDR 11,307,700,000 (USD 1,190,284) or IDR 6,578,069 (USD 692) per hectare, respectively. Provision of nursery grounds and supply of nutrient services were estimated to amount to IDR 13,542,282,000 (USD 1,425,503) or IDR 7,878,000 (USD 892) per hectare and 1,616,554,476 (USD 170,164) or IDR 940,404 (USD 99) per hectare, respectively. Thus, annually the aggregate benefit of IUV mangroves was IDR 37,795,048,476 (USD 3,978,426) or IDR 21,986,648 (USD 2,314) per hectare (Table 2). Some studies have reported benefit values of such mangrove services and [31] estimated the cost of constructing breakwaters to prevent coastal erosion in Southern Thailand to be USD 3,679/Ha. [21] estimated the benefit value of preventing coastline erosion and supplying nursery grounds from mangroves in the Bohol Marine Triangle, Philippines to be USD 672/Ha/yr and USD 243 Ha/yr, respectively. [32] calculated the annual benefit value of preventing seawater intrusion in Probolinggo district, East Java to be IDR 68,227,500 (USD 7,182) per hectare and [43] estimated each hectare of mangrove in the Bhitarkanika National Park, India to contain nutrient values of USD 232.49.

Table 2. IUV of mangroves

No.	Services	Use value (IDR/yr)	use value (USD/yr)	use value (IDR/Ha/yr)	use value (USD/Ha/yr)	% use value/yr
1	Coastline protection	11,328,512,000	1,192,475	6,590,176	694	30
2	Seawater intrusion prevention	11,307,700,000	1,190,284	6,578,069	692	30
3	Provision of nursery grounds	13,542,282,000	1,425,503	7,878,000	829	36
4	Supply of nutrients (nitrogen and phosphate)	1,616,554,476	170,164	940,404	99	4
Total of IUV =		37,795,048,476	3,978,426	21,986,648	2,314	100

Exchange rate : USD 1 = IDR 9,500 ; Total area of mangrove = 1,719 Ha

4.3. OV of mangroves

The benefit values of mangrove as medicine is the option value, which will be crucial in the future. Most mangrove plants have medicinal importance, such as *Avecennia sp.*, *Bruguiera sp.*, *Ceriops sp.*, *Excoecaria sp.*, *Rhizophora sp.*, *Sonneratia sp.* and *Xylocarpus sp.* [44,45]. [46] reported that communities living in mangrove areas in Indian Sundarban have used *Rhizophora sp.*, *Excoecaria sp.* and *Bruguiera sp.* to treat angina, leprosy, and diarrhea and blood pressure, respectively. [47] reported that the tree bark of *Rhizophora sp.* is commonly used to treat fractures, cure diarrhea and stop hemorrhages. In addition, [44] stated that dried plant samples of *Excoecaria agallocha* prevent pathogenic bacteria. Mangroves are furthermore a rich source of steroids, triterpenes, saponins, flavonoids, alkaloids and tannins [45]. By transferring benefit values of medicine material of mangroves in East Luwu district Indonesia [29], the estimation of the annual benefit value of medicinal material in this area was IDR 2,563,888,500 (USD 269,883) (mangrove extent of 1,719 Ha) or IDR 1,491,500 (USD 157) per hectare (Table 3). However, over the past decades mangroves in the study area have degraded, leading to depletion of their composition and diversity [25]. Nonetheless, the economic value of medicinal material in this area is quite high and many species commonly used for medicine are available, such as *Avicennia sp.*, *Bruguiera sp.*, *Ceriops sp.*, *Excoecaria sp.*, *Sonneratia sp.*, and especially *Rhizophora sp.* [25].

Table 3. OV of mangroves

No	Option value	Total use value (USD/yr)	Total use value (IDR/yr)	Total use value (IDR/Ha/yr)	Total use value (USD/Ha/yr)
1	Medicines	269,883	2,563,888,500	1,491,500	157

Exchange rate : USD 1 = IDR 9,500 ; Total area of mangrove = 1,719 Ha

4.4. TEV and NPV of Mangroves

On the basis of the sum values of the DUV, IUV and OV, the annual benefit of the TEV of mangroves is estimated to be IDR 41,464,146,576 (USD 4,364,647) or IDR 24,121,086 (USD 2,539) per hectare (Table 4). In addition, the NPVs per hectare for all three values (the DUV, IUV and OV) of mangroves benefits over a 10-year time period with a discount rate of 10% were IDR 4,579,584 (USD 482), IDR 171,757,468 (USD 18,080) and IDR 11,416,610 (USD 1,202) (Table 5).

The largest benefit value of mangroves (91%) and the highest NPV are derived from the IUV, including the values of coastline protection, seawater intrusion prevention and nutrient and nursery ground provision. This suggests that the ecological functioning of mangrove has an important role in supporting local people's livelihoods. Currently, there is a lack of awareness in local communities concerning the value of such benefits. People are driven by urgent needs and quick and real benefits that can be easily obtained by exploiting mangroves; they may tend to disregard the sustainability and the greater benefit value provided by this resource. In addition, the lower values of the DUV and OV as compared to the IUV suggest that the mangroves have been degraded and have decreased, thereby impacting fishery and forestry production.

Table 4. TEV of mangroves

No.	Economic use value	Use value (IDR/yr)	Use value (IDR/yr)	Use value (IDR/Ha/yr)	Use value (IDR/Ha/yr)	%
1	DUV	1,105,209,600	116,338	642,938	68	3
2	IUV	37,795,048,476	3,978,426	21,986,648	2,314	91
3	OV	2,563,888,500	269,883	1,491,500	157	6
TEV		41,464,146,576	4,364,647	24,121,086	2,539	100

Total area of mangrove = 1,719 Ha; Exchange rate : USD 1 = IDR 9,500

Table 5. NPV of mangroves

NPV	DUV	IUV	OV
NPV (IDR)	7,872,304,104	295,251,087,549	19,625,152,186
NPV (IDR/Ha)	4,579,584	171,757,468	11,416,610
NPV (USD/Ha)	482	18,080	1,202

4.5. Benefit value of commercial shrimp farming and comparison to economic value of mangroves

Production and commercialization of shrimp farming in Indonesia started in the 1960s and three regions (Java, South Sulawesi and Aceh) have developed into the centres of production. In the early 1980s, shrimp farming experienced a peak, not only in these three regions; the development of shrimp ponds was noticeable in most regions in Indonesia. The demand from importing countries (such as America, Japan and European countries) increased rapidly during this period, and to meet it, shrimp farming was expanded by clearing mangroves and intensifying farming practices [48].

Interviews of 23 of shrimp farmers revealed that shrimp ponds in the study area have been constructed (to an average extent of 3 hectares) by clearing mangrove forests. The types of shrimp ponds found were monoculture of shrimp (3 ponds), monoculture of milkfish (3 ponds), polyculture of shrimp and milkfish (9 ponds) and polyculture of milkfish and seaweed, mainly from *Gracilaria sp*. (8 ponds). The total investment cost, including construction costs and equipment, for all pond areas were IDR 543,549,500 (USD 57,216) (average cost per shrimp pond is about IDR 23 million (USD 2,488)). Meanwhile, the total production cost, including fixed costs (e.g. equipment depreciation costs and taxes) and variable costs (e.g. costs of labour, seed, feed, fertilizer, fuel, etc.) for all pond areas was about IDR 406,600,000 (USD 42,800) (average per shrimp pond IDR 17.6 million (USD 1.860)). Annually, shrimp production generated on average 7,600 kg, milkfish production, 30,150 kg, and seaweed production, 34,350 kg (2 harvests per year). The market prices of shrimp, milkfish and seaweed (*Gracilaria sp.*) were IDR 55,000 (USD 5.79) per kg, IDR 15,000 (USD 1.58) per kg and IDR 4,000 (USD 0.42) per kg, respectively. Thus, annually the net benefit amounts to IDR 1,373,250,500 (USD 144,553) or IDR 19,902,181 (USD 2,095) per hectare and the NPV of the revenue of shrimp ponds per hectare during the 10-year project period (with a discount rate of 10%) is estimated to be IDR 15,052,424 (USD 1,584) (Table 6). This suggests that shrimp farming is financially feasible and when compared to the NPV of the DUV and the OV of mangroves, the revenue is 3 and 1.3 times higher, respectively. However, when the comparison includes the NPV of the IUV of mangroves, the economic benefit value of mangroves providing environmental services (e.g. providing nursery grounds, protecting coastlines, preventing seawater intrusion, and supplying nutrients) were far higher (11.4 times). However, when the estimation of the NPV of shrimp farming 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 shrimp farming becomes negative (USD -459 per hectare) or no longer economically beneficial (Table 6 and Figure 2). It is often the case for shrimp farming in Indonesia that the expected levels of shrimp production are met during the first five years, after which production starts to decline and many shrimp farmers suffer from heavy economic losses, often leading to bankruptcy [49]. Consequently, many shrimp farms are abandoned as owners try to find new locations for farming [30]; a general pattern also observed in other Asian countries as reported by [4] and [31]. Abandoned shrimp ponds are exposed to abrasion and the soil becomes very acidic, making it difficult to use for other purposes [31]. In summary, degraded and decreased areas of mangroves, water pollution caused by waste ponds and the loss of nursery, feeding and spawning grounds of marine organisms have become visible evidence of the environmental impacts of shrimp farming development. If local environmental conditions are recoverable, the associated costs are very high and therefore, the economic benefit value of commercial shrimp farming in the long term becomes questionable, as also discussed by [50].

Table 6. Benefit value of commercial shrimp farming

No	Description	Unit	Value	In USD
1	Investment	IDR	543,549,500	57,216
2	Production cost	IDR/yr	406,600,000	42,800
3	Production			
	Shrimp	Kg/yr	7,600	-
	Milkfish	Kg/yr	30,150	-
	Seaweed (*Gracilaria sp.*)	Kg/yr	34,350	-
4	Market price			
	Shrimp	IDR/Kg	55,000	5.79
	Milkfish	IDR/Kg	15,000	1.58
	Seaweed (*Gracilaria sp.*)	IDR/Kg	4,000	0.42
5	Benefit	IDR/yr	2,323,400,000	244,568
6	Net benefit	IDR/yr	1,373,250,500	144,553
	Net benefit per Ha	IDR/Ha/yr	19,902,181	2,095
7	NPV without external cost:			
	NPV	IDR	25,875,117,657	2,723,696
	NPV	IDR/Ha	15,052,424	1,584
8	NPV with external cost:			
	NPV	IDR	-7,491,812,355	-788,61
	NPV	IDR/Ha	-4,358,239	-459

Exchange rate: USD 1 = IDR 9,500

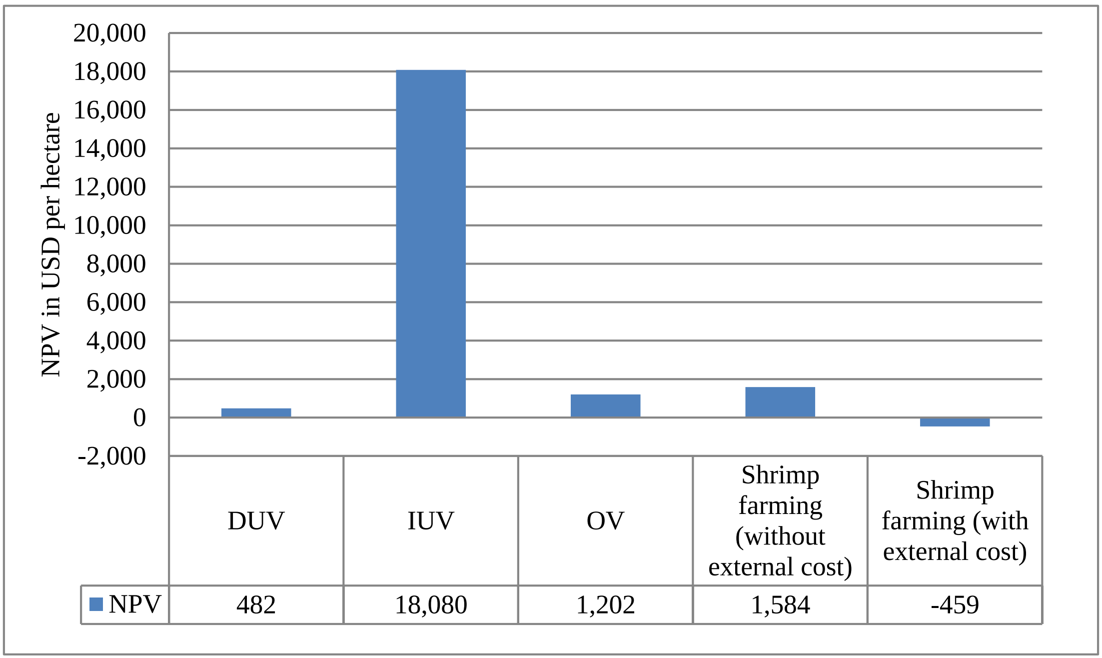

Figure 2. Comparison of NPV of mangroves versus commercial shrimp farming.

5. Conclusions

This study has demonstrated that the annual TEV of mangrove benefits is IDR 41,464,146,576 (USD 4,364,647) or IDR 24,121,086 (USD 2,539) per hectare. The calculation included the DUV of mangroves (the benefit value of fisheries and forestry products), the IUV of mangroves (the benefit value of protecting the coastline, preventing seawater intrusion, acting as a nursery ground and supplying nutrients), and the OV of mangroves (benefit value of medicines). The highest contribution of the TEV of mangroves was derived from the IUV of mangroves (91%). The benefit value of commercial shrimp farming amounts to IDR 1,373,250,500 (USD 144,553) or IDR 19,902,181 (USD 2,095) per hectare. In addition, the NPVs per hectare for the DUV, IUV and OV and shrimp farming were IDR 4,579,584 (USD 482), IDR 171,757,468 (USD 18,080), IDR 11,416,610 (USD1,202) and IDR 15,052,424 (USD 1,584), respectively. The conversion of mangroves into commercial shrimp farms has a higher beneficial value than the DUV and OV of mangroves and at a first glance seems to be financially viable, but when the IUV of mangroves is included in the comparison, the benefit value of mangroves is considerably higher. In addition, when the analysis of NPV was extended to include the costs of environmental restoration (from water pollution) and forest rehabilitation, the revenue of shrimp farming became negative or no longer economically beneficial.

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Author Contributions

Abdul Malik led the design of the study, conducted the field work and data analysis used for the economic valuation and wrote the first draft of the paper, with subsequent improvements by the co-authors.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Fauzi, A., *Economics of Natural Resources and Environment. Theory and Applications*. PT Gramedia Pustaka Utama: Jakarta, Indonesia, 2004; p 259.
2. Suparmoko, M., *Neraca Sumberdaya Alam (Natural Resource Accounting)*. BPFE UGM: Yogyakarta, Indonesia, 2005.
3. Rukmana, D., *Ekonomi Lingkungan dan Sumberdaya Alam*. Penerbit Arus Timur Makassar, Indonesia, 2012.
4. Bann, C., *The economic valuation of mangroves _A manual for researchers*. Economy and Environment Program for Southeast Asia (EEPSEA): Singapore. , 1998.
5. Barbier, E. B., Sustainable use of wetlands valuing tropical wetland benefits: economic methodologies and applications. *The Geographical Journal* **1993,***159*, 22-32.
6. Brander, L. M.; Wagtendonk, A. J.; Hussain, S. S.; McVittie, A.; Verburg, P. H.; Groot, R. S. d.; Ploeg, S. v. d., Ecosystem service values for mangroves in Southeast Asia: A meta-analysis and value transfer application. *Ecosystem Services* **2012,***1* (1), 62-69.
7. Vo, Q. T.; Kuenzer, C.; Vo, Q. M.; Moder, F.; Oppelt, N., Review of valuation methods for mangrove ecosystem services. *Ecological Indicators* **2012,***23*, 431-446.
8. Curran, S., Migration, Social Capital, and the Environment: Considering Migrant Selectivity and Networks in Relation to Coastal Ecosystems *Population and Development Review* **2002,***28*, 89-125.
9. Giri, C.; Ochieng, E.; Tieszen, L. L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J.; Duke, N., Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography* **2011,***20* (1), 154-159.
10. FAO *The World's Mangroves 1980 – 2005*; Food and Agriculture Organization (FAO): Rome, Italy, 2007.
11. Onrizal, Perubahan Tutupan Hutan Mangrove di Pantai Timur Sumatera Utara Periode 1977 – 2006. *Jurnal Biologi Indonesia* **2010,***6* (2), 163-172.
12. Nurkin, B., Degradation of Mangrove Forests in South Sulawesi, Indonesia. *Hydrobiologia* **1994,***285*, 271-276.
13. Malik, A.; Fensholt, R.; Mertz, O., Consequences of Mangrove Forest Change in South Sulawesi. REEC, under review.
14. Forest-Ministry-Indonesia, *Luas Mangrove per Propinsi di Indonesia In Noor Y.R., Khazali M., Suryadiputra I N.N. Panduan Pengenalan Mangrove di Indonesia*. PHKA/WI-IP: Bogor, Indonesia. , 2006; p 219.
15. WGMFDA. *Kelautan dan Perikanan dalam Angka 2013*; Working Group of Marine and Fisheries Data Arrangement (WGMFDA). Centre of Data, Statistics and Information, Ministry of Marine and Fisheries of Indonesia: Jakarta, Indonesia, 2013.
16. GlobeFish. Food Market: Shrimp Production http://www.globefish.org. (accessed May 5, 2013).
17. Barbier, E. B., Habitat-Fishery Linkages and Mangrove Loss in Thailand. *Contemporary Economic Policy* **2003,***21* (1), 59-77.
18. Hogarth, P., *The Biology of Mangroves and Seagrass* 2ed.; Oxford University Press: New York, 2007.

19. Chee, Y. E., An Ecological Perspective on the Valuation of Ecosystem Services. *Biological Conservation* **2004,***120*, 549-565.
20. Beaumont, N. J.; Austen, M. C.; Mangi, S. C.; Townsend, M., Economic valuation for the conservation of marine biodiversity. *Marine pollution bulletin* **2008,***56* (3), 386-96.
21. Samonte-Tan, G. P. B.; White, A. T.; Tercero, M. A.; Diviva, J.; Tabara, E.; Caballes, C., Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines. *Coastal Management* **2007,***35* (2-3), 319-338.
22. Ukkas, M. *Pemetaan Potensi/Zonasi Wilayah Pesisir dan Pulau-pulau Kecil Kabupaten Takalar*; Laporan Penelitian. Universitas Hasanuddin: Makassar, Indonesia, 2001.
23. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2012.* ; Badan Pusat Statistik (BPS) Kabupaten Takalar: Takalar, Indonesia, 2012.
24. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2004-2012.*; Badan Pusat Statistik (BPS) Kabupaten Takalar: Takalar: Takalar, Indonesia, 2004-2012.
25. Malik, A.; Fensholt, R.; Mertz, O., Mangrove Exploitation Effects on Biodiversity and Ecosystem Services. BIOC, under review.
26. Pearce, D.; Moran, D., *The Economic Value of Biodiversity*. Earthscan: UK, 1994.
27. UNEP, *Guidelines for conducting economic valuation of coastal ecosystem goods and services*. UNEP/GEF/SCS Technical Publication 2007.
28. Mayudin, A., Kondisi Ekonomi Pasca Konversi Hutan Mangrove menjadi Lahan Tambak di Kabupaten Pangkajene Kepulauan Propinsi Sulawesi Selatan. *Eksos* **2012,***8* (2), 90-104.
29. Sribianti, I., Valuasi Ekonomi Hutan Mangrove: Studi Kasus Valuasi Ekonomi Kawasan Hutan Mangrove Malili Kabupaten Luwu Timur *Jurnal Sains & Teknologi* **2008,***8* (3), 186-192.
30. Hong, P. N., Impact of Shrimp Culture Extension on Environmental and Biodiversity resources in Marsh of Coastal Zone. *Journal of Fisheries* . **1995,***3*, 6-9 and 25.
31. Sathirathai, S.; Barbier, E. B., Valuing Mangrove Conservation in Southern Thailand. *Contemporary Economic Policy* **2001,***19* (2), 109-122.
32. Harahab, N., *Penilaian Ekonomi Ekosistem Hutan Mangrove dan Aplikasinya dalam Perencanaan Wilayah Pesisir*. Graha Ilmu Publisher: Yogyakarta, Indonesia, 2010.
33. Lan, T. D., Coastal aquaculture and shrimp farming in North Vietnam and environmental cost estimation. *Aquatic Ecosystem Health & Management* **2009,***12* (3), 235-242.
34. Setyawan, A. D.; Winarno, K., Pemanfaatan Langsung Ekosistem Mangrove di Jawa Tengah danPenggunaan Lahan di Sekitarnya; Kerusakan dan Upaya Restorasinya. *Biodiversitas* **2006,***7* (3), 282-291.
35. Ong, J. E.; Gong, W. K., *Structure, Function and Management of Mangrove Ecosystems* International Society for Mangrove Ecosystems (ISME) Okinawa, Japan, and International Tropical Timber Organization (ITTO Yokohama, Japan.: 2013.
36. Mazda, Y.; Magi, M.; Kogo, M.; Hong, P. N., Mangroves as a coastal protection from waves in the Tong King delta, Vietnam. *Mangroves and Salt Marshes* **1997,***1* (2), 127-135.

37. Hajramurni, A. Abrasion speed in Takalar hits 100 meters a year. http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html (accessed March 13, 2013).
38. Halim, A. Kerusakan Mangrove Memiskinkan Warga. http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga (accessed March 13, 2013).
39. Pirzanet, A. M.; Gunarto; Daud, R.; Utoyo; Kabangnga, N. *Pemantapan Budidaya Kepiting Bakau untuk Mengantisipasi Dampak Penangkapan di perairan Sungai Lamuru, Kabupaten Bone*; Balai Penelitian Perikanan Pantai: Maros, Indonesia, 1999.
40. Gunarto, Konservasi mangrove sebagai pendukung sumberdaya hayati perikanan pantai *Jurnal Litbang Pertanian* **2004,***23* (1).
41. Sasekumar, A.; Chong, V. C.; Leh, M. U.; D'Cruz, R., Mangroves as a Habitat for Fish and Prawns. *Hyrobiologia* **1992,***247*, 195-207.
42. Asbar. Optimalisasi Pemanfaatan Kawasan Pesisir untuk Pengembangan Budidaya Tambak Berkelanjutan di KabupatenSinjai, Sulawesi Selatan. Dissertation, Bogor Agricultural University, Bogor, Indonesia, 2007.
43. Hussain, S. A.; Badola, R., Valuing mangrove ecosystem services: linking nutrient retention function of mangrove forests to enhanced agroecosystem production. *Wetlands Ecology and Management* **2008,***16* (6), 441-450.
44. Prakash, M.; Sivakumar, T., A study on antibacterial activity of mangrove plant Excoecaria agallocha L. *International Journal of Current Microbiology and Applied Sciences* **2013,** *2* (8), 260-262.
45. Bandaranayake, W. M., Traditional and medicinal uses of mangroves. *Mangroves and Salt Marshes* **1998,***2*, 133-148.
46. Frost, R., Dwindling Indian Sundarban Mangrove: The Way Out. *Science and Culture* **2010,***76* (7–8), 275-282.
47. Jusoff, K.; Taha, D., Managing Sustainable Mangrove Forests in Peninsular Malaysia. *Journal of Sustainable Development* **2008,***1* (1).
48. Purnomo, A., *Pemilihan Lokasi Tambak Udang Berwawasan Lingkungan*. Pusat Penelitian dan Pengembangan Perikanan: Jakarta, Indonesia, 1992; p 40.
49. MAP-Indonesia *Kajian Risilian (Situational and contextual field assessment and analysis-Restoring Coastal Livelihood Project)*; Mangrove Action Project (MAP) Indonesia: Sulawesi Selatan, Indonesia, 2011.
50. Sigit, R. R. Ekonomi Lingkungan: Pilih Mangrove atau Tambak. http://www.mongabay.co.id/2013/10/25/ekonomi-lingkungan-pilih-mangrove-atau-tambak/ (accessed January 5, 2013).

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Re: [Forests] Manuscript ID: forests-91071 - Major Revisions

nathan.li@mdpi.com

Wed 7/22/2015 2:34 AM

Inbox

To: Abdul Malik <jwp495@alumni.ku.dk>;

Cc: Forests Editorial Office <forests@mdpi.com>;

Dear Dr. Malik,

Thank you very much for your email.
We gladly extend the due time to 3 week later. Please kindly upload
your revised version as soon as it is ready.

If you have any questions, please fell free to let me know.

Kind regards,
Nathan Li
Assistant Editor
E-mail: nathan.li@mdpi.com

On 2015/7/21 19:08, Abdul Malik wrote:
> Dear Nathan Li Assistant Editor
>
> Thanks for your information that our manuscript has been reviewed and
> also thank to the reviewers for their excellent comments. We will
> revise the manuscript according to the reviewer's comments. However,
> if possible we need more than 2 weeks for the revision, because
> currently my co-authors in their summer holiday, so it certainly
> difficult to discuss. They will be back to the office on 3 and 10
> Aug, respectively.
>
>
> Kind regards, Abdul Malik
>
> ____ From: nathan.li@mdpi.com
> [nathan.li@mdpi.com] Sent: Tuesday, July 21, 2015 3:50 AM To: Abdul
> Malik Cc: Rasmus Fensholt; Ole Mertz; Forests Editorial Office
> Subject: [Forests] Manuscript ID: forests-91071 - Major Revisions
>
> Dear Dr. Malik,
>
> Thank you for submitting the following manuscript to Forests:
>
> Manuscript ID: forests-91071 Type of manuscript: Article Title:
> Economic Valuation of Mangroves for Comparison with Commercial
> Shrimp Farming in South Sulawesi Authors: Abdul Malik *, Rasmus
> Fensholt, Ole Mertz Received: 20 June 2015 E-mails: malik@ign.ku.dk,
> rf@ign.ku.dk, om@ign.ku.dk
>
>
> It has been reviewed by experts in the field and we request that you
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> Do not hesitate to contact us if you have any questions regarding
> the revision of your manuscript. We look forward to hearing from you
> soon.
>
> Kind regards, Nathan Li Assistant Editor E-mail: nathan.li@mdpi.com
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Re: [Forests] Manuscript ID: forests-91071 - Major Revisions

nathan.li@mdpi.com

Tue 8/11/2015 4:40 AM

Inbox

To: Abdul Malik <jwp495@alumni.ku.dk>;

Cc: Rasmus Fensholt <rf@ign.ku.dk>; Ole Mertz <om@ign.ku.dk>; Forests Editorial Office <forests@mdpi.com>;

Dear Dr. Malik,

Greetings! Just a gentle reminder for your revision. Hope you will able to resubmit the revised version within 1-2 days to process your manuscript as soon as possible.

If you have difficulties or any other questions during the revision, please feel free to let us know. We would like to ask you for the approximate date for your submission. Thank you in advance for your understanding.

Kind regards,

Nathan Li
Assistant Editor
E-mail: nathan.li@mdpi.com

On 2015/7/21 9:50, Qinglin Li wrote:
> Dear Dr. Malik,
>
> Thank you for submitting the following manuscript to Forests:
>
> Manuscript ID: forests-91071 Type of manuscript: Article Title:
> Economic Valuation of Mangroves for Comparison with Commercial
> Shrimp Farming in South Sulawesi Authors: Abdul Malik *, Rasmus
> Fensholt, Ole Mertz Received: 20 June 2015 E-mails: malik@ign.ku.dk,
> rf@ign.ku.dk, om@ign.ku.dk
>
>
> It has been reviewed by experts in the field and we request that you
> make major revisions before it is processed further. Please find your
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> Please revise the manuscript according to the reviewers' comments and
> upload the revised file within *two weeks*. Use the version of your
> manuscript found at the above link for your revisions, as the
> editorial office may have made formatting changes to your original
> submission. Any revisions should be *clearly highlighted*, for
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> the revisions in the manuscript and your responses to the reviewers'
> comments. Please include in your rebuttal if you found it impossible
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> Do not hesitate to contact us if you have any questions regarding
> the revision of your manuscript. We look forward to hearing from you
> soon.
>
> Kind regards, Nathan Li Assistant Editor E-mail: nathan.li@mdpi.com
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>

We would like thank to the two reviewers for their valuable comments. We found the reviews to be highly constructive and after implementing most of the revisions we feel the paper has improved a great deal.

Reviewer 1:

Major comments:

1. The title and manuscript suggests that this is comparison between shrimp farming and mangrove forests. However, on line 327-331 it turns out that only 12 out of 23 ponds produce shrimp. In the meantime you treat them as an average.
   Response:
   Thanks this is correct and we have changed the title to "Economic Valuation of Mangroves for Comparison with Commercial Aquaculture in South Sulawesi". We have used the term aquaculture instead of shrimp farming throughout the revised version of the manuscript.

2. While you treat a diverse set of farms as averages, you fail to acknowledge uncertainties and variability in data. Likewise for your monetary values for ecosystem services you only cite individual sources, without looking at ranges of numbers. Valuating ecosystem services is highly objective and can therefore result in a wide range of outcomes. Now you simply pick values randomly across papers therefore easily becomes like comparing apples and pears. For instance the Coastline prevention value (CPV) was calculated based on one single figure for the cost of artificial coastline protection, which was based on solely one reference (in Bahasa Indonesia). In the meantime Rönnbäck 1999 write "Estimates of the annual market value of capture fisheries supported by mangroves ranges from US$750 to 16 750 per hectare, which illustrates the potential support value of mangroves".
   Response:
   Thank you for pointing out this. We have changed to use a range of number for valuation of mangrove ecosystem service in the revised version. For instance, for the Coastline protection (CPV) value, we used 2 references for the replacement cost and for Carbon sequestration value (CSV), we used 1 reference, however the reported values in the cited work provides a range and variability in data rather than a specific number (See line 190 - 195 and 200).

3. As for your own selection of you have limited yourself to four different services. However, you miss out on some ecosystem services that are strongly linked to mangrove forests, such as carbon sequestration. Moreover, you never motivate your selection of ecosystem services.
   Response:
   Yes, reviewer is right about this. We have revised accordingly and included carbon sequestration services as part of the analysis (see line 174)

4. Some values seem counter-productive or double counting. For example, the supply of nutrients from mangroves to seaweed farming. I don't see the link here and I don't understand why mangroves would provide nutrients when they are nutrient sinks? Moreover, mangrove litter is greatly different from inorganic fertilizers.
   Response:
   Thanks, reviewer is right about this. This service did involve double counting with respect to forestry product value (firewood, charcoal production and Nypa) since the N & P sink in mangrove will be transformed to wood and Nypa and would therefore not use cost of organic fertilizer as a replacement cost to this service. Consequently, we have revised the

manuscript accordingly by ignoring this mangrove service and implemented other suggested services (carbon sequestration).

5. Key references missing:
   Rönnbäck et al. 1999 The ecological basis for economic value of seafood production supported by mangrove ecosystems
   Barbier et al. 2008 Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values
   Response:
   Thanks for pointing towards these highly relevant references which are now included in the revised manuscript. (line 64, 336, and 438).

Minor comments:

1. How representative is the study area for South Sulawesi – title suitable
   Response:

   The selected study area is considered as representing one of the hot spots of mangrove rich area in South Sulawesi at the same time being under pressure mainly from aquaculture development (the study area has become one of the largest producers of aquaculture products in South Sulawesi). Consequently, more than half of the total mangrove in this area has undergone deforestation and degradation due to conversion into aquaculture.

   We have now added some info on that in the revised manus. (line 118-120)

2. Lack of references in several places
   Response:
   Thanks, we have added some key references as mentioned above. For instance, see line 64, 44 and 438.

3. Value of shrimp lower than for both milkfish and Gracillaria – how was this considered in the calculations (if it was…)?
   Response:

Below is a calculation of the benefit values as given in the manus

<u>Shrimp production</u>

Average of shrimp pond area = 3ha; Total area of shrimp pond = 12 x 3ha = 36 ha
Shrimp harvest per year = 2 times
Production per hectare per year = 211 kg x 2 = 422 kg/ha/yr
Total production of shrimp pond per year = 36 x 422 = 15,192 kg
Total production of per harvest = 15,192/ 2 = 7600 kg.
Price of shrimp per kg = IDR 55,000 (USD 5.79)
Total shrimp benefit value per year = 15,192 x 55,000 = IDR 835,560,000 (USD 87,954)

<u>Milkfish production:</u>

Average of pond area = 3ha
Total area of pond = 3 x 3ha = 9 ha
Milkfish harvest per year = 2 times
Production per hectare per year = 3,350 kg x 2 = 6,700 kg/ha/yr
Total production of milkfish per year = 9 x 6700 = 60,300 kg/yr

Total production per harvest = 60,300 / 2 = 31,150 kg
Price of milkfish per kg = IDR 15,000 (USD 1.58)
Total milkfish benefit value per year = 60,300 x 15,000 = IDR 904,500,000 (USD 95,210)

Seaweed production (Gracilaria):
Average of pond area = 3ha
Total area of pond = 8 x 3ha = 24 ha
Seaweed harvest per year = 2 times
Production per hectare per year = 1,431 kg x 2 = 2,862 kg/ha/yr
Total production of seaweed per year = 24 x 2862 = 68,700 kg/yr
Total production per harvest = 68,700 / 2 = 34,350 kg
Price of seaweed per kg = IDR 4000 (USD 0.42)
Total seaweed benefit value per year = 34,350 x 4,000 = IDR 1,374,000,000 (USD 144,632)

4. L206: how did they use mangrove for fish capture? As fishing grounds?
   Response:
   Yes, and they are still using traditional fishing gear such as fishing rods, fishing nets, fish/crab traps and scoop. Annually, fish capture is conducted during 8 months (February-September), when sea conditions are good, whereas the remaining 4 months (October – January; when there are high waves and winds), are used to rest, repair boats and fishing gear or engage in alternative work.

   We have added this paragraph to the revised version of the manus (line 267-271).

5. L238: …to a decrease in fish…
   Response:
   Thanks, we have rephrased that sentence (line 304).

6. L251: Please write out references. Pirzanet et al. (1999) and Gunarto et al (2004).
   Response:
   We have changes accordingly throughout the revised manuscript.

7. L327: Please delete an "of"
   Response:
   Thanks, done.

We would like to the two reviewers for their valuable comments. We found the reviews to be highly constructive and after implementing most of the revisions we feel the paper has improved a great deal.

Reviewer 2:

- Many aspects of methods used are not mentioned in the Method chapter; e.g. the household surveys (line 206), the method of extrapolation from survey data to total and per ha benefits (survey 23 * 3 ha; total area close to 2600 ha of ponds); the environmental cost of shrimp ponds (line 348 to).

  Response:

  Thanks for pointing this out. We have revised the manuscript according to this and mentioned these aspects in the amended methods chapter.

  For the household survey, see line 150 – 161

  For the method of extrapolation from survey data to total per ha benefits, see line 206;

  The environmental cost of shrimp and forest rehabilitation, see line 256.

Moreover, at least four aspects of the method are highly questionable:

1. The N and P captured by mangrove will be transformed to wood, Nypah etcetera, and can be marketed as e.g. nypah craft and timber which are the final use value. Mangroves have a value as converter of waste from e.g. shrimp ponds, i.e. mangrove reduces pollution in case of excess nutrients. But I would not value this as fertilizer (line 158) because this N and P are not extracted as a product. Please use other TEV studies to identify a better method.

   Response:

   Yes, reviewer is right about this (as also pointed out by reviewer #1). So, to avoid double counting as calculated on DUV mangrove (forestry products) we have removed that part from the calculation. Furthermore (as also suggested by other reviewer) we have addressed another mangrove service (carbon sequestration) to be included in the revised calculations. See line 183-185.

2. The replacement value of nursery by construction (and management) of ponds (line 156) because for many species of shrimp, crab, bivalves and fish the nursery is not yet possible. Moreover the method misses the foregone benefit from fishery, which I would suggest to use.

   Response:

   Reviewer is right; so we have changed and applied the valuation method of nursery to the forgone benefit from fishery (line 179 – 182).

3. It is not clear how the assumptions (line 173 & 184) are related to the survey data. Regarding the forest: age of the present forest and duration of exploitation by the population should be considered.

Response:
As for the comment related to line 173:
Thanks, as suggested by reviewer we have revised the assumptions and used the cost and benefit values of each products and services over a 10-year project period considering the age of present mangrove and duration of exploitation. See line 231 – 236.

As for the comment related to line 184:
This assumption is based on the fact that even though shrimp farming in this area is feasible as financial means, it does charge external costs such as environmental cost (water pollution cost) related to the high salinity content water released from the ponds and agrochemical runoff and forest rehabilitation cost for land degradation. Thus, this analysis requires also including the NPV of external cost. The value of environmental cost was adopted from Lan (2009) and the forest rehabilitation was estimated from the cost of seed provision, planting and maintenance costs (Harahab, 2010). The forest rehabilitation cost was estimated from year 6 to year 10 since many of shrimp farms are abandoned after 5 years. These issues have been addressed in the revised version line 219 – 230.

4. Regarding the assumption on line 184-18xx: if the farms are already older than the 5 years, one may assume their production level is already low; however if they manage well their ponds the production will not decline. And if they indeed harvest 7600 kg /ha/yr, we may assume they manage well their ponds.
Response:
We are grateful for this comment that made us realize that an error in the calculations (related to the units used) was causing this very high number reported.
Shrimp production (7,600 kg) is not per ha/yr, but it is per harvest of 2 times harvests in a year. So shrimp production is 422 kg/ha/yr. See the extrapolation below:

Average of shrimp pond area = 3ha
Total area of shrimp pond = 12 x 3ha = 36 ha
Shrimp harvest per year = 2 times
Production per hectare per year (average value per farmer) = 211 kg x 2 = 422 kg/ha/yr
Total production of shrimp pond per year = 36 x 422 = 15,192 kg/yr
Total production per harvest = 15,192 / 2 = 7600 kg

The farms in this area already older than the 5 years and according to the shrimp production, their production level are already low and they do not manage well their ponds. So this is the reason we used this assumption.

5. Furthermore, reporting of results is not precise: units are often missing or not well specified. The authors don't interpret well the acidification problem (line 357). Please see the annotated pdf
Response:
Thanks also for this valid comment. We have revised the usage of units throughout the manuscript (in particular in the results and the method section). We have also revised how the acidification problem is interpreted (see line 444 – 451)

Annotated pdf for some problems:

- L155: What about forgone benefits from fishing?
  Response:
  Thanks, we have changed accordingly (line 179 – 182)

- L158: Why uses this fertilizer? It is more about the reduction and prevention of pollution
  Response:
  Reviewer is right. So we have changed the calculation by ignoring this one in the revised calculations and included other mangrove service value as suggested above.

- L173-177: Based on what?
  Response:
  Please see our response to reviewer comment number 3 above.

- L206: Not in Method
  Response:
  Thanks, we have mentioned this in revised version of the manuscript line 150 – 161

- L209: does one need mangrove for seaweed farming?
  Response:
  No reviewer is right, mangrove is not deeded as such. We have deleted this formulation. In this area, seaweed farming is another marine-based activity conducted in the coastal area (close to the mangrove areas) and many households engage in this both as single activity and alternative income source.

- L262: Does not seem correct as the value for protection of mangrove further away from the coast would be less.
  Response:
  Thanks, we have revised the manuscript in a way to reflect that comment. We do believe that no universal relation can be pointed out on this. As stated by Sanford (2009) the replacement cost using the breakwater construction cost undoubtedly vary between places/countries, because of difference in currencies, labor cost, market values, and raw material. Thus, replacement cost data should be interpreted for comparative purposes rather than as absolute values.
  Therefore it will be appropriate to report on these numbers as a range of values instead of one fixed value. So, we have changed to use a range of number for valuation of mangrove ecosystem service in the revised version. In relation to the Coastline protection (CPV) value, we have used 2 references (see revised manuscript) for the replacement cost providing such interval/range in values (please see the result in Table 2).

  The range number of coastal protection value used in the revised version is USD 694 to USD 3,768/ha/yr. This range as suggested by the two references above also aligns well with Salem and Mercer (2012) who summarized some studies concerning coastal protection value (USD 39.89 to USD 4,265/ha/yr).

- L276: Not explained in Method (percentage for DUV, IUV and TEV)
  Response:

Thanks, we have explained this in the revised methods section (line 165). We have also deleted percentage for DUV and IUV on Table 1 and 2, except for the TEV of mangrove in Table 4.

- L278: base on what? Please give reference. Direct use for medical treatment may rather be a threat to the mangrove
  Response:
  Reviewer is right; medical treatment may rather be a threat to the mangrove, but it is also potentially a pharmaceutical resource. We have revised the sentence and added a reference, see line 362.

- L320: Integrate to introduction; has no sense here.
  Response:
  Thanks, we have now deleted this paragraph

- L332: How was this extrapolated?
  Response:
  This we have explained in the method, line 206

- L333-336: How calculated
  Response:
  This we have explained in the method, line 206

- L337: per ha or per ??
  Response:
  This is per harvest (now specified in the revised manuscript). See the extrapolation below:

  <u>Milkfish production:</u>
  Average of pond area = 3ha
  Total area of pond = 3 x 3ha = 9 ha
  Milkfish harvest per year = 2 times
  Production per hectare per year = 3,350 kg x 2 = 6,700 kg/ha/yr
  Total production of milkfish per year = 9 x 6700 = 60,300 kg/yr
  Total production per harvest = 60,300 / 2 = 31,150 kg

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  Average of pond area = 3ha
  Total area of pond = 8 x 3ha = 24 ha
  Seaweed harvest per year = 2 times
  Production per hectare per year = 1,431 kg x 2 = 2,862 kg/ha/yr
  Total production of milkfish per year = 24 x 2862 = 68,700 kg/yr
  Total production per harvest = 68,700 / 2 = 34,350 kg

- L343: new paragraph
  Response:
  Thanks, done

- L349-351: Not in method

Response:
We have now mentioned this in methods section.

- L352: It = what?
  Response:
  “It” referred to the level shrimp production in Indonesia. We have revised the sentence for increased readability.

- L357: is one of the causes for declining yield; this is not due to abandoning but to the lack of frequent water exchange (flooding and draining)
  Response:
  Reviewer is right. The revised sentence now reads: “Abandoned shrimp ponds are exposed to abrasion and transforms into wastelands of limited value for other productive use such as agriculture due to very acidic and poor soil quality” (line xx – xx).

Forests **2015**, *6*, 1-xmanuscripts; doi:10.3390/f60x000x

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Article

Economic Valuation of Mangroves for Comparison with Commercial ~~Shrimp Farming~~Aquaculture ~~Pond~~ in South Sulawesi

Abdul Malik[1,2,*], Rasmus Fensholt[2] and Ole Mertz[2]

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Academic Editor:

Received:/Accepted:/Published:

Abstract: Mangroves are recognized as a provider of a variety of products and essential ecosystem services that contribute significantly to the livelihood of local communities. However, over the past decades, mangroves in many tropical areas including the Takalar district, South Sulawesi have degraded and decreased mainly due to conversion to shrimp ponds. Currently, little is known about the economic benefits of commercialization of shrimp ponds as compared to those derived from mangroves in the form of products and services. Here, we estimate the Total Economic Value (TEV) of mangrove benefits in order to compare it with the benefit value of commercial ~~shrimp~~ aquaculture ~~ponds~~. Market prices, replacement costs, benefit transfer value and Cost-Benefit Analyses (CBA) have been used for value determination and comparison. The results show that the per year TEV of mangroves during the study period was IDR 41,501,241,298 – 100,666,954,298 (USD 4,368,582 – 10,596,552) or IDR 38,165,377 – 72,584,058 (USD 4,018 – 7,641) ~~41,464,146,576 (USD 4,364,647) or IDR 24,121,086 (USD 2,539)~~ per hectare, (the highest value contribution derived from the indirect use value (~~91~~94%)), whereas the commercial ~~shrimp~~ aquaculture ~~ponds~~ had a net benefit value of IDR 2,163,910,500 (USD 227,780) or IDR 31,361,022 (USD 3,301) ~~IDR 1,373,250,500 (USD 144,553) or IDR 19,902,181 (USD 2,095)~~ per hectare. In addition, the comparison of Net Present Value (NPV) between the benefit value of mangroves and that of commercial ~~shrimp ponds~~aquaculture revealed that conversion of mangroves into commercial ~~shrimp~~ aquaculture ~~ponds~~ was not economically beneficial when the analysis was expanded to cover the costs of environmental and forest rehabilitation.

Keywords: Economic valuation; mangroves; commercial shrimp farming; Indonesia; South Sulawesi.

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1. Introduction

One of the crucial issues in development based on the use of natural resources is how to integrate economic development on the one hand with natural resources and environmental sustainability on the other in order to mitigate negative impacts and problems in future [1]. In principle, development should take place by utilizing the natural resources optimally [2]. In many countries, development is considered inevitable as a way to improve the welfare of communities. Unfortunately, failure to take into account the costs and benefits of the use of natural resources, which leads to negligence in decision-making, is still common and currently, we are facing an increasing scarcity of the resources necessary to support local livelihoods [3].

Mangroves, which are considered an important natural resource, occupy coastal and estuarine areas in many tropical places, provide goods and services for both direct use (e.g. timber, firewood, charcoal, Nypa palm leaves for crafting, wood chips, fisheries, food, medicines, material construction and tourism and recreational areas) and indirect use (e.g. coastline protection, prevention of seawater intrusion, provision of nursery and breeding grounds for fish, supply of nutrients for marine life, biodiversity maintenance and carbon sequestration) that have contributed significantly to community livelihoods [4].

Although mangroves provide a variety of products and services, they have been under great pressure due to decision making commonly based on assumptions of larger net benefits without considering the loss of wider mangrove services [5] and natural capital stocks [6]. Mangrove products and services are often undervalued [7,8] or even ignored in the economy and by industry and local inhabitants [9]. Consequently, nearly half of the total mangrove areas in the world have been lost over the past decades, with the largest areas of decline in Asia [10,11,12]. In Indonesia (which has the largest mangrove areas in the world), mangroves are threatened primarily by aquaculture but also by overharvesting of timber, firewood collection, charcoal production and conversion to other land uses such as agriculture, urbanization, mining and salt ponds [12,13,14,15]. Mangrove areas are characterized by some of the most rapid loss rates of coastal ecosystems in Indonesia; from 1980 to 2003, at least 1.1 million hectares of mangrove were lost, with 75 % of these areas being converted to shrimp ponds [12,16]. High economic revenues from the increase in exports and foreign trade in shrimp have become the main driving forces for the expansion of shrimp ponds by clearing mangroves [14]. In 2012, for instance, shrimp exports from Indonesia were valued at USD 1,304,149,000, of which 38 percent went to the United States of America (USA), 29 percent to Japan, 9 percent to European countries and 24 percent to other countries [17]. In South Sulawesi, the value of shrimp exports in 2011 reached USD 42,407,000 [15]. Since the early 1990s, Indonesia has become one of the major shrimp producing and exporting countries in the world [18]. However, the expansion of shrimp export which mostly comes from aquaculture production has triggered a heated debate in Indonesia as well as in other exporting countries such as Thailand due to the significant consequences for coastal areas [19,20].

Evaluation of the value of mangrove products and services affected by shrimp pond expansion is therefore important as a vehicle to integrate both ecological perspectives and economic considerations [21]. Such an evaluation will support reliable instruments that can be used to shift focus towards a green economy and guide policy makers to make sustainable decisions about mangrove utilization [4,2,22]. In addition, it is ~~away~~ one way to increase knowledge and awareness among stakeholders of the importance of the mangrove ecosystem for sustainable and environmentally friendly economic development [23].

Economic valuations of mangroves have been conducted in many areas of the world [9]. However, little attention has been paid in the scientific literature to an economic valuation of mangroves in areas threatened by commercial ~~shrimp farming~~aquaculture ~~pond~~ development in Indonesia and other Asian countries and to the discussion of the economic benefits of ~~shrimp farming~~aquaculture ~~pond~~ as compared to mangroves as a provider of a variety of products and environmental services. This paper aims to estimate the TEV of mangrove, including estimations of Direct Use Value (DUV), Indirect Use Value (IUV) and Option Value (OV), to enable a direct comparison with the benefit value of commercial ~~shrimp farming~~aquaculture ~~pond~~ for a case study area in southern South Sulawesi, Indonesia using the CBA method. Given the threat of aquaculture expansion, information from such analyses is critical as the net benefit value generated from mangroves is currently not considered by policy makers dealing with sustainable management of mangroves.

2. Study Area

Takalar district is located in southern South Sulawesi, Indonesia (between latitude 5°12’ - 5°38’ and longitude 119°10’- 119°39’, see figure 1), 45 km from Makassar city (the capital of South Sulawesi). The district has a coastline of 74 km [24], occupied by mangroves, coral reefs, sea grass, sandy beaches, rocky beaches, estuaries, aquaculture ponds, rice fields and tourism and residential areas. Most areas of Takalar are plain and coastal areas (including small islands) with an altitude of 0 - 100 metres above sea level and the rest are hilly areas [25]. The district covers 566.51 km^2 and is divided into nine sub districts (Galesong, South Galesong, North Galesong, Mangarabombang, Mappakasunggu, Pattalassang, South Polongbangkeng, North Polongbangkeng and Sanrobone). Mappakasunggu consists of a mainland part and small islands

(Tanakeke, Lantangpeo, Bauluang, Satangnga and Dayang Dayang). The population is 272,316 and the population density is 481 persons per km^2. Mean temperatures vary from 23˚C - 33˚C and the monthly precipitation average over the past eight years (2004 – 2011) has been between 174 mm and 712 mm; the greatest amount of precipitation occurred in 2008 from November to March [26].

The selected study area ~~is considered as~~ represents one of the hot spots of mangrove rich environments in Indonesia~~in South Sulawesi where~~. However, the region is characterised by ~~-~~being amongst the largest producers of aquaculture product in South Sulawesi [27]~~under pressure mainly from aquaculture development. Thus, the study area becomes one of the most producers of aquaculture product in South Sulawesi [27]. However,~~ and i~~I~~n past decades, mangroves in this area have degraded and decreased mainly due to conversion to aquaculture~~ ponds~~. About 2,593 hectares (77.4%) of the total mangrove forest area has been changed to aquaculture, mainly on Tanakeke Island and in Banyuanyara village. Currently, the total extent of intact mangrove forest is 1,719 hectares and covers the sub districts of Mappakasunggu, Mangarabombang, Pattallassang, Sanrobone, Galesong, South Galesong and North Galesong [15]. Mangroves in this region are dominated by saplings and seedlings and comprise 10 species (*Avicennia alba*, *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Excoecaria agallocha*, *Lumnitzera racemosa*, *Nypa fruticans*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhizophora stylosa* and *Sonneratia alba*). The most dominant species has been *Rhizophora mucronata*, followed by *Sonneratia alba*. The Diameter at Breast High (DBH) of mangrove trees is between 6.37 cm and 23.57 cm and the diameter size classes of 10-15 cm are dominant, followed by 15-20 cm [28].

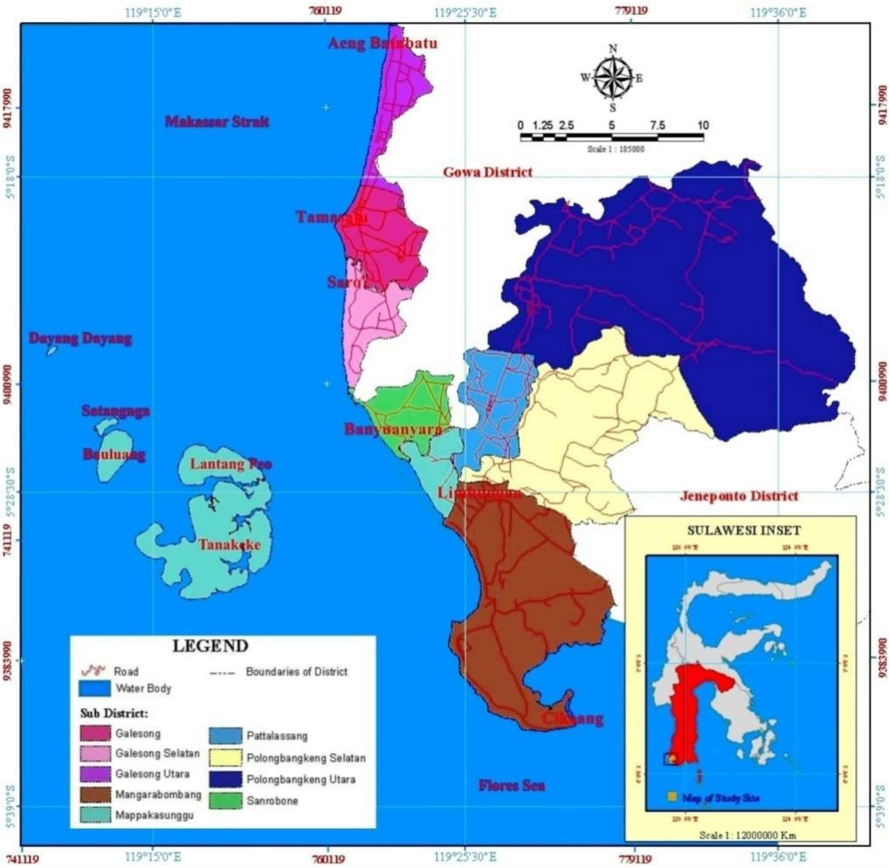

Figure 1. Map of the Takalar District Study Area, South Sulawesi, Indonesia

3. Materials and Methods

3.1. Data Collection

Households Surveys

Data on direct use of mangrove products and aquaculture were produce from household surveys by us~~ing~~e of questionnaires. 93 households were ~~administrated, who were~~ selected by a Purposive Sampling method [29]~~. These~~ and all households ~~all~~ had a direct relation to, and dependence on mangrove forests ~~, such as~~ (fishermen, shrimp farmers, firewood collectors, charcoal producers and Nypa palm crafters). Th~~is~~e survey ~~is~~was conducted in ~~ten~~10 areas covering the islands of Lantangpeo, Tanakeke, Bauluang and Satanga (sub-district of Mappakasunggu), and the villages of Laikang (sub-district of Mangarabombang), Limbungan (sub-district of Pattallassang), Banyuanyara (sub-district of Sanrobone), Sa'ro (sub-district of South Galesong), Tamasaju (sub-district of Galesong) and Aeng Batu-batu (sub-district of North Galesong) (Figure 1). ~~Thus, t~~The areas were selected based on the criteria that mangrove forests should be present and utilized by communities for fishery and forestry production.

3.2. Data Analysis ~~Data~~

3.2.1. Economic Valuation of Mangrove

The TEV of mangroves was calculated from monetary values of the DUV, IUV and OV of mangroves [30,4,31]~~, subsequent the~~and TEV values ~~is~~are reported in percentage. The DUV of mangroves was derived from benefit values of fishery products (fish, crab and shrimp capture~~ as well as seaweed farming~~) and forestry products (firewood collection, charcoal production and Nypa palm crafting), which have been estimated using market prices [4,31] and the following formulas:

- Fish, crab and shrimp capture ~~and seaweed farming~~ values (FV;CV; SV~~; SFV~~)

  FV; CV; SV ~~; SFV~~= Production (~~unit~~kg/yr) x ~~price~~ Price (IDR/kg~~unit~~) – Production cost (IDR) (1)

- Firewood value (FwV)

  FwV= Wood collection (~~unit~~bundle/yr) x ~~price~~ Price (IDR/~~unit~~bundle) – Production cost (IDR) (1 bundle = 100 stems with a length of 1 m and a diameter of 4 ~~cm~~ to 8 cm) (2)

- Charcoal value (CcV)

  CcV = Production (~~unit~~sack/yr) x Price (IDR/sack~~unit~~) – Production cost (IDR) (1 sack = 25kg) (3)

- Nypa palm crafting value (NpcV)

  NpcV= Production (~~Unit~~piece/yr) x Price (IDR/~~unit~~piece) – Production cost (IDR) (4)

The IUV of mangroves is derived from benefit values of mangrove services such as coastline protection, seawater intrusion prevention, provision of nursery grounds and carbon sequestration~~supply of nutrients for marine organisms~~. These benefit values were estimated using replacement costs and benefit transfer methods ~~-~~[4,31]. The coastline protection service was estimated by the cost of breakwater construction over a 10-year project lifespan; the seawater intrusion prevention service was assessed by the cost of the water supply needs of people if the availability of fresh water was reduced due to mangrove loss; the provision of nursery grounds service was estimated by foregone benefit from fishery according to the KKP-Indonesia (Ministry of Marine and Fisheries of Indonesia) [32], who ~~was~~ reported the average loss volume of fish catch in South Sulawesi include Takalar district of 1,211 tons per year during the period 2003-2011. ~~the construction cost of ponds for nursery groundsfor shrimp or fish.~~ Finally, ~~the~~ carbon sequestration was estimated by using transferring rates of carbon storage of mangrove (100-200 tons C/ha) from Ong [33]. The price of carbon credits (USD 5.5/tCO_2) is based on Diaz et al. [34]~~the supply of nutrients service was assessed by the value of nutrient production (nitrogen and phosphate) from mangrove litter converted to the fertilizer market price of Urea ($(NH_2)_2CO$) and SP-36 (Superphosphate, 36 percent P2O5),~~. Calculation of IUV is conducted using the following formulas:

- Coastline prevention value (CPV)

$$CPV = \text{~~Coastal~~ coastal length (m)} \times \text{~~Cost~~ cost of breakwater construction (IDR)} \quad (5)$$

Coastal length = 74,000 m; The c~~C~~ost of breakwater construction has been reported to range between ~~with specification of length (1m), width (11m) and height (2.5m) =~~ IDR 1,530,880/m^3 (USD 158/m^3) [35] ~~according to South Sulawesi's Public Work Agency~~ and~~.~~ IDR 8,312,500/m^3 (USD 875/m^3) [36] ~~according to Thailand's Harbour Department of the Ministry of Communications and Transport~~.

- Seawater intrusion prevention value~~-~~ (SwIPV)

$$SwIPV = \text{household population} \times \text{number of water supply (gallon/day)} \times \text{Price (IDR/gallon)} \times 365 \text{ days} \quad (6)$$

- Provision of nursery grounds value (PNGV)

$$PNGV = \text{~~Total of mangrove area~~ loss volume of fish catch (kg~~Ha~~/yr)} \times \text{fish price (IDR/kg)} / \text{total loss of mangrove area during period 2003-2011 (612 ha) from Malik et al. [15]} \text{~~Construction cost of the pond (IDR/Ha)~~} \quad (7)$$

- ~~Supply of nutrients value (SNV)~~

~~SNV = Organic material Nitrogen and Phosphate (Kg/Ha/yr) x Total area of mangrove (Ha) x Price of Urea & SP-36 fertilizers (IDR/kg)~~ ~~(8)~~

- Carbon sequestration value (CSV)

$$CSV = \text{carbon sequestration rate (100 - 200 ton C/ha)} \times \text{total area of mangrove (1,719 ha)} \times \text{price of carbon market (USD 5.5/ton } CO_2) \quad (8)$$

The OV of mangroves was calculated using the benefit transfer value method [4,31,23]. The benefit values of medicinal material from mangrove ecosystems was estimated by transferring the available value from Sribianti [37], who studied in East Luwu district, Indonesia. The annual benefit was IDR 1,500,000 (USD 157) per hectare [37].

3.2.2. Commercial ~~of~~ Aquaculture ~~Pond~~

The economic value of ~~shrimp~~ aquaculture ~~ponds~~ (A~~S~~~~p~~V) was calculated using the formulas:

Total area of aquaculture ~~ponds~~ (ha) = number of farmers (23 farmers) x area of aquculture ~~pond~~ per farmer (3 ha) (9)

Investment cost = cost construction (IDR/ha) + farming equipment (IDR/unit) x total area of aquaculture ~~pond~~ (ha) (10)

Production cost = fixed cost (e.g. equipment depreciation) (IDR/unit) + variable cost (fry, feed, fertilizer, fuel, etc) (IDR/unit) x total area of aquaculture ~~pond~~ (ha) (11)

Benefit of A~~p~~V = production (kg/ha/yr) x price (IDR/kg) x total area of aquaculture ~~pond~~ (ha) (12)

Net Benefit of A~~p~~V = benefit of A~~p~~V (IDR/yr) – (investment cost + production cost) (IDR/yr) (13)

Net benefit/ha/yr of A~~p~~V = net benefit of A~~p~~V (IDR/yr) / total area of aquaculture ~~pond~~ (ha)~~SpV = Production (unit/yr) x Price (IDR/unit) – Production cost (IDR)~~ (14)

3.2.3. Cost-Benefit Analysis (CBA)

CBA is conducted to compare economic value of mangrove with commercial aquaculture ~~pond~~, to address whether converting mangrove forest ~~for~~into commercial aquaculture ~~pond~~ is economically feasible ~~as financial~~. ~~To facilicate,~~ CBA is used to determin~~inge~~ the NPV of internal costs and benefits of commercial aquaculture ~~pond~~. Based on Malik et al. [15], the project life of aquaculture ~~pond~~ ~~is~~was found to be ~~normally~~ five years on average in this area. ~~The NPV of mangroves and commercial shrimp ponds was estimated using CBA with the following assumptions:~~

~~The benefit value of fisheries and forestry, medicines and mangrove services over a 10-year project period will decrease 5% – 20% (the decrease will begin in the second year of the project) with a subsequent decrease in mangrove ecosystem functions that provide products and services due to the expansion of shrimp ponds. In contrast, the costs of production will increase by 2% - 20% during such a project period.~~

Several studies (e.g. [38,4,36,39]) have observed that shrimp production decreases successively after the fifth year due to the lower survival rate of shrimp. Hence, the production of shrimp over a 10-year project period also decreases by 5 – 20% and investment and production costs increase to sustain shrimp production [39]. ~~–~~ However, aquaculture ~~ponds~~ ~~charges~~involves external costs including environmental cost (water pollution cost) ~~which~~ related to the high salinity content of the water released from the ponds, ~~and~~ agrochemical runoff and forest rehabilitation cost for land degradation [36]. Thus, CBA is required to ~~extend including~~including also the NPV of external cost. The value of environmental cost was adopted from Lan [40], who reported that the production of 360,000 tons of shrimps generates an environmental cost of USD 280 million (1 kg shrimp produced = USD 1.28), whereas the forest rehabilitation cost was estimated from seed provision, planting and maintenance costs [39]. The forest rehabilitation cost was estimated from year 6 to year 10.

Furthermore, CBA is required to determine the NPV of mangroves from fishery and forestry, medicines and mangrove services over a 10-year project period using the cost and benefit values of each products and services ~~with consider to the~~based on an average age of the present mangrove (17 years) [28] and duration of exploitation of mangrove by local communities. Whereas ~~T~~the exploitation of mangrove for fishery and forestry products ~~is~~has been ongoing ~~occurred in~~during past several decades~~. However~~, the most intensive exploitation ~~is conducted~~has occured over the past 20 years [15].

A discount rate of 10% was used in the CBA reflecting the predominant cost of the loan interest rate ~~prevailing~~ at financial institutions ~~such as banks~~ when the survey was conducted [41;39].

~~In accordance with the loan interest rate prevailing at financial institutions such as banks when the survey was conducted, a discount rate of 10% was used in the CBA.~~

~~The environmental cost (water pollution cost) of shrimp ponds was adopted from Lan , who reported that the production of 360,000 tons of shrimp generates an environmental cost of USD 280 million (1 kg shrimp produced = USD 1.28), whereas the forest rehabilitation cost was estimated from seed provision, planting and maintenance costs. The forest rehabilitation cost was estimated from year 6 to year 10 (assuming normal shrimp pond production during the first 5 years).~~ The formula for calculating the NPV is as follows: [31]

$$NPV = \sum_{i=1}^{n} \frac{Bit - Cit}{(1+r)^t} \quad \text{(Ordinary CBA)}$$

$$NPV = \sum_{i=1}^{n} \frac{(Bit + EBit) - (Cit - ECit)}{(1+r)^t} \quad \text{(Extended CBA)} \qquad (~~10~~15)$$

Where:

NPV = Net Present Value

B = annual gross benefit; EB = annual extended benefit

C = annual gross cost; EC = annual extended cost

r = discount rate

i = each benefit or cost

t = period of time

Criteria: NPV > 0: financially feasible; NPV = 0: impasse; and NPV <0: not financially feasible.

Environmental cost of shrimp ponds = shrimp production (kg/ha/yr) x USD 1.28 x total area of shrimp ponds (ha) (16)

Forest rehabilitation cost = seed provision cost (IDR/ha) + planting cost (IDR/ha) + maintenance cost (IDR/ha) x total area of shrimp ponds (ha) (17)

~~3.~~4. Results and Discussion

~~3.1.~~4.1. DUV of mangroves

In past decades, people who lived around mangroves in this area were highly dependent on mangroves for various fishery and forestry products for domestic and commercial purposes. In fisheries, mangrove forest has benefits for the capture of fish, crab and shrimp as well as ~~shrimp farming~~aquaculture~~ ponds~~, whereas in forestry, benefits ~~connected with~~related to the collection of firewood, charcoal production and Nypa palm leaf crafting are generated.

The results of the household survey showed that 43 households have been directly using mangrove for fish capture, six for crab capture, and six for shrimp capture~~ and seven for seaweed farming~~. They are using ~~a~~ traditional ~~of~~ fishing gear such as fishing rods, fishing nets, fish/crab traps and scoop. Annually, fish capture is conducted during 8 months (February-September), when sea conditions are good, whereas the remaining 4 months (October~~- and~~ January~~),~~; characterized by ~~when there are~~ high waves and strong winds)~~,~~ are used to rest, repair boats and fishing gear or engage in alternative work [15]. Eight households have been using mangrove for harvest firewood, three for charcoal production and four for Nypa palm leaf crafting. The production averages of fish, crab and shrimp capture~~ and seaweed farming (*Eucheuma cottonii*)~~ per household per year are 2,450 kg, 338 kg, and 213 kg~~ and 8,914 kg~~, respectively. The production of firewood, charcoal and handcrafts such as roofs, walls, floor mats, baskets and especially hats from Nypa palm leaves per household per year amounted to 60 bundles~~ (1 bundle = 100 stems with a length of 1 m and a diameter of 4 cm to 8 cm)~~, 720 sacks ~~(1 sack = 25kg)~~ and 6,750 ~~units~~pieces, respectively. The total of fish, crab and shrimp production was 105,350 kg/year, 2,028 kg/year and 1,278 kg/year, respectively~~, whereas seaweed (*Eucheuma cottonii*) production was 62,398 kg per year~~. Harvested mangrove forests for firewood reached 480 bundles per year, charcoal production was 2,160 sacks per year and handcrafting produced 27,000 ~~units~~ pieces per year.

The highest benefit of DUV was obtained from fish production, earning IDR 498,850,000 (USD 52,511) per year, followed by ~~seaweed farming~~charcoal production for IDR ~~327,588,000~~83,685,600 (USD ~~19,402~~8,809) per year. Thus, the total benefit of the DUV of mangrove ecosystem is IDR ~~1,105,209,6~~777,621,600 (USD ~~116,338~~81,855) per year (Table 1).

Table 1. DUV of mangroves

No	Products	House-hold users (n=~~77~~70)	Net use value (IDR/yr)	Net use value/ household (IDR/yr)	Net use value (USD/yr)	Net use value/ household (USD/yr)	Net use value (IDR/~~Ha~~ha/ yr)	Net use value (USD/~~Ha~~ha/ yr)
Fishery products								
1	Fish capture	43	498,850,000	11,601,163	52,511	1,221	290,198	31
2	Crab capture	6	62,040,000	10,340,000	6,531	1,088	36,091	4
3	Shrimp capture	6	26,810,000	4,468,333	2,822	470	15,586	2
~~4~~	~~Seaweed farming (*Eucheuma cottonii*)~~	~~7~~	~~327,588,000~~	~~46,798,286~~	~~34,483~~	~~4,926~~	~~190,569~~	~~20~~
	Sub Total of DUV =		~~915,288~~587,700,000		~~96,346~~61,863		~~532,454~~341,885	~~56~~36

Forestry products								
1	Firewood	8	32,100,000	4,012,500	3,379	422	18,674	2
2	Charcoal	3	83,685,600	27,895,200	8,809	2,936	48,683	5
3	Nypa palm crafting	4	74,136,000	18,534,000	7,804	1,951	43,127	5
	Sub Total DUV =		189,921,600		19,992		110,484	12
	Total of DUV =		~~1,105,209,600~~ 777,621,600		~~116,33~~88 1,855		~~642,938~~45 2,369	~~68~~48

Exchange rate: USD1 = IDR 9,500; Total area of mangrove = 1,719 ~~Ha~~ha

A large number and variety of fish species and other marine species use the mangroves for nursery, spawning and feeding grounds ~~and for migrating to the coral reef areas or offshore~~ [42]. The main fish, shrimp and crab species available for fishery in the mangrove area include small pelagic fish, snapper (*lates calcarifer*), milkfish (*Chanos chanos*), white shrimp (*Pennaeus vannamei*) and mud crab (*Scylla sp*.). ~~In seaweed farms on the seashore (near mangrove areas), cultures of *Eucheuma cottonii* are developed.~~ Furthermore, the harvest of mangroves for home consumption and firewood and charcoal for commercial use are mostly derived from *Rhizophora sp*., whereas leaves of *Nypa fruticans* are used for handcrafts such as hats, floor mats, baskets, roofs and walls.

Even though fish capture is the dominant source of revenue for the local population and the highest generator of net benefit per year (IDR 498,850,000 = USD 52,511), the highest net benefit value per household per year (IDR ~~46,798,286~~27,895,200 = USD ~~4,926~~2,936) is derived from charcoal production~~seaweed farming~~. Over the last decades, clearing mangrove to expand shrimp ponds has been wide spread in this area, causing mangrove areas to decrease and degrade rapidly, which in turn has led to a decrease in fish production and fishermen's income~~. Consequently, seaweed farming has become an alternative livelihood strategy that has proven to be more profitable than fishing~~ [15].

~~3.2.~~4.2. IUV of mangroves

Besides providing a variety of products, mangrove forest supports ecological services by protecting the coastline from exposure to waves, preventing seawater intrusion and providing nursery grounds and ~~supplying nutrients for marine organisms~~carbon sequestration [43]. Mazda et al. [44] stated that the stand of *Kandelia candel* (six years old) can reduce waves with an offshore height of 1 m to 0.05 m when they reach the shore. Hajramurni [45] and Halim [46] revealed that abrasion and seawater intrusion occurred in several places in the region where mangrove is absent. Abrasion was found along the coast in six subdistricts of Takalar district (Mappakasunggu, Mangarabombang, Sanrobone, South Galesong, Galesong and North Galesong), reaching 20-100 metres per year over the past five years. Moreover, seawater intrusion into inland areas has made growth conditions difficult for local crops such as banana. Furthermore, Pirzanet et al. [47] and Gunarto [48] found that 17 commercial fish species inhabit and use mangroves as nursery grounds in Lamuru Estuary, Bone district, South Sulawesi while 27 commercial fish species do so in the Tongke-tongke mangrove forest area and Sinjai district. In

Selangor, Malaysia, Sasekumar et al. [49] noted that many species of fish (119) and prawn (9) inhabit and use mangrove as nursery and feeding grounds. In addition, Ong [33] reported that mangrove ~~above ground~~ could store 100 – 200 ton C/ha above ground, whereas below ground carbon can reach ~~to~~ 700 ton C/1 m soil thickness/ha (with an estimat~~ing~~ed carbon sink rate of 1.5 ton C/ha/yr).

~~In addition, reported that the average production of nitrogen and phosphate of mangrove litter in Sinjai district, South Sulawesi reached 497.98 kg/ha and 22.02 kg/ha, respectively. report the availability of nutrients in the soil of the Bhitarkanika National Park, India to be 2,907 kg/ha (nitrogen) and 28.11 kg/ha (phosphate).~~

In this case study area, the net benefit values of these mangrove services have been estimated using the replacement cost and benefit transfer method. Annual values of prevention of coastline erosion and seawater intrusion provided by mangroves were estimated to be IDR 11,328,512,000 (USD 1,192,475) to 61,512,500,000 (USD 6,475,000) or IDR 6,590,176/ha (USD 694/ha) to 35,783,886 (USD 3,767) ~~per hectare~~ and IDR ~~11,307,700,000~~4,523,080,000 (USD ~~1,190,284~~476,114) or IDR ~~6,578,069~~2,631,227/ha (USD ~~692~~277/ha) ~~per hectare~~, respectively. The value of coastline protection services is dominated ~~of~~by the TEV of mangrove. This finding is similar in Thailand as reported by Barbier et al. [8]. Provision of nursery grounds ~~and supply of nutrient~~ services ~~were~~ was estimated to amount to IDR 13,~~542,282~~326,364,198~~000~~ (USD ~~1,425,503~~1,402,775) or IDR ~~7,878,000~~21,775,105/ha (USD ~~892~~2,292/ha). Furthermore, carbon sequestration service was estimated to ~~per hectare and~~ IDR ~~1,616,554,476~~8,981,775,000 – IDR 17,963,500,000 (USD ~~170,164~~945,450 – USD 1,890,895) or IDR ~~940,404~~5,225,000/ha – IDR 10,449,971/ha (USD ~~99~~550/ha – USD 1,100/ha) ~~per hectare, respectively~~. Thus, annually the aggregate benefit of IUV mangroves was IDR ~~37,795,048,476~~38,159,731,198 – IDR 97,325,444,198 (USD ~~3,978,426~~4,016,814 – USD 10,244,784) or IDR ~~21,986,648~~36,221,508/ha – IDR 70,640,189/ha (USD ~~2,314~~3,813 – USD 7,436/ha) ~~per hectare~~ (Table 2).

Some studies have reported benefit values of such mangrove services and Sathirathai and Barbier [36] estimated the cost of constructing breakwaters to prevent coastal erosion in Southern Thailand to be USD 3,679/~~Ha~~ha. Samonte-Tan et al. [23] estimated the benefit value of preventing coastline erosion and supplying nursery grounds from mangroves in the Bohol Marine Triangle, Philippines to be USD 672/Ha/yr and USD 243Ha/yr, respectively. Harahab [39] calculated the annual benefit value of preventing seawater intrusion in Probolinggo district, East Java to be IDR 68,227,500/ha/yr (USD 7,182/ha/yr) ~~per hectare~~. In addition, ~~and~~ Salem and Mercer [50] summarized the range of economic value of mangrove from coastal protection and carbon sequestration services of USD 10.45 – 8,044/ha/yr and USD 39.89 – USD 4,265/ha/yr, respectively.

~~estimated each hectare of mangrove in the Bhitarkanika National Park, India to contain nutrient values of USD 232.49.~~ **Table 2.** IUV of mangroves

~~No.~~	~~Services~~	~~Usevalue (IDR/yr)~~	~~use value (USD/yr)~~	~~use value (IDR/Ha/yr)~~	~~use value (USD/Ha/yr)~~

No.	Services	Use value (IDR/yr)	use value (USD/yr)	use value (IDR/ha/yr)	use value (USD/ha/yr)
~~1~~	~~Coastline protection~~	~~11,328,512,000~~	~~1,192,475~~	~~6,590,176~~	~~694~~
~~2~~	~~Seawater intrusion prevention~~	~~11,307,700,000~~	~~1,190,284~~	~~6,578,069~~	~~692~~
~~3~~	~~Provision of nursery grounds~~	~~13,542,282,000~~	~~1,425,503~~	~~7,878,000~~	~~829~~
~~4~~	~~Supply of nutrients (nitrogen and phosphate)~~	~~1,616,554,476~~	~~170,164~~	~~940,404~~	~~99~~
~~Total of IUV =~~		~~37,795,048,476~~	~~3,978,426~~	~~21,986,648~~	~~2,314~~
1	Coastline protection	11,328,512,000 – 61,512,500,000	1,192,475 – 6,475,000	6,590,176 – 35,783,886	694 – 3,767
2	Seawater intrusion prevention	4,523,080,000	476,114	2,631,227	277
3	Provision of nursery grounds	13,326,364,198	1,402,775	21,775,105	2,292
4	Carbon sequestration	8,981,775,000 – 17,963,500,000	945,450 – 1,890,895	5,225,000 – 10,449,971	550 – 1,100
Total of IUV =		38,159,731,198 – 97,325,444,198	4,016,814 – 10,244,784	36,221,508 – 70,640,189	3,813 – 7,436

Exchange rate: USD 1 = IDR 9,500; Total area of mangrove = 1,719 ha

~~3.3.~~4.3. OV of mangroves

The benefit values of mangrove as medicine is the option value, which includes the ~~will be crucial in the future~~potential use of mangrove as a pharmaceutical resource [51]. Most mangrove plants have medicinal importance, such as *Avecennia sp., Bruguiera sp., Ceriops sp., Excoecaria sp., Rhizophora sp., Sonneratia sp.* and *Xylocarpus sp.* [52,53]. Frost [54] reported that communities living in mangrove areas in Indian Sundarban have used *Rhizophora sp., Excoecaria sp.* and *Bruguiera sp.* to treat angina, leprosy, and diarrhea and blood pressure, respectively. Jusoff and Taha [51] reported that the tree bark of *Rhizophora sp.* is commonly used to treat fractures, cure diarrhea and stop hemorrhages. In addition, Prakash and Sivakumar [52] stated that dried plant samples of *Excoecaria agallocha* prevent pathogenic bacteria. Mangroves are furthermore a rich source of steroids, triterpenes, saponins, flavonoids, alkaloids and tannins [53].

By transferring benefit values of medicine material of mangroves in East Luwu district Indonesia [37], the estimation of the annual benefit value of medicinal material in this area was IDR 2,563,888,500 (USD 269,883) (mangrove extent of 1,719 Ha) or IDR 1,491,500 (USD 157) per hectare (Table 3). However, over the past decades mangroves in the study area have degraded, leading to depletion of their composition and diversity [28]. Nonetheless, the economic value of medicinal material in this area is quite high and many species commonly used for medicine are available, such as *Avicennia sp., Bruguiera sp., Ceriops sp., Excoecaria sp., Sonneratia sp.*, and especially *Rhizophora sp.* [28].

Table 3. OV of mangroves

No	Option value	Total use Value (USD/yr)	Total use value (IDR/yr)	Total use value (IDR/~~Ha~~ha/yr)	Total use value (USD/~~Ha~~ha/yr)

1	Medicines	269,883	2,563,888,500	1,491,500	157

Exchange rate : USD 1 = IDR 9,500 ; Total area of mangrove = 1,719 Ha

~~3.4.~~4.4. TEV and NPV of Mangroves

On the basis of the sum values of the DUV, IUV and OV, the annual benefit of the TEV of mangroves is estimated to be IDR 41,~~464,146,576~~501,241,298 – 100,666,954,298 (USD 4,36~~4,647~~8,582 – 10,596,552) or IDR ~~24,121,086~~38,165,377 – 72,584,058 (USD ~~2,539~~4,018 – 7,641) per hectare (Table 4). In addition, the NPVs per hectare for all three values (the DUV, IUV and OV) of mangroves benefits over a 10-year time period with a discount rate of 10% were IDR ~~4,579,584~~2,572,943 (USD ~~482~~271), IDR ~~171,757,468~~126,260,406 – 322,024,022 (USD ~~18,080~~13,291 – 33,897) and IDR ~~11~~8,483~~16~~,225~~610~~ (USD ~~1,202~~893) (Table 5).

The largest benefit value of mangroves (~~91~~94%) and the highest NPV are derived from the IUV, including the values of coastline protection, seawater intrusion prevention, ~~and nutrient and~~ nursery ground provision and carbon sequestration.

This suggests that the ecological functioning of mangrove has an important role in supporting local people's livelihoods [7]. Currently, there is a lack of awareness in local communities concerning the value of such benefits. People are driven by urgent needs and quick and real benefits that can be easily obtained by exploiting mangroves; they may tend to disregard the sustainability and the greater benefit value provided by this resource. In addition, the lower values of the DUV and OV as compared to the IUV suggest that the mangroves have been degraded and have decreased, thereby impacting fishery and forestry production.

Table 4. TEV of mangroves

No.	Economic use value	Use value (IDR/yr)	Use value (~~IDR~~USD/yr)	Use value (IDR/~~Ha~~ha/yr)	Use value (~~IDR~~USD/~~Ha~~ ha/yr)	%
1	DUV	~~1,105,209,600~~777,621,600	~~116,338~~81,885	~~642,938~~452,369	~~68~~48	2~~3~~
2	IUV	~~37,795,048,476~~38,159,731,198 – 97,325,444,198	~~3,978,426~~4,106,814 – 10,244,784	~~21,986,648~~36,221,508 – 70,640,189	~~2,314~~3,813 – 7,436	94~~1~~
3	OV	2,563,888,500	269,883	1,491,500	157	~~6~~4
	TEV	41,~~464,146,576~~501,241,298 – 100,666,954,298	4,36~~4,647~~8,582 – 10,596,552	~~24,121,086~~38,165,377 – 72,584,058	~~2,539~~4,018 – 7,641	100

Total area of mangrove = 1,719 Ha; Exchange rate : USD 1 = IDR 9,500

Table 5. NPV of mangroves

NPV	DUV	IUV	OV
NPV (IDR)	~~7,872,304,104~~4,422,889,286	~~295,251,087,549~~217,041,638,583 – 553,559,294,612	~~19,625,152,186~~14,582,664,597
NPV (IDR/~~Ha~~ha)	~~4,579,584~~2,572,943	~~171,757,468~~126,260,406 – 322,024,022	8,483,225~~11,416,610~~
NPV (USD/~~Ha~~ha)	~~482~~271	13,291 – ~~18,080~~33,897	~~1,202~~893

~~3.5.~~4.5. Benefit value of commercial ~~shrimp farming~~aquaculture ~~pond~~ and comparison to economic value of mangroves

~~Production and commercialization of shrimp farming in Indonesia started in the 1960s and three regions (Java, South Sulawesi and Aceh) have developed into the centres of production. In the early 1980s, shrimp farming experienced a peak, not only in these three regions; the development of shrimp ponds was notice able in most regions in Indonesia. The demand from importing countries (such as America, Japan and European countries) increased rapidly during this period, and to meet it, shrimp farming was expanded by clearing mangroves and intensifying farming practices .~~

Interviews of 23 ~~of shrimp~~ aquaculture farmers revealed that ~~shrimp~~ aquaculture ponds in the study area have been constructed (to an average extent of 3 hectares) by clearing mangrove forests. The types of ~~shrimp~~ aquaculture ponds found were monoculture of shrimp (3 ponds), monoculture of milkfish (3 ponds), polyculture of shrimp and milkfish (9 ponds) and polyculture of milkfish and seaweed, mainly from *Gracilaria sp*. (8 ponds). The total investment cost, including construction costs and equipment, for all pond areas were IDR 543,549,500 (USD 57,216) (average cost per shrimp pond is about IDR 23 million (USD 2,488)). Meanwhile, the total production cost, including fixed costs (e.g. equipment depreciation costs and taxes) and variable costs (e.g. costs of labour, seed, feed, fertilizer, fuel, etc.) for all pond areas was about IDR 406,600,000 (USD 42,800) (average per ~~shrimp~~ pond IDR 17.6 million (USD 1.860)). Two a~~A~~nnual harvests~~ly~~, shrimp production generated on average ~~7,600~~422 kg, milkfish production, ~~30,150~~6,700 kg/ha/yr, and seaweed production, ~~34,350~~2,862 kg/ha/yr ~~(2 harvests per year)~~. The market prices of shrimp, milkfish and seaweed (*Gracilaria sp.*) were IDR 55,000 (USD 5.79) per kg, IDR 15,000 (USD 1.58) per kg and IDR 4,000 (USD 0.42) per kg, respectively. Thus, annually the net benefit amounts to IDR ~~1,373,250,500~~2,163,910,500 (USD ~~144,553~~227,780) or IDR ~~19,902,181~~31,361,022/ha (USD ~~2,095~~3,301/ha) ~~per hectare~~ and the NPV of the revenue of ~~shrimp~~ aquaculture ponds per hectare during the 10-year project period (with a discount rate of 10%) is estimated to be IDR ~~15,052,424~~13,481,460 (USD ~~1,584~~1,419) (Table 6).

This suggests that ~~shrimp farming~~aquaculture ~~pond~~ is financially feasible and when compared to the NPV of the DUV and the OV of mangroves, the revenue is ~~3~~ 5.2 and 1.~~3~~ 7 times higher, respectively. However, when the comparison includes the NPV of the IUV of mangroves, the economic benefit value of mangroves providing environmental services (e.g. providing nursery grounds, protecting coastlines, preventing seawater intrusion, and ~~supplying nutrients~~carbon sequestration) were far higher (~~11.4~~9.3 times – 23.89) as also reported by Rönnbäck ~~and do not~~

~~covered most of the benefit value of these services~~ [7]. ~~However, w~~When the estimation of the NPV of ~~shrimp farming~~aquaculture ~~pond~~ 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 ~~shrimp farming~~aquaculture ~~pond~~ becomes negative (USD -~~459~~1,282/ha ~~per hectare~~) or no longer economically beneficial~~-~~ (Table 6 and Figure 2).

In Indonesia, generally~~It is often the case for shrimp farming in Indonesia that~~ the expected levels of shrimp production are met during the first five years, after which production starts to decline and many shrimp farmers suffer from heavy economic losses, often leading to bankruptcy [55]. Consequently, many shrimp farms are abandoned as owners try to find new locations for farming [38]; a general pattern also observed in other Asian countries as reported by Bann [4] and Sathirathai and Barbier [36]. Abandoned shrimp ponds are exposed to abrasion ~~. Moreover, the abandoned shrimp ponds~~and transforms ~~become~~ into wastelands ~~and~~of limited value ~~difficult to use~~ for other productive use such as agriculture due to ~~and the soil of ponds is becomes~~ very acidic and poor ~~in~~soil quality ~~, making it difficult to use for other purposes~~ [36].

In summary, degraded and decreased areas of mangroves, water pollution caused by waste ponds and the loss of nursery, feeding and spawning grounds of marine organisms have become visible evidence of the environmental impacts of ~~shrimp farming~~aquaculture ~~pond~~ development. If local environmental conditions are recoverable, the associated costs are very high and therefore, the economic benefit value of commercial ~~shrimp farming~~aquaculture ~~pond~~ in the long term becomes questionable, as also discussed by [56].

Table 6. Benefit value of commercial ~~shrimp farming~~aquaculture ~~pond~~

No	Description	Unit	Value	In USD
1	Investment	IDR	543,549,500	57,216
2	Production cost	IDR/yr	406,600,000	42,800
3	Production			
	Shrimp	Kg/ha/yr	~~7,600~~422	-
	Milkfish	Kg/ha/yr	~~30,150~~6,700	-
	Seaweed (*Gracilaria sp.*)	Kg/ha/yr	~~34,350~~2,862	-
4	Market price			
	Shrimp	IDR/Kg	55,000	5.79
	Milkfish	IDR/Kg	15,000	1.58
	Seaweed (*Gracilaria sp.*)	IDR/Kg	4,000	0.42
5	Benefit of A~~p~~V	IDR/yr	~~2,323,400,000~~3,114,060,000	~~244,568~~327,796
~~6~~	Net benefit of A~~p~~V	IDR/yr	~~1,373,250,500~~2,163,920,500	~~144,553~~227,780
	Net benefit/~~ per Ha~~ha/yr of A~~p~~V	IDR/~~Ha~~ha/yr	~~19,902,181~~31,361,022	~~2,095~~3,301
6	NPV without external cost:			

7	NPV without external cost:			
	NPV NPV	IDR	25,875,117,657930,220,762	2,723,69697,918
	NPV	IDR/Haha	15,052,42413,481,460	1,5841,419
87	NPV with external cost:			
	NPV	IDR	-7,491,812,355-840,662,415	-788,61-88,491
	NPV	IDR/Haha	-4,358,239-12,183,513	-459-1,282

Exchange rate: USD 1 = IDR 9,500

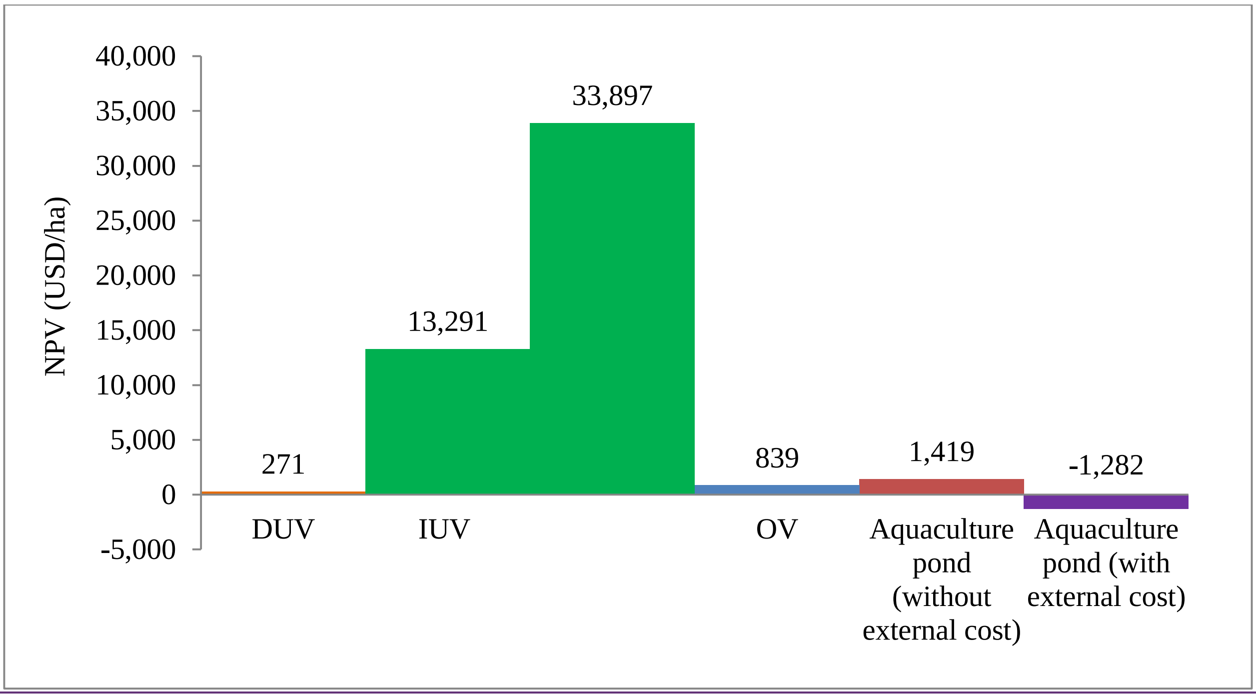

Figure 2. Comparison of NPV of mangroves versus commercial shrimp farmingaquaculture pond.

5. Conclusions

This study has demonstrated that the annual TEV of mangrove benefits is IDR 41,464,146,57641,501,241,298 – 100,666,954,298 (USD 4,364,6474,368,582 – 10,596,552) or IDR 24,121,08638,165,377 – 72,584,058 (USD 2,5394,018 – 7,641) per hectare. The calculation included the DUV of mangroves (the benefit value of fisheries and forestry products), the IUV of mangroves (the benefit value of protecting the coastline, preventing seawater intrusion, acting as a nursery ground and ~~supplying nutrients~~carbon sequestration), and the OV of mangroves (benefit value of medicine~~s material~~). The highest contribution of the TEV of mangroves was derived from the IUV of mangroves (~~91~~94%). The net benefit value of commercial ~~shrimp farming~~aquaculture ~~pond~~ amounts to IDR ~~1,373,250,500~~2,163,910,500 (USD ~~144,553~~227,780) or IDR ~~19,902,181~~31,361,022 (USD ~~2,095~~3,301) per hectare. In addition, the NPVs per hectare for the DUV, IUV and OV and ~~shrimp farming~~aquaculture ~~pond~~ were IDR ~~4,579,584~~2,572,943 (USD ~~482~~271), IDR ~~171,757,468~~126,260,406 – 322,024,022 (USD ~~18,080~~13,291 – 33,897), IDR ~~11,416,610~~8,483,225 (USD ~~1,202~~893) and IDR ~~15,052,424~~13,481,460 (USD ~~1,584~~1,419), respectively. The conversion of mangroves into commercial ~~shrimp farms~~aquaculture ~~pond~~ has a higher beneficial value than the DUV and OV ~~and OV~~ of mangroves and at a first glance seems to be financially viable, but when the IUV of mangroves is included in the comparison, the benefit value of mangroves is considerably higher. In addition, when the analysis of NPV was extended to include the costs of environmental ~~restoration (from water pollution)~~ and forest rehabilitation, the revenue of ~~shrimp farming~~aquaculture ~~pond~~ became negative or no longer economically beneficial.

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Author Contributions

Abdul Malik led the design of the study, conducted the field work and data analysis used for the economic valuation and wrote the first draft of the paper, with subsequent improvements by the co-authors.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Fauzi, A., *Economics of Natural Resources and Environment. Theory and Applications*. PT Gramedia Pustaka Utama: Jakarta, Indonesia, 2004; p 259.
2. Suparmoko, M., *Neraca Sumberdaya Alam (Natural Resource Accounting)*. BPFE UGM: Yogyakarta, Indonesia, 2005.

3. Rukmana, D., *Ekonomi Lingkungan dan Sumberdaya Alam*. Penerbit Arus Timur Makassar, Indonesia, 2012.
4. Bann, C., *The economic valuation of mangroves _A manual for researchers*. Economy and Environment Program for Southeast Asia (EEPSEA): Singapore 1998
5. Barbier, E. B., Sustainable use of wetlands valuing tropical wetland benefits: economic methodologies and applications. *The Geographical Journal* **1993,** *159*, 22-32.
6. Brander, L. M.; Wagtendonk, A. J.; Hussain, S. S.; McVittie, A.; Verburg, P. H.; Groot, R. S. d.; Ploeg, S. v. d., Ecosystem service values for mangroves in Southeast Asia: A meta-analysis and value transfer application. *Ecosystem Services* **2012,** *1* (1), 62-69.
7. Rönnbäck, P., The ecological basis for economic value of seafood production supported by mangrove ecosystems. *Ecological Economics* **1999,** *29*, 235-252.
8. Barbier, E. B.; Koch, E. W.; Silliman, B. R.; Hacker, S. D.; Wolanski, E.; Primavera, J.; Granek, E. F.; Polasky, S.; Aswani, S.; Cramer, L. A.; Stoms, D. M.; Kennedy, C. J.; Bael, D.; Kappel, C. V.; Perillo, G. M. E.; Reed, D. J., Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values *Science* **2008,** *319*, 321-323.
9. Vo, Q. T.; Kuenzer, C.; Vo, Q. M.; Moder, F.; Oppelt, N., Review of valuation methods for mangrove ecosystem services. *Ecological Indicators* **2012,** *23*, 431-446.
10. Curran, S., Migration, Social Capital, and the Environment: Considering Migrant Selectivity and Networks in Relation to Coastal Ecosystems *Population and Development Review* **2002,** *28*, 89-125.
11. Giri, C.; Ochieng, E.; Tieszen, L. L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J.; Duke, N., Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography* **2011,** *20* (1), 154-159.
12. FAO *The World's Mangroves 1980 – 2005*; Food and Agriculture Organization (FAO): Rome, Italy, 2007.
13. Onrizal, Perubahan Tutupan Hutan Mangrove di Pantai Timur Sumatera Utara Periode 1977 – 2006. *Jurnal Biologi Indonesia* **2010,** *6* (2), 163-172.
14. Nurkin, B., Degradation of Mangrove Forests in South Sulawesi, Indonesia. *Hydrobiologia* **1994,** *285*, 271-276.
15. Malik, A.; Fensholt, R.; Mertz, O., Consequences of Mangrove Forest Change in South Sulawesi. REEC, under review.
16. Forest-Ministry-Indonesia, *Luas Mangrove per Propinsi di Indonesia In Noor Y.R., Khazali M., Suryadiputra I N.N. Panduan Pengenalan Mangrove di Indonesia*. PHKA/WI-IP: Bogor, Indonesia. , 2006; p 219.
17. WGMFDA. *Kelautan dan Perikanan dalam Angka 2013*; Working Group of Marine and Fisheries Data Arrangement (WGMFDA). Centre of Data, Statistics and Information, Ministry of Marine and Fisheries of Indonesia: Jakarta, Indonesia, 2013.
18. GlobeFish. Food Market: Shrimp Production http://www.globefish.org. (accessed May 5, 2013).
19. Barbier, E. B., Habitat-Fishery Linkages and Mangrove Loss in Thailand. *Contemporary Economic Policy* **2003,** *21* (1), 59-77.
20. Hogarth, P., *The Biology of Mangroves and Seagrass* 2ed.; Oxford University Press: New York, 2007.
21. Chee, Y. E., An Ecological Perspective on the Valuation of Ecosystem Services. *Biological Conservation* **2004,** *120*, 549-565.
22. Beaumont, N. J.; Austen, M. C.; Mangi, S. C.; Townsend, M., Economic valuation for the conservation of marine biodiversity. *Marine pollution bulletin* **2008,** *56* (3), 386-96.
23. Samonte-Tan, G. P. B.; White, A. T.; Tercero, M. A.; Diviva, J.; Tabara, E.; Caballes, C., Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines. *Coastal Management* **2007,** *35* (2-3), 319-338.

24. Ukkas, M. *Pemetaan Potensi/Zonasi Wilayah Pesisir dan Pulau-pulau Kecil Kabupaten Takalar*; Laporan Penelitian. Universitas Hasanuddin: Makassar, Indonesia, 2001.
25. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2012.* ; Badan Pusat Statistik (BPS) Kabupaten Takalar: Takalar, Indonesia, 2012.
26. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2004-2012.*; Badan Pusat Statistik (BPS) Kabupaten Takalar: Takalar: Takalar, Indonesia, 2004-2012.
27. BPS-Sulsel, *Sulawesi Selatan Dalam Angka 2012*. Badan Pusat Statistik Sulawesi Selatan (BPS-Sulsel): Sulawesi Selatan, Indonesia, 2012.
28. Malik, A.; Fensholt, R.; Mertz, O., Mangrove Exploitation Effects on Biodiversity and Ecosystem Services. BIOC, under review.
29. Patton, M., *Qualitative Evaluation and Research Methods*. Sage: Baverly Hills, CA, 1990 p532.
30. Pearce, D.; Moran, D., *The Economic Value of Biodiversity*. Earthscan: UK, 1994.
31. UNEP, *Guidelines for conducting economic valuation of coastal ecosystem goods and services*. UNEP/GEF/SCS Technical Publication 2007.
32. KKP-Indonesia, *Statistical Data of Marine and Fisheries* Kementerian Kelautan dan Perikanan (KKP) Indonesia http://statistik.kkp.go.id/ (Accessed 1 March 2013): Jakarta, Indonesia, 2012.
33. Ong, J. E., Mangroves – a carbon source or sink. *Chemosphere* **1993,** *27*, 1097-1107.
34. Diaz, D.; Hamilton, K.; Johnson, E., *Forest Carbon Market 2011: From Canopy to Currency*. Forest Trend Ecosystem Marketplace: Washington DC 2011; p 93.
35. Mayudin, A., Kondisi Ekonomi Pasca Konversi Hutan Mangrove menjadi Lahan Tambak di Kabupaten Pangkajene Kepulauan Propinsi Sulawesi Selatan. *Eksos* **2012,** *8* (2), 90-104.
36. Sathirathai, S.; Barbier, E. B., Valuing Mangrove Conservation in Southern Thailand. *Contemporary Economic Policy* **2001,** *19* (2), 109-122.
37. Sribianti, I., Valuasi Ekonomi Hutan Mangrove: Studi Kasus Valuasi Ekonomi Kawasan Hutan Mangrove Malili Kabupaten Luwu Timur *Jurnal Sains & Teknologi* **2008,** *8* (3), 186-192.
38. Hong, P. N., Impact of Shrimp Culture Extension on Environmental and Biodiversity resources in Marsh of Coastal Zone. *Journal of Fisheries* . **1995,** *3*, 6-9 and 25.
39. Harahab, N., *Penilaian Ekonomi Ekosistem Hutan Mangrove dan Aplikasinya dalam Perencanaan Wilayah Pesisir*. Graha Ilmu Publisher: Yogyakarta, Indonesia, 2010.
40. Lan, T. D., Coastal aquaculture and shrimp farming in North Vietnam and environmental cost estimation. *Aquatic Ecosystem Health & Management* **2009,** *12* (3), 235-242.
41. Gunawardena, M.; Rowan, J. S., Economic Valuation of a Mangrove Ecosystem Threatened by Shrimp Aquaculture in Sri Lanka. *Environmental management* **2005,** *4,* 535-550
42. Setyawan, A. D.; Winarno, K., Pemanfaatan Langsung Ekosistem Mangrove di Jawa Tengah danPenggunaan Lahan di Sekitarnya; Kerusakan dan Upaya Restorasinya. *Biodiversitas* **2006,** *7* (3), 282-291.
43. Ong, J. E.; Gong, W. K., *Structure, Function and Management of Mangrove Ecosystems* International Society for Mangrove Ecosystems (ISME) Okinawa, Japan, and International Tropical Timber Organization (ITTO Yokohama, Japan.: 2013.
44. Mazda, Y.; Magi, M.; Kogo, M.; Hong, P. N., Mangroves as a coastal protection from waves in the Tong King delta, Vietnam. *Mangroves and Salt Marshes* **1997,** *1* (2), 127-135.
45. Hajramurni, A. Abrasion speed in Takalar hits 100 meters a year. http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html (accessed March 13, 2013).
46. Halim, A. Kerusakan Mangrove Memiskinkan Warga. http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga (accessed March 13, 2013).

47. Pirzanet, A. M.; Gunarto; Daud, R.; Utoyo; Kabangnga, N. *Pemantapan Budidaya Kepiting Bakau untuk Mengantisipasi Dampak Penangkapan di perairan Sungai Lamuru, Kabupaten Bone*; Balai Penelitian Perikanan Pantai: Maros, Indonesia, 1999.
48. Gunarto, Konservasi mangrove sebagai pendukung sumberdaya hayati perikanan pantai *Jurnal Litbang Pertanian* **2004,** *23* (1).
49. Sasekumar, A.; Chong, V. C.; Leh, M. U.; D'Cruz, R., Mangroves as a Habitat for Fish and Prawns. *Hyrobiologia* **1992,** *247*, 195-207.
50. Salem, M. E.; Mercer, D. E., The Economic Value of Mangrove: A Meta-Analysis. *Sustainability* **2012,** *4*, 359-383.
51. Jusoff, K.; Taha, D., Managing Sustainable Mangrove Forests in Peninsular Malaysia. *Journal of Sustainable Development* **2008,** *1* (1).
52. Prakash, M.; Sivakumar, T., A study on antibacterial activity of mangrove plant Excoecaria agallocha L. *International Journal of Current Microbiology and Applied Sciences* **2013,** *2* (8), 260-262.
53. Bandaranayake, W. M., Traditional and medicinal uses of mangroves. *Mangroves and Salt Marshes* **1998,** *2*, 133-148.
54. Frost, R., Dwindling Indian Sundarban Mangrove: The Way Out. *Science and Culture* **2010,** *76* (7–8), 275-282.
55. MAP-Indonesia *Kajian Risilian (Situational and contextual field assessment and analysis-Restoring Coastal Livelihood Project)*; Mangrove Action Project (MAP) Indonesia: Sulawesi Selatan, Indonesia, 2011.
56. Sigit, R. R. Ekonomi Lingkungan: Pilih Mangrove atau Tambak. http://www.mongabay.co.id/2013/10/25/ekonomi-lingkungan-pilih-mangrove-atau-tambak/ (accessed January 5, 2013).

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Article

Economic Valuation of Mangroves for Comparison with Commercial ~~ShrimpFarming~~Aquaculture ~~Pond~~ in South Sulawesi

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Abstract: Mangroves are recognized as a provider of a variety of products and essential ecosystem services that contribute significantly to the livelihood of local communities. However, over the past decades, mangroves in many tropical areas including the Takalar district, South Sulawesi have degraded and decreased mainly due to conversion to ~~shrimp ponds~~aquaculture. Currently, little is known about the economic benefits of commercialization of ~~shrimp ponds~~ aquaculture as compared to those derived from mangroves in the form of products and services. Here, we estimate the Total Economic Value (TEV) of mangrove benefits in order to compare it with the benefit value of commercial ~~shrimp~~ aquaculture~~ponds~~. Market prices, replacement costs, benefit transfer value and Cost-Benefit Analyses (CBA) have been used for value determination and comparison. The results show that the per year TEV of mangroves during the study period was IDR 41,501,241,298 – 100,666,954,298 (USD 4,368,582 – 10,596,552) or IDR 38,165,377 – 72,584,058 (USD 4,018 – 7,641) ~~41,464,146,576 (USD 4,364,647) or~~

~~IDR 24,121,086 (USD 2,539)~~ per hectare, (the highest value contribution derived from the indirect use value (~~91~~94%)), whereas the commercial ~~shrimp~~ aquaculture~~ponds~~ had a net benefit value of IDR 2,163,910,500 (USD 227,780) or IDR 31,361,022 (USD 3,301) ~~IDR 1,373,250,500 (USD 144,553) or IDR 19,902,181 (USD 2,095)~~ per hectare. In addition, the comparison of Net Present Value (NPV) between the benefit value of mangroves and that of commercial ~~shrimp ponds~~aquaculture revealed that conversion of mangroves into commercial ~~shrimp~~ aquaculture~~ponds~~ was not economically beneficial when the analysis was expanded to cover the costs of environmental and forest rehabilitation.

Keywords: Economic valuation; mangroves; commercial ~~shrimp farming~~aquaculture; Indonesia; South Sulawesi.

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1. Introduction

One of the crucial issues in development based on the use of natural resources is how to integrate economic development on the one hand with natural resources and environmental sustainability on the other in order to mitigate negative impacts and problems in future [1]. In principle, development should take place by utilizing the natural resources optimally [2]. In many countries, development is considered inevitable as a way to improve the welfare of communities. Unfortunately, failure to take into account the costs and benefits of the use of natural resources, which leads to negligence in decision-making, is still common and currently, we are facing an increasing scarcity of the resources necessary to support local livelihoods [3].

Mangroves, which are considered an important natural resource, occupy coastal and estuarine areas in many tropical places, provide goods and services for both direct use (e.g. timber, firewood, charcoal, Nypa palm leaves for crafting, wood chips, fisheries, food, medicines, material construction and tourism and recreational areas) and indirect use (e.g. coastline protection, prevention of seawater intrusion, provision of nursery and breeding grounds for fish, supply of nutrients for marine life, biodiversity maintenance and carbon sequestration) that have contributed significantly to community livelihoods [4].

Although mangroves provide a variety of products and services, they have been under great pressure due to decision making commonly based on assumptions of larger net benefits without considering the loss of wider mangrove services [5] and natural capital stocks [6]. Mangrove products and services are often undervalued [7,8] or even ignored in the economy and by industry and local inhabitants [9]. Consequently, nearly half of the total mangrove areas in the world have been lost over the past decades, with the largest areas of decline in Asia [10,11,12]. In Indonesia (which has the largest mangrove areas in the world), mangroves are threatened primarily by aquaculture but also by overharvesting of timber, firewood collection, charcoal production and conversion to other land uses such as agriculture, urbanization, mining and salt ponds [12,13,14,15]. Mangrove areas are characterized by some of the most rapid loss rates of coastal ecosystems in Indonesia; from 1980 to 2003, at least 1.1 million hectares of mangrove were lost, with 75 % of these areas being converted to shrimp ponds [12,16]. High economic revenues from the increase in exports and foreign trade in shrimp have become the main driving forces for the expansion of shrimp ponds by clearing mangroves [14]. In 2012, for instance, shrimp exports from Indonesia were valued at USD 1,304,149,000, of which 38 percent went to the United States of America (USA), 29 percent to Japan, 9 percent to European countries and 24 percent to other countries [17]. In South Sulawesi, the value of shrimp exports in 2011 reached USD 42,407,000 [15]. Since the early 1990s, Indonesia has become one of the major shrimp producing and exporting countries in the world [18]. However, the expansion of shrimp export which mostly comes from aquaculture production has triggered a heated debate in Indonesia as well as in other exporting countries such as Thailand due to the significant consequences for coastal areas [19,20].

Evaluation of the value of mangrove products and services affected by shrimp pond expansion is therefore important as a vehicle to integrate both ecological perspectives and economic considerations [21]. Such an evaluation will support reliable instruments that can be used to shift focus towards a green economy and guide policy makers to make sustainable decisions about mangrove utilization [4,2,22]. In addition, it is ~~away~~ one way to increase knowledge and awareness among stakeholders of the importance of the mangrove ecosystem for sustainable and environmentally friendly economic development [23].

Economic valuations of mangroves have been conducted in many areas of the world [9]. However, little attention has been paid in the scientific literature to an economic valuation of mangroves in areas threatened by commercial ~~shrimp farming~~aquaculture ~~pond~~development in Indonesia and other Asian countries and to the discussion of the economic benefits of ~~shrimp farming~~aquaculture ~~pond~~as compared to mangroves as a provider of a variety of products and environmental services. This paper aims to estimate the TEV of mangrove, including estimations of Direct Use Value (DUV), Indirect Use Value (IUV) and Option Value (OV), to enable a direct comparison with the benefit value of commercial ~~shrimp farming~~aquaculture ~~pond~~for a case study area in southern South Sulawesi, Indonesia using the CBA method. Given the threat of aquaculture expansion, information from such analyses is critical as the net benefit value generated from mangroves is currently not considered by policy makers dealing with sustainable management of mangroves.

2. StudyArea

Takalar district is located in southern South Sulawesi, Indonesia (between latitude 5°12’ - 5°38’ and longitude 119°10’- 119°39’, see figure 1), 45 km from Makassar city (the capital of South Sulawesi). The district has a coastline of 74 km [24], occupied by mangroves, coral reefs, sea grass, sandy beaches, rocky beaches, estuaries, aquaculture ponds, rice fields and tourism and residential areas. Most areas of Takalar are plain and coastal areas (including small islands) with an altitude of 0 - 100 metres above sea level and the rest are hilly areas [25]. The district covers 566.51 km^2 and is divided into nine sub districts (Galesong, South Galesong, North

Galesong, Mangarabombang, Mappakasunggu, Pattalassang, South Polongbangkeng, North Polongbangkeng and Sanrobone). Mappakasunggu consists of a mainland part and small islands (Tanakeke, Lantangpeo, Bauluang, Satangnga and Dayang Dayang). The population is 272,316 and the population density is 481 persons per km^2. Mean temperatures vary from 23˚C - 33˚C and the monthly precipitation average over the past eight years (2004 – 2011) has been between 174 mm and 712 mm; the greatest amount of precipitation occurred in 2008 from November to March [26].

The selected study area ~~is considered as~~ represents one of the hot spots of mangrove rich environments in Indonesia~~in South Sulawesiwhere~~. However, the region is characterised by being amongst the largest producers of aquaculture product in South Sulawesi [27]~~under pressure mainly from aquaculture development.Thus, the study area becomes one of the mostproducers of aquaculture product in South Sulawesi [27]. However,~~ and i~~I~~n past decades, mangroves in this area have degraded and decreased mainly due to conversion to aquaculture~~ponds~~. About 2,593 hectares (77.4%) of the total mangrove forest area has been changed to aquaculture, mainly on Tanakeke Island and in Banyuanyara village. Currently, the total extent of intact mangrove forest is 1,719 hectares and covers the sub districts of Mappakasunggu, Mangarabombang, Pattallassang, Sanrobone, Galesong, South Galesong and North Galesong [15]. Mangroves in this region are dominated by saplings and seedlings and comprise 10 species (*Avicennia alba, Bruguiera gymnorrhiza, Ceriops tagal, Excoecaria agallocha, Lumnitzera racemosa*, *Nypa fruticans*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhizophora stylosa* and *Sonneratia alba*). The most dominant species has been *Rhizophora mucronata*, followed by *Sonneratia alba*. The Diameter at Breast High (DBH) of mangrove trees is between 6.37cm and 23.57cm and the diameter size classes of 10-15 cm are dominant, followed by 15-20 cm [28].

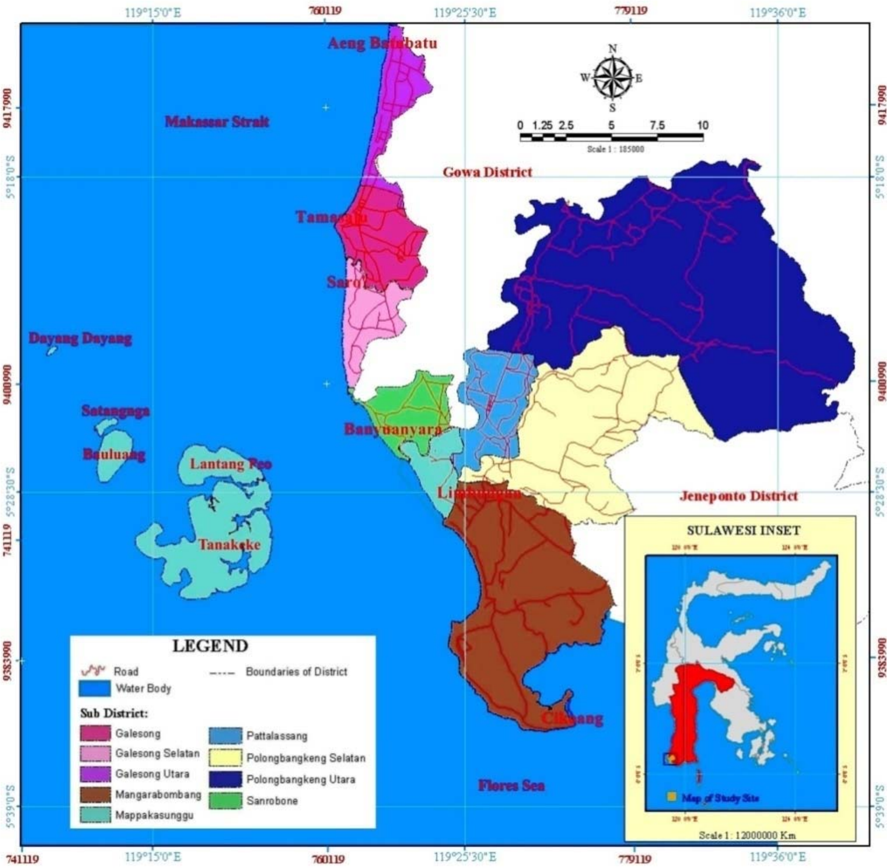

Figure 1. Map of the Takalar District Study Area, South Sulawesi, Indonesia

3. Materials and Methods

3.1. Data Collection

Household~~s~~ Surveys

Data on direct use of mangrove products and aquaculture were produce from household surveys by usi~~ng~~e of questionnaires. 93 households were ~~administrated, whowere~~ selected by a Purposive Sampling method [29]~~.These~~ and all households ~~all~~ had a direct relation to, and dependence on mangrove forests ~~, such as~~ (fishermen, shrimp farmers, firewood collectors, charcoal producers and Nypa palm crafters). Th~~ise~~ survey ~~is~~was conducted in ~~ten~~10 areas covering the islands of Lantangpeo, Tanakeke, Bauluang and Satanga (sub-district of Mappakasunggu), and the villages of Laikang (sub-district of Mangarabombang), Limbungan (sub-district of Pattallassang), Banyuanyara (sub-district of Sanrobone), Sa'ro (sub-district of South Galesong), Tamasaju (sub-district of Galesong) and Aeng Batu-batu (sub-district of North Galesong) (Figure 1). ~~Thus, t~~The areas were selected based on the criteria that mangrove forests should be present and utilized by communities for fishery and forestry production.

3.2. Data Analysis

3.2.1. Economic Valuation of Mangrove

The TEV of mangroves was calculated from monetary values of the DUV, IUV and OV of mangroves [30,4,31], ~~subsequent the~~and TEV values are reported in percentage. The DUV of mangroves was derived from benefit values of fishery products (fish, crab and shrimp capture ~~as well as seaweed farming~~) and forestry products (firewood collection, charcoal production and Nypa palm crafting), which have been estimated using market prices [4,31] and the following formulas:

- Fish, crab and shrimp capture ~~and seaweed farming~~values (FV;CV; SV~~; SFV~~)

FV; CV; SV ~~; SFV~~= Production (~~unit~~kg/yr) x ~~price~~ Price (IDR/kg~~unit~~) – Production cost (IDR) (1)

- Firewood value (FwV)

FwV= Wood collection (~~unit~~bundle/yr) x ~~price~~ Price (IDR/~~unit~~bundle) – Production cost (IDR) (1 bundle = 100 stems with a length of 1 m and a diameter of 4 ~~cm~~ to 8 cm) (2)

- Charcoal value (CcV)

CcV = Production (~~unit~~sack/yr) x Price (IDR/sack~~unit~~) – Production cost (IDR) (1 sack = 25 kg) (3)

- Nypa palm crafting value (NpcV)

$$NpcV = Production (~~Unit~~piece/yr) \times Price (IDR/~~unit~~piece) – Production\ cost (IDR) \quad (4)$$

The IUV of mangroves is derived from benefit values of mangrove services such as coastline protection, seawater intrusion prevention, provision of nursery grounds and carbon sequestration~~supply of nutrients for marine organisms~~. These benefit values were estimated using replacement costs and benefit transfer methods [4,31]. The coastline protection service was estimated by the cost of breakwater construction over a 10-year project lifespan; the seawater intrusion prevention service was assessed by the cost of the water supply needs of people if the availability of fresh water was reduced due to mangrove loss; the provision of nursery grounds service was estimated by foregone benefit from fishery according to the KKP-Indonesia (Ministry of Marine and Fisheries of Indonesia) [32], who ~~was~~ reported the average loss volume of fish catch in South Sulawesi include Takalar district of 1,211 tons per year during the period 2003-2011.~~the construction cost of ponds for nursery groundsfor shrimp or fish.~~ Finally, ~~the~~ carbon sequestration was estimated by using transferring rates of carbon storage of mangrove (100-200 tons C/ha) from Ong [33]. The price of carbon credits (USD 5.5/tCO_2) is based on Diaz et al. [34]~~the supply of nutrientsservice was assessedby the value of nutrient production (nitrogen and phosphate) from mangrove litter converted to the fertilizer market price of Urea ($(NH_2)_2CO$ and SP-36 (Superphosphate, 36 percent P2O5),~~. Calculation of IUV is conducted using the following formulas:

- Coastline prevention value (CPV)

$$CPV = ~~Coastal~~ coastal\ length (m) \times ~~Cost~~ cost\ of\ breakwater\ construction (IDR) \quad (5)$$

Coastal length = 74,000 m; The c~~C~~ost of breakwater construction has been reported to range between ~~withspecification oflength (1m), width (11m) and height (2.5m) =~~IDR 1,530,880/m^3 (USD 158/m^3) [35] ~~according to South Sulawesi'sPublic Work Agency~~ and ~~-~~IDR 8,312,500/m^3 (USD 875/m^3) [36]~~according to Thailand's Harbour Department of the Ministry of Communications and Transport~~.

- Seawater intrusion prevention value (SwIPV)

$$SwIPV = household\ population \times number\ of\ water\ supply (gallon/day) \times Price (IDR/gallon) \times 365\ days \quad (6)$$

- Provision of nursery grounds value (PNGV)

$$PNGV = ~~Total\ of\ mangrove\ area~~ loss\ volume\ of\ fish\ catch (kg~~Ha~~/yr) \times fish\ price (IDR/kg) / total\ loss\ of\ mangrove\ area\ during\ the\ period\ 2003\text{-}2011 (612\ ha)\ from\ Malik\ et\ al.\ [15]~~Construction\ cost\ of\ the\ pond (IDR/Ha)~~ \quad (7)$$

- ~~Supply of nutrients value (SNV)~~

~~SNV = Organic material Nitrogen and Phosphate (Kg/Ha/yr) x Total area of mangrove (Ha) x Price of Urea & SP-36fertilizers (IDR/kg)~~ ~~(8)~~

- Carbon sequestration value (CSV)

$$CSV = carbon\ sequestration\ rate (100 - 200\ ton\ C/ha) \times total\ area\ of\ mangrove (1,719\ ha) \times price\ of\ carbon\ market (USD\ 5.5/ton\ CO_2) \quad (8)$$

The OV of mangroves was calculated using the benefit transfer value method [4,31,23]. The benefit values of medicinal material from mangrove ecosystems was estimated by transferring the available value from Sribianti [37], who studied in East Luwu district, Indonesia. The annual benefit was IDR 1,500,000 (USD 157) per hectare [37].

3.2.2. Commercial ~~of~~ Aquaculture ~~Pond~~

The economic value of ~~shrimp~~ aquaculture ~~ponds~~ (AS~~p~~V) was calculated using the formulas:

Total area of aquaculture ~~ponds~~ (ha) = number of farmers (23 farmers) x area of aquculture ~~pond~~ per farmer (3 ha) (9)

Investment cost = cost construction (IDR/ha) + farming equipment (IDR/unit) x total area of aquaculture ~~pond~~ (ha) (10)

Production cost = fixed cost (e.g. equipment depreciation) (IDR/unit) + variable cost (fry, feed, fertilizer, fuel, etc) (IDR/unit) x total area of aquaculture ~~pond~~ (ha) (11)

Benefit of A~~p~~V = production (kg/ha/yr) x price (IDR/kg) x total area of aquaculture ~~pond~~ (ha) (12)

Net Benefit/yr of A~~p~~V = benefit of A~~p~~V (IDR/yr) – (investment cost + production cost) (IDR/yr) (13)

Net benefit/ha/yr of A~~p~~V = net benefit of A~~p~~V (IDR/yr) / total area of aquaculture ~~pond~~ (ha) (14)~~SpV= Production (unit/yr) x Price (IDR/unit) – Production cost (IDR)~~

3.2.3. Cost-Benefit Analysis (CBA)

CBA is conducted to compare economic value of mangrove with commercial aquaculture ~~pond~~, to address whether converting mangrove forest ~~for~~into commercial aquaculture ~~pond~~ is economically feasible ~~as financial~~. ~~To facilicate,~~ CBA is used to ~~e~~determining the NPV of internal costs and benefits of commercial aquaculture ~~pond~~. Based on Malik et al. [15], the project life of aquaculture ~~pond~~is was found to be ~~normally~~ five years on average in this area. ~~The NPV of mangroves and commercialshrimp ponds wasestimated using CBA with the following assumptions:~~

~~The benefitvalueof fisheries and forestry, medicinesand mangrove services over a 10-year project period will decrease 5% – 20% (the decrease willbegin in the second year ofthe project) with a subsequentdecreasein mangrove ecosystem functionsthat provide products and services due to the expansion of shrimp ponds. In contrast, the costs of production willincrease by2% - 20% during such a project period.~~

Several studies (e.g. [38,4,36,39]) have observed that shrimp production decreases successively after the fifth year due to the lower survival rate of shrimp. Hence, the production of shrimp over a 10-year project period also decreases by 5 – 20% and investment and production costs increase to sustain shrimp production [39]. However, aquaculture ~~pondscharges~~involves external costs including environmental cost (water pollution cost) ~~which~~related to the high salinity content of the water released from the ponds, ~~and~~ agrochemical runoff and forest rehabilitation cost for land degradation [36]. Thus, CBA is required to ~~extendincluding~~including also the NPV of external cost. The value of environmental cost was adopted from Lan [40], who reported that the production of 360,000 tons of shrimps generates an environmental cost of USD 280 million (1 kg shrimp produced = USD 1.28), whereas the forest rehabilitation cost was estimated from seed provision, planting and maintenance costs [39]. The forest rehabilitation cost was estimated from year 6 to year 10.

Furthermore, CBA is required to determine the NPV of mangroves from fishery and forestry, medicines and mangrove services over a 10-year project period using the cost and benefit values of each products and services ~~with consider to the~~based on an average age of the present mangrove (17 years) [28] and duration of exploitation of mangrove by local communities. Whereas ~~T~~the exploitation of mangrove for fishery and forestry products ~~is~~has been ongoing ~~occurred in~~during past several decades~~. However~~, the most intensive exploitation ~~is conducted~~has occured over the past 20 years [15].

A discount rate of 10% was used in the CBA reflecting the predominant cost of the loan interest rate ~~prevailing~~ at financial institutions ~~such as banks~~ when the survey was conducted [41;39].

~~In accordance with theloan interest rate prevailing at financial institutions such as banks when the survey was conducted, a discount rate of 10% was used inthe CBA.~~

~~The environmental cost (water pollution cost) of shrimp ponds was adopted from Lan, who reported that the production of 360,000 tons of shrimp generates an environmental costof USD280 million (1 kg shrimp produced = USD1.28), whereas the forest rehabilitation cost was estimated from seed provision, planting and maintenance costs. The forest rehabilitation cost was estimated from year 6 to year 10 (assuming normal shrimp pond production during the first 5 years).~~ The formula for calculating the NPV is as follows: [31]

$$NPV = \sum_{i=1}^{n} \frac{Bit - Cit}{(1+r)^t} \quad \text{(Ordinary CBA)}$$

(~~10~~15)

$$NPV = \sum_{i=1}^{n} \frac{(Bit+EBit)-(Cit-ECit)}{(1+r)^t} \quad \text{(Extended CBA)}$$

Where:

NPV = Net Present Value

B = annual gross benefit; EB = annual extended benefit

C = annual gross cost; EC = annual extended cost

r = discount rate

i = each benefit or cost

t = period of time

Criteria: NPV > 0: financially feasible; NPV = 0: impasse; and NPV <0: not financially feasible.

Environmental cost = shrimp production (kg/ha/yr) x USD 1.28 x total area of shrimp ponds (ha) (16)

Forest rehabilitation cost = seed provision cost (IDR/ha) + planting cost (IDR/ha) + maintenance cost (IDR/ha) x total area of aquaculture (ha) (17)

4. Results and Discussion

4.1. DUV of mangroves

In past decades, people who lived around mangroves in this area were highly dependent on mangroves for various fishery and forestry products for domestic and commercial purposes. In fisheries, mangrove forest has benefits for the capture of fish, crab and shrimp as well as ~~shrimp farming~~aquaculture~~ ponds~~, whereas in forestry, benefits ~~connected with~~related to the collection of firewood, charcoal production and Nypa palm leaf crafting are generated.

The results of the household survey showed that 43 households have been directly using mangrove for fish capture, six for crab capture, and six for shrimp capture~~ and seven for seaweed farming~~. They are using ~~a ~~traditional ~~of ~~fishing gear such as fishing rods, fishing nets, fish/crab traps and scoop. Annually, fish capture is conducted during 8 months (February - September), when sea conditions are good, whereas the remaining 4 months (October - ~~and ~~January~~),~~; characterized by ~~when there are ~~high waves and strong winds)~~,~~ are used to rest, repair boats and fishing gear or engage in alternative work [15]. Eight households have been using mangrove for harvest firewood, three for charcoal production and four for Nypa palm leaf crafting. The production averages of fish, crab and shrimp capture ~~and seaweed farming (*Eucheumacottonii*)~~ per household per year are 2,450 kg, 338 kg, and 213 kg~~ and 8,914kg~~, respectively. The production of firewood, charcoal and handcrafts such as roofs, walls, floor mats, baskets and especially hats from Nypa palm leaves per household per year amounted to 60 bundles~~ (1 bundle = 100 stems with a length of 1 m and a diameter of 4 cm to 8 cm)~~, 720 sacks ~~(1 sack = 25kg) ~~and 6,750 ~~units~~pieces, respectively. The total of fish, crab and shrimp production was 105,350 kg/year, 2,028 kg/year and 1,278 kg/year, respectively~~, whereas seaweed (*Eucheumacottonii*) production was 62,398 kg per year~~. Harvested mangrove forests for firewood reached 480 bundles per year, charcoal production was 2,160 sacks per year and handcrafting produced 27,000 ~~units ~~pieces per year.

The highest benefit of DUV was obtained from fish production, earning IDR 498,850,000 (USD 52,511) per year, followed by ~~seaweed farming~~charcoal production for IDR ~~327,588,000~~83,685,600 (USD ~~19,402~~8,809) per year. Thus, the total benefit of the DUV of mangrove ecosystem is IDR ~~1,105,209,6~~777,621,600 (USD ~~116,338~~81,855) per year (Table 1).

Table 1. DUV of mangroves

No	Products	House-hold users (n=~~77~~70)	Net use value (IDR/yr)	Net use value/ household (IDR/yr)	Net use value (USD/yr)	Net use value/ household (USD/yr)	Net use value (IDR/~~Ha~~ha/yr)	Net use value (USD/~~Ha~~ha/yr)
Fishery products								
1	Fish capture	43	498,850,000	11,601,163	52,511	1,221	290,198	31

2	Crab capture	6	62,040,000	10,340,000	6,531	1,088	36,091	4
3	Shrimp capture	6	26,810,000	4,468,333	2,822	470	15,586	2
~~4~~	~~Seaweedfarming(*Eucheuma cottonii*)~~	~~7~~	~~327,588,000~~	~~46,798,286~~	~~34,483~~	~~4,926~~	~~190,569~~	~~20~~
	Sub Total of DUV =		~~915,288~~587,700,000		~~96,346~~61,863		~~532,454~~341,885	~~56~~36
Forestry products								
1	Firewood	8	32,100,000	4,012,500	3,379	422	18,674	2
2	Charcoal	3	83,685,600	27,895,200	8,809	2,936	48,683	5
3	Nypa palm crafting	4	74,136,000	18,534,000	7,804	1,951	43,127	5
	Sub Total DUV =		189,921,600		19,992		110,484	12
	Total of DUV =		~~1,105,209,600~~ 777,621,600		~~116,338~~81,855		~~642,938~~452,369	~~68~~48

Exchange rate: USD1 = IDR 9,500; Total area of mangrove = 1,719 ~~Ha~~ha

A large number and variety of fish species and other marine species use the mangroves for nursery, spawning and feeding grounds ~~and for migrating to the coral reef areas or offshore~~ [42]. The main fish, shrimp and crab species available for fishery in the mangrove area include small pelagic fish, snapper (*lates calcarifer*), milkfish (*Chanos chanos*), white shrimp (*Pennaeus vannamei*) and mud crab (*Scylla sp.*).~~In seaweed farms on the seashore (near mangrove areas), cultures of *Eucheumacottonii*are developed.~~ Furthermore, the harvest of mangroves for home consumption and firewood and charcoal for commercial use are mostly derived from *Rhizophora sp*., whereas leaves of *Nypa fruticans* are used for handcrafts such as hats, floor mats, baskets, roofs and walls.

Even though fish capture is the dominant source of revenue for the local population and the highest generator of net benefit per year (IDR 498,850,000 = USD 52,511), the highest net benefit value per household per year (IDR ~~46,798,286~~27,895,200 = USD ~~4,926~~2,936) is derived from charcoal production~~seaweed farming~~. Over the last decades, clearing mangrove to expand shrimp ponds has been wide spread in this area, causing mangrove areas to decrease and degrade rapidly, which in turn has led to a decrease in fish production and fishermen's income ~~. Consequently, seaweed farming has become an alternative livelihood strategythat has proven to be more profitable than fishing~~[15].

4.2. IUV of mangroves

Besides providing a variety of products, mangrove forest supports ecological services by protecting the coastline from exposure to waves, preventing seawater intrusion and providing nursery grounds and ~~supplying nutrients for marine organisms~~carbon sequestration [43]. Mazda et al. [44] stated that the stand of *Kandelia candel* (six years old) can reduce waves with an offshore height of 1 m to 0.05 m when they reach the shore. Hajramurni [45] and Halim [46] revealed that abrasion and seawater intrusion occurred in several places in the region where mangrove is absent. Abrasion was found along the coast in six sub districts of Takalar district

(Mappakasunggu, Mangarabombang, Sanrobone, South Galesong, Galesong and North Galesong), reaching 20-100 metres per year over the past five years. Moreover, seawater intrusion into inland areas has made growth conditions difficult for local crops such as banana. Furthermore, Pirzanet et al. [47] and Gunarto [48] found that 17 commercial fish species inhabit and use mangroves as nursery grounds in Lamuru Estuary, Bone district, South Sulawesi while 27 commercial fish species do so in the Tongke-tongke mangrove forest area and Sinjai district. In Selangor, Malaysia, Sasekumar et al. [49] noted that many species of fish (119) and prawn (9) inhabit and use mangrove as nursery and feeding grounds. In addition, Ong [33] reported that mangrove ~~above ground~~ could store 100 – 200 ton C/ha above ground, whereas below ground carbon can reach ~~to~~ 700 ton C/1 m soil thickness/ha (with an estimat~~ing~~ed carbon sink rate of 1.5 ton C/ha/yr).

~~In addition, reported that the average production of nitrogen and phosphate of mangrove litter in Sinjai district, South Sulawesi reached 497.98 kg/ha and 22.02 kg/ha, respectively. report the availability of nutrients in thesoil of the Bhitarkanika National Park, India to be2,907 kg/ha (nitrogen) and 28.11 kg/ha (phosphate).~~

In this case study area, the net benefit values of these mangrove services have been estimated using the replacement cost and benefit transfer methods. Annual values of prevention of coastline erosion and seawater intrusion provided by mangroves were estimated to be IDR 11,328,512,000 (USD 1,192,475) to 61,512,500,000 (USD 6,475,000) or IDR 6,590,176/ha (USD 694/ha) to 35,783,886/ha (USD 3,767/ha) ~~per hectare~~ and IDR ~~11,307,700,000~~4,523,080,000 (USD ~~1,190,284~~476,114) or IDR ~~6,578,069~~2,631,227/ha (USD ~~692~~277/ha) ~~per hectare~~, respectively. The value of coastline protection services is dominated ~~of~~by the TEV of mangrove. This finding is similar in Thailand as reported by Barbier et al. [8]. Provision of nursery ground~~s and supply of nutrient~~service~~s were~~ was estimated to amount to IDR 13,~~542,282~~326,364,198~~000~~ (USD ~~1,425,503~~1,402,775) or IDR ~~7,878,000~~21,775,105/ha (USD ~~892~~2,292/ha). Furthermore, carbon sequestration service was estimated to ~~per hectare and~~ IDR ~~1,616,554,476~~8,981,775,000 – IDR 17,963,500,000 (USD ~~170,164~~945,450 – USD 1,890,895) or IDR ~~940,404~~5,225,000/ha – IDR 10,449,971/ha (USD ~~99~~550/ha – USD 1,100/ha) ~~per hectare, respectively~~. Thus, annually the aggregate benefit of IUV mangroves was IDR ~~37,795,048,476~~38,159,731,198 – IDR 97,325,444,198 (USD ~~3,978,426~~4,016,814 – USD 10,244,784) or IDR ~~21,986,648~~36,221,508/ha – IDR 70,640,189/ha (USD ~~2,314~~3,813/ha – USD 7,436/ha) ~~per hectare~~(Table 2).

Some studies have reported benefit values of such mangrove services and Sathirathai and Barbier [36] estimated the cost of constructing breakwaters to prevent coastal erosion in Southern Thailand to be USD 3,679/~~Ha~~ha. Samonte-Tan et al. [23] estimated the benefit value of preventing coastline erosion and supplying nursery grounds from mangroves in the Bohol Marine Triangle, Philippines to be USD 672/~~Ha~~ha/yr and USD 243/~~Ha~~ha/yr, respectively. Harahab [39] calculated the annual benefit value of preventing seawater intrusion in Probolinggo district, East Java to be IDR 68,227,500/ha/yr (USD 7,182/ha/yr) ~~per hectare~~. In addition, ~~and estimated each hectare of mangrove in the Bhitarkanika National Park, India to contain nutrient values of USD 232.49.~~ Salem and Mercer [50] summarized the range of economic value of mangrove from coastal protection and carbon sequestration services of USD 10.45 – 8,044/ha/yr and USD 39.89 – USD 4,265/ha/yr, respectively.

Table 2. IUV of mangroves

No.	Services	Usevalue (IDR/yr)	Use value (USD/yr)	Use value (IDR/ha/yr)	Use value (USD/ha/yr)
1	Coastline protection	11,328,512,000 – 61,512,500,000	1,192,475 – 6,475,000	6,590,176 – 35,783,886	694 – 3,767
~~1~~	~~Coastline protection~~	~~11,328,512,000~~	~~1,192,475~~	~~6,590,176~~	~~694~~
~~2~~	~~Seawaterintrusion prevention~~	~~11,307,700,000~~	~~1,190,284~~	~~6,578,069~~	~~692~~
2	Seawater intrusion prevention	4,523,080,000	476,114	2,631,227	277
~~3~~	~~Provision of nurserygrounds~~	~~13,542,282,000~~	~~1,425,503~~	~~7,878,000~~	~~829~~
3	Provision of nursery grounds	13,326,364,198	1,402,775	21,775,105	2,292
~~4~~	~~Supply of nutrients (nitrogen and phosphate)~~	~~1,616,554,476~~	~~170,164~~	~~940,404~~	~~99~~
4	Carbon sequestration	8,981,775,000 – 17,963,500,000	945,450 – 1,890,895	5,225,000 – 10,449,971	550 – 1,100
	~~Total of IUV =~~	~~37,795,048,476~~	~~3,978,426~~	~~21,906,640~~	~~2,314~~
	Total of IUV =	38,159,731,198 – 97,325,444,198	4,016,814 – 10,244,784	36,221,508 – 70,640,189	3,813 – 7,436

Exchange rate: USD1 = IDR 9,500; Total area of mangrove = 1,719 ha

4.3. OV of mangroves

The benefit values of mangrove as medicine is the option value, which includes the ~~will be crucial in the future~~potential use of mangrove as a pharmaceutical resource [51]. Most mangrove plants have medicinal importance, such as *Avecennia sp.*, *Bruguiera sp.*, *Ceriops sp.*, *Excoecaria sp.*, *Rhizophora sp.*, *Sonneratia sp.* and *Xylocarpus sp.* [52,53]. Frost [54] reported that communities living in mangrove areas in Indian Sundarban have used *Rhizophora sp.*, *Excoecaria sp.* and *Bruguiera sp.* to treat angina, leprosy, and diarrhea and blood pressure, respectively. Jusoff and Taha [51] reported that the tree bark of *Rhizophora sp.* is commonly used to treat fractures, cure diarrhea and stop hemorrhages. In addition, Prakash and Sivakumar [52] stated that dried plant samples of *Excoecaria agallocha* prevent pathogenic bacteria. Mangroves are furthermore a rich source of steroids, triterpenes, saponins, flavonoids, alkaloids and tannins [53].

By transferring benefit values of medicine material of mangroves in East Luwu district Indonesia [37], the estimation of the annual benefit value of medicinal material in this area was IDR 2,563,888,500 (USD 269,883) (mangrove extent of 1,719 ~~Ha~~ha) or IDR 1,491,500 (USD 157) per hectare (Table 3). However, over the past decades mangroves in the study area have degraded, leading to depletion of their composition and diversity [28]. Nonetheless, the economic value of medicinal material in this area is quite high and many species commonly used for medicine are available, such as *Avicennia sp.*, *Bruguiera sp.*, *Ceriops sp.*, *Excoecaria sp.*, *Sonneratia sp.*, and especially *Rhizophora sp.* [28].

Table 3. OV of mangroves

No	Option value	Total use ~~Value~~value (USD/yr)	Total use value (IDR/yr)	Total use value (IDR/~~Ha~~ha/yr)	Total use value (USD/~~Ha~~ha/yr)
1	Medicines	269,883	2,563,888,500	1,491,500	157

Exchange rate : USD 1 = IDR 9,500 ; Total area of mangrove = 1,719 ~~Ha~~ha

~~4.5.~~4.4. TEV and NPV of Mangroves

On the basis of the sum values of the DUV, IUV and OV, the annual benefit of the TEV of mangroves is estimated to be IDR 41,~~464,146,576~~501,241,298 – 100,666,954,298 (USD 4,3~~64,647~~68,582 – 10,596,552) or IDR ~~24,121,086~~38,165,377 – 72,584,058 (USD ~~2,539~~4,018 – 7,641) per hectare (Table 4). In addition, the NPVs per hectare for all three values (the DUV, IUV and OV) of mangroves benefits over a 10-year time period with a discount rate of 10% were IDR ~~4,579,584~~2,572,943 (USD ~~482~~271), IDR ~~171,757,468~~126,260,406 – 322,024,022 (USD ~~18,080~~13,291 – 33,897) and IDR ~~11~~8,4~~8~~83~~16~~,225 ~~610~~(USD ~~1,202~~893) (Table 5).

The largest benefit value of mangroves (~~91~~94%) and the highest NPV are derived from the IUV, including the values of coastline protection, seawater intrusion prevention, ~~andnutrient and~~ nursery ground provision and carbon sequestration.

This suggests that the ecological functioning of mangrove has an important role in supporting local people's livelihoods [7]. Currently, there is a lack of awareness in local communities concerning the value of such benefits. People are driven by urgent needs and quick and real benefits that can be easily obtained by exploiting mangroves; they may tend to disregard the sustainability and the greater benefit value provided by this resource. In addition, the lower values of the DUV and OV as compared to the IUV suggest that the mangroves have been degraded and have decreased, thereby impacting fishery and forestry production.

Table 4. TEV of mangroves

No.	Economic usevalue	Use value (IDR/yr)	Use value (~~IDR~~USD/yr)	Use value (IDR/~~Ha~~ha/yr)	Use value (~~IDR~~USD/~~Ha~~ha/yr)	%
1	DUV	~~1,105,209,600~~777,621,600	~~116,338~~81,885	~~642,938~~452,369	~~68~~48	2~~3~~
2	IUV	~~37,795,048,476~~38,159,731,198 – 97,325,444,198	~~3,978,426~~4,106,814 – 10,244,784	~~21,986,648~~36,221,508 – 70,640,189	~~2,314~~3,813 – 7,436	94~~1~~
3	OV	2,563,888,500	269,883	1,491,500	157	~~6~~4
	TEV	41,~~464,146,576~~50	4,36~~4,647~~8,5	~~24,121,086~~38,	~~2,539~~4,018 –	100

	1,241,298 – 100,666,954,298	82 – 10,596,552	165,377 – 72,584,058	7,641

Total area of mangrove = 1,719 ~~Ha~~ha; Exchange rate : USD 1 = IDR 9,500

Table 5. NPV of mangroves

NPV	DUV	IUV	OV
NPV (IDR)	~~7,872,304,104~~ 4,422,889,286	~~295,251,087,549~~217,041,638,583 –553,559,294,612	~~19,625,152,186~~14,582,664,597
NPV (IDR/~~Ha~~ha)	~~4,579,584~~2,572,943	~~171,757,468~~126,260,406 – 322,024,022	8,483,225~~11,416,610~~
NPV (USD/~~Ha~~ha)	~~482~~271	13,291–~~18,080~~33,897	~~1,202~~893

~~4.6.~~4.5. Benefit value of commercial ~~shrimp farming~~aquaculture ~~pond~~and comparison to economic value of mangroves

~~Production and commercialization of shrimp farmingin Indonesia startedinthe 1960s andthree regions (Java, South Sulawesi and Aceh) have developedinto thecentresof production. In the early 1980s, shrimp farming experienced a peak,not only in these threeregions;the development of shrimp ponds wasnoticeable in most regions in Indonesia. The demand from importing countries (such as America, Japan and European countries) increased rapidlyduring this period, andto meet it,shrimp farmingwas expanded by clearing mangroves and intensifyingfarming practices.~~

Interviews of 23 ~~of shrimp~~ aquaculture farmers revealed that ~~shrimp~~ aquaculture ponds in the study area have been constructed (to an average extent of 3 hectares) by clearing mangrove forests. The types of ~~shrimp~~ aquaculture ponds found were monoculture of shrimp (3 ponds), monoculture of milkfish (3 ponds), polyculture of shrimp and milkfish (9 ponds) and polyculture of milkfish and seaweed, mainly from *Gracilaria sp.* (8 ponds). The total investment cost, including construction costs and equipment, for all pond areas were IDR 543,549,500 (USD 57,216) (average cost per shrimp pond is about IDR 23 million (USD 2,488)). Meanwhile, the total production cost, including fixed costs (e.g. equipment depreciation costs and taxes) and variable costs (e.g. costs of labour, seed, feed, fertilizer, fuel, etc.) for all pond areas was about IDR 406,600,000 (USD 42,800) (average per ~~shrimp~~ pond IDR 17.6 million (USD 1.860)). Two a~~A~~nnual harvests~~ly~~, shrimp production generated on average ~~7,600~~422 kg/ha/yr, milkfish production, ~~30,150~~6,700 kg/ha/yr, and seaweed production, ~~34,350~~2,862 kg/ha/yr~~(2 harvests per year)~~. The market prices of shrimp, milkfish and seaweed (*Gracilaria sp.*) were IDR 55,000 (USD 5.79) per kg, IDR 15,000 (USD 1.58) per kg and IDR 4,000 (USD 0.42) per kg, respectively. Thus, annually the net benefit amounts to IDR ~~1,373,250,500~~2,163,910,500 (USD ~~144,553~~227,780) or IDR ~~19,902,181~~31,361,022/ha (USD ~~2,095~~3,301/ha) ~~per hectare~~ and the NPV of the revenue of ~~shrimp~~ aquaculture ponds per hectare during the 10-year project period (with a discount rate of 10%) is estimated to be IDR ~~15,052,424~~11,655,943 (USD ~~1,584~~1,227) (Table 6).

This suggests that ~~shrimp farming~~aquaculture ~~pond~~is financially feasible and when compared to the NPV of the DUV and the OV of mangroves, the revenue is ~~3~~4.5 and 1.~~3~~4 times higher, respectively. However, when the comparison includes the NPV of the IUV of mangroves, the economic benefit value of mangroves providing environmental services (e.g. providing nursery grounds, protecting coastlines, preventing seawater intrusion, and ~~supplying nutrients~~carbon sequestration) were far higher (~~11.4~~10.8 – 27.6 times) as also reported by Rönnbäck ~~and do not coveredmost of the benefit value of these services~~[7]. ~~However, w~~When the estimation of the NPV of ~~shrimp farming~~aquaculture ~~pond~~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 ~~shrimp farming~~aquaculture ~~pond~~becomes negative (USD ~~-~~-~~459~~663/ha ~~per hectare~~) or no longer economically beneficial (Table 6 and Figure 2).

In Indonesia, generally~~It is often the casefor shrimp farming inIndonesiathat~~ the expected levels of shrimp production are met during the first five years, after which production starts to decline and many shrimp farmers suffer from heavy economic losses, often leading to bankruptcy [55]. Consequently, many shrimp farms are abandoned as owners try to find new locations for farming [38]; a general pattern also observed in other Asian countries as reported by Bann [4] and Sathirathai and Barbier [36]. Abandoned shrimp ponds are exposed to abrasion ~~. Moreover, the abandoned shrimp ponds~~and transforms ~~become~~into wastelands ~~and~~of limited value~~difficult to use~~ for other productive use such as agriculture due to ~~and the soil of pondsis becomes~~ very acidic and poor ~~in~~soil quality ~~,makingit difficult to use for other purposes~~[36].

In summary, degraded and decreased areas of mangroves, water pollution caused by waste ponds and the loss of nursery, feeding and spawning grounds of marine organisms have become visible evidence of the environmental impacts of ~~shrimp farming~~aquaculture ~~pond~~development. If local environmental conditions are recoverable, the associated costs are very high and therefore, the economic benefit value of commercial ~~shrimpfarming~~aquaculture ~~pond~~in the long term becomes questionable, as also discussed by [56].

Table 6. Benefit value of commercial ~~shrimp farming~~aquaculture ~~pond~~

No	Description	Unit	Value	In USD
1	Investment	IDR	543,549,500	57,216
2	Production cost	IDR/yr	406,600,000	42,800
3	Production			
	Shrimp	Kg/ha/yr	~~7,600~~422	-
	Milkfish	Kg/ha/yr	~~30,150~~6,700	-
	Seaweed (*Gracilaria sp.*)	Kg/ha/yr	~~34,350~~2,862	-
4	Market price			
	Shrimp	IDR/Kg	55,000	5.79
	Milkfish	IDR/Kg	15,000	1.58

	Seaweed (*Gracilaria sp.*)	IDR/Kg	4,000	0.42
5	Benefit of ApV	IDR/yr	2,323,400,0003,114,060,000	244,568327,796
6	Net benefit of ApV	IDR/yr	1,373,250,5002,163,910,500	144,553227,780
	Net benefit/ perHaha/yr of ApV	IDR/Haha/yr	19,902,18131,361,022	2,0953,301
6	NPV without external cost:			
7	NPV withoutexternalcost:			
	NPV NPV	IDR	25,875,117,657804,260,088	2,723,69684,659
	NPV	IDR/Haha	15,052,42411,655,943	1,5841,227
87	NPV with external cost:			
	NPV	IDR	-7,491,812,355-434,647,387	-788,61-45,752
	NPV	IDR/Haha	-4,358,239-6,299,237	-459-663

Exchange rate: USD 1 = IDR 9,500

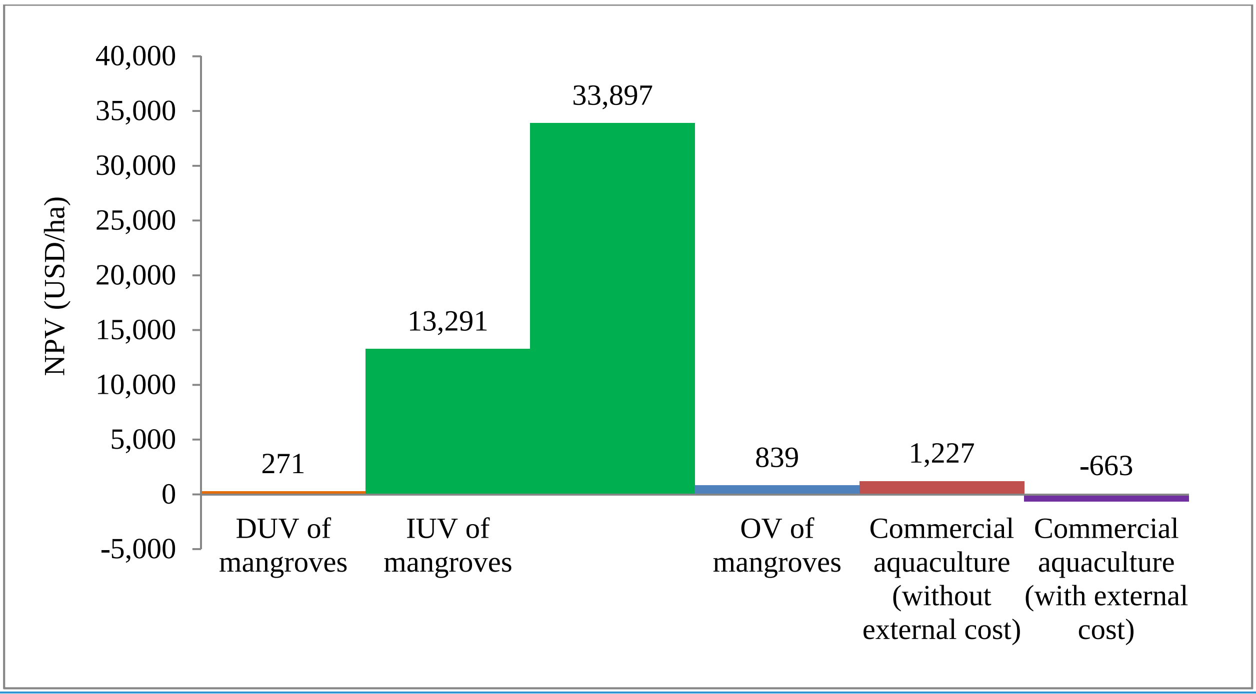

Figure 2. Comparison of NPV of mangroves versus commercial ~~shrimp farming~~aquaculture ~~pond~~.

5. Conclusions

This study has demonstrated that the annual TEV of mangrove benefits is IDR ~~41,464,146,576~~41,501,241,298 – 100,666,954,298 (USD ~~4,364,647~~4,368,582 – 10,596,552) or IDR ~~24,121,086~~38,165,377 – 72,584,058 (USD ~~2,539~~4,018 – 7,641) per hectare. The calculation included the DUV of mangroves (the benefit value of fisheries and forestry products), the IUV of mangroves (the benefit value of protecting the coastline, preventing seawater intrusion, acting as a nursery ground and ~~supplying nutrients~~carbon sequestration), and the OV of mangroves (benefit value of medicines~~ material~~). The highest contribution of the TEV of mangroves was derived from the IUV of mangroves (~~91~~94%). The net benefit value of commercial ~~shrimp farming~~aquaculture ~~pond~~amounts to IDR ~~1,373,250,500~~2,163,910,500 (USD ~~144,553~~227,780) or IDR ~~19,902,181~~31,361,022 (USD ~~2,095~~3,301) per hectare. In addition, the NPVs per hectare for the DUV, IUV and OV and ~~shrimp farming~~aquaculture ~~pond~~were IDR ~~4,579,584~~2,572,94[illegible] (USD ~~482~~271), IDR ~~171,757,468~~126,260,406 – 322,024,022 (USD ~~18,080~~13,291 – 33,897), IDR ~~11,416,610~~8,483,225 (USD ~~1,202~~893) and IDR ~~15,052,424~~11,655,943 (USD ~~1,584~~1,227), respectively. The conversion of mangroves into commercial ~~shrimp farms~~aquaculture ~~pond~~has a higher beneficial value than the DUV and OV of mangroves and at a first glance seems to be financially viable, but when the IUV of mangroves is included in the comparison, the benefit value of mangroves is considerably higher. In addition, when the analysis of NPV was extended to include the costs of environmental ~~restoration (from water pollution)~~ and forest rehabilitation, the revenue of ~~shrimp farming~~aquaculture ~~pond~~became negative or no longer economically beneficial.

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Author Contributions

Abdul Malik led the design of the study, conducted the field work and data analysis used for the economic valuation and wrote the first draft of the paper, with subsequent improvements by the co-authors.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Fauzi, A., *Economics of Natural Resources and Environment. Theory and Applications*. PT Gramedia Pustaka Utama: Jakarta, Indonesia, 2004; p 259.
2. Suparmoko, M., *Neraca Sumberdaya Alam (Natural Resource Accounting)*. BPFE UGM: Yogyakarta, Indonesia, 2005.
3. Rukmana, D., *Ekonomi Lingkungan dan Sumberdaya Alam*. Penerbit Arus Timur Makassar, Indonesia, 2012.
4. Bann, C., *The economic valuation of mangroves _A manual for researchers*. Economy and Environment Program for Southeast Asia (EEPSEA): Singapore 1998
5. Barbier, E. B., Sustainable use of wetlands valuing tropical wetland benefits: economic methodologies and applications. *The Geographical Journal* **1993,***159*, 22-32.
6. Brander, L. M.; Wagtendonk, A. J.; Hussain, S. S.; McVittie, A.; Verburg, P. H.; Groot, R. S. d.; Ploeg, S. v. d., Ecosystem service values for mangroves in Southeast Asia: A meta-analysis and value transfer application. *Ecosystem Services* **2012,***1* (1), 62-69.
7. Rönnbäck, P., The ecological basis for economic value of seafood production supported by mangrove ecosystems. *Ecological Economics* **1999,** *29*, 235-252.
8. Barbier, E. B.; Koch, E. W.; Silliman, B. R.; Hacker, S. D.; Wolanski, E.; Primavera, J.; Granek, E. F.; Polasky, S.; Aswani, S.; Cramer, L. A.; Stoms, D. M.; Kennedy, C. J.; Bael, D.; Kappel, C. V.; Perillo, G. M. E.; Reed, D. J., Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values *Science* **2008,***319*, 321-323.
9. Vo, Q. T.; Kuenzer, C.; Vo, Q. M.; Moder, F.; Oppelt, N., Review of valuation methods for mangrove ecosystem services. *Ecological Indicators* **2012,***23*, 431-446.
10. Curran, S., Migration, Social Capital, and the Environment: Considering Migrant Selectivity and Networks in Relation to Coastal Ecosystems *Population and Development Review* **2002,***28*, 89-125.
11. Giri, C.; Ochieng, E.; Tieszen, L. L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J.; Duke, N., Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography* **2011,***20* (1), 154-159.
12. FAO *The World's Mangroves 1980 – 2005*; Food and Agriculture Organization (FAO): Rome, Italy, 2007.
13. Onrizal, Perubahan Tutupan Hutan Mangrove di Pantai Timur Sumatera Utara Periode 1977 – 2006. *Jurnal Biologi Indonesia* **2010,***6* (2), 163-172.
14. Nurkin, B., Degradation of Mangrove Forests in South Sulawesi, Indonesia. *Hydrobiologia* **1994,***285*, 271-276.
15. Malik, A.; Fensholt, R.; Mertz, O., Consequences of Mangrove Forest Change in South Sulawesi. REEC, under review.
16. Forest-Ministry-Indonesia, *Luas Mangrove per Propinsi di Indonesia In Noor Y.R., Khazali M., Suryadiputra I N.N. Panduan Pengenalan Mangrove di Indonesia*. PHKA/WI-IP: Bogor, Indonesia. , 2006; p 219.

17. WGMFDA. *Kelautan dan Perikanan dalam Angka 2013*; Working Group of Marine and Fisheries Data Arrangement (WGMFDA). Centre of Data, Statistics and Information, Ministry of Marine and Fisheries of Indonesia: Jakarta, Indonesia, 2013.
18. GlobeFish. Food Market: Shrimp Production http://www.globefish.org. (accessed May 5, 2013).
19. Barbier, E. B., Habitat-Fishery Linkages and Mangrove Loss in Thailand. *Contemporary Economic Policy* **2003,***21* (1), 59-77.
20. Hogarth, P., *The Biology of Mangroves and Seagrass* 2ed.; Oxford University Press: New York, 2007.
21. Chee, Y. E., An Ecological Perspective on the Valuation of Ecosystem Services. *Biological Conservation* **2004,***120*, 549-565.
22. Beaumont, N. J.; Austen, M. C.; Mangi, S. C.; Townsend, M., Economic valuation for the conservation of marine biodiversity. *Marine pollution bulletin* **2008,***56* (3), 386-96.
23. Samonte-Tan, G. P. B.; White, A. T.; Tercero, M. A.; Diviva, J.; Tabara, E.; Caballes, C., Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines. *Coastal Management* **2007,***35* (2-3), 319-338.
24. Ukkas, M. *Pemetaan Potensi/Zonasi Wilayah Pesisir dan Pulau-pulau Kecil Kabupaten Takalar*; Laporan Penelitian. Universitas Hasanuddin: Makassar, Indonesia, 2001.
25. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2012.* ; Badan Pusat Statistik (BPS) Kabupaten Takalar: Takalar, Indonesia, 2012.
26. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2004-2012.*; Badan Pusat Statistik (BPS) Kabupaten Takalar: Takalar: Takalar, Indonesia, 2004-2012.
27. BPS-Sulsel, *Sulawesi Selatan Dalam Angka 2012*. Badan Pusat Statistik Sulawesi Selatan (BPS-Sulsel): Sulawesi Selatan, Indonesia, 2012.
28. Malik, A.; Fensholt, R.; Mertz, O., Mangrove Exploitation Effects on Biodiversity and Ecosystem Services. BIOC, under review.
29. Patton, M., *Qualitative Evaluation and Research Methods*. Sage: Baverly Hills, CA, 1990 p532.
30. Pearce, D.; Moran, D., *The Economic Value of Biodiversity*. Earthscan: UK, 1994.
31. UNEP, *Guidelines for conducting economic valuation of coastal ecosystem goods and services*. UNEP/GEF/SCS Technical Publication 2007.
32. KKP-Indonesia, *Statistical Data of Marine and Fisheries* Kementerian Kelautan dan Perikanan (KKP) Indonesia http://statistik.kkp.go.id/ (Accessed 1 March 2013): Jakarta, Indonesia, 2012.
33. Ong, J. E., Mangroves – a carbon source or sink. *Chemosphere* **1993,***27*, 1097-1107.
34. Diaz, D.; Hamilton, K.; Johnson, E., *Forest Carbon Market 2011: From Canopy to Currency*. Forest Trend Ecosystem Marketplace: Washington DC 2011; p 93.
35. Mayudin, A., Kondisi Ekonomi Pasca Konversi Hutan Mangrove menjadi Lahan Tambak di Kabupaten Pangkajene Kepulauan Propinsi Sulawesi Selatan. *Eksos* **2012,***8* (2), 90-104.
36. Sathirathai, S.; Barbier, E. B., Valuing Mangrove Conservation in Southern Thailand. *Contemporary Economic Policy* **2001,***19* (2), 109-122.
37. Sribianti, I., Valuasi Ekonomi Hutan Mangrove: Studi Kasus Valuasi Ekonomi Kawasan Hutan Mangrove Malili Kabupaten Luwu Timur *Jurnal Sains & Teknologi* **2008,***8* (3), 186-192.
38. Hong, P. N., Impact of Shrimp Culture Extension on Environmental and Biodiversity resources in Marsh of Coastal Zone. *Journal of Fisheries* . **1995,***3*, 6-9 and 25.
39. Harahab, N., *Penilaian Ekonomi Ekosistem Hutan Mangrove dan Aplikasinya dalam Perencanaan Wilayah Pesisir*. Graha Ilmu Publisher: Yogyakarta, Indonesia, 2010.
40. Lan, T. D., Coastal aquaculture and shrimp farming in North Vietnam and environmental cost estimation. *Aquatic Ecosystem Health & Management* **2009,***12* (3), 235-242.

41. Gunawardena, M.; Rowan, J. S., Economic Valuation of a Mangrove Ecosystem Threatened by Shrimp Aquaculture in Sri Lanka. *Environmental management* **2005,***4*, 535-550
42. Setyawan, A. D.; Winarno, K., Pemanfaatan Langsung Ekosistem Mangrove di Jawa Tengah danPenggunaan Lahan di Sekitarnya; Kerusakan dan Upaya Restorasinya. *Biodiversitas* **2006,***7* (3), 282-291.
43. Ong, J. E.; Gong, W. K., *Structure, Function and Management of Mangrove Ecosystems* International Society for Mangrove Ecosystems (ISME) Okinawa, Japan, and International Tropical Timber Organization (ITTO Yokohama, Japan.: 2013.
44. Mazda, Y.; Magi, M.; Kogo, M.; Hong, P. N., Mangroves as a coastal protection from waves in the Tong King delta, Vietnam. *Mangroves and Salt Marshes* **1997,***1* (2), 127-135.
45. Hajramurni, A. Abrasion speed in Takalar hits 100 meters a year. http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html (accessed March 13, 2013).
46. Halim, A. Kerusakan Mangrove Memiskinkan Warga. http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga (accessed March 13, 2013).
47. Pirzanet, A. M.; Gunarto; Daud, R.; Utoyo; Kabangnga, N. *Pemantapan Budidaya Kepiting Bakau untuk Mengantisipasi Dampak Penangkapan di perairan Sungai Lamuru, Kabupaten Bone*; Balai Penelitian Perikanan Pantai: Maros, Indonesia, 1999.
48. Gunarto, Konservasi mangrove sebagai pendukung sumberdaya hayati perikanan pantai *Jurnal Litbang Pertanian* **2004,***23* (1).
49. Sasekumar, A.; Chong, V. C.; Leh, M. U.; D'Cruz, R., Mangroves as a Habitat for Fish and Prawns. *Hyrobiologia* **1992,***247*, 195-207.
50. Salem, M. E.; Mercer, D. E., The Economic Value of Mangrove: A Meta-Analysis. *Sustainability* **2012,***4*, 359-383.
51. Jusoff, K.; Taha, D., Managing Sustainable Mangrove Forests in Peninsular Malaysia. *Journal of Sustainable Development* **2008,***1* (1).
52. Prakash, M.; Sivakumar, T., A study on antibacterial activity of mangrove plant Excoecaria agallocha L. *International Journal of Current Microbiology and Applied Sciences* **2013,** *2* (8), 260-262.
53. Bandaranayake, W. M., Traditional and medicinal uses of mangroves. *Mangroves and Salt Marshes* **1998,***2*, 133-148.
54. Frost, R., Dwindling Indian Sundarban Mangrove: The Way Out. *Science and Culture* **2010,***76* (7–8), 275-282.
55. MAP-Indonesia *Kajian Risilian (Situational and contextual field assessment and analysis-Restoring Coastal Livelihood Project)*; Mangrove Action Project (MAP) Indonesia: Sulawesi Selatan, Indonesia, 2011.
56. Sigit, R. R. Ekonomi Lingkungan: Pilih Mangrove atau Tambak. http://www.mongabay.co.id/2013/10/25/ekonomi-lingkungan-pilih-mangrove-atau-tambak/ (accessed January 5, 2013).

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Article

Economic Valuation of Mangroves for Comparison with Commercial Aquaculture in South Sulawesi

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Abstract: Mangroves are recognized as a provider of a variety of products and essential ecosystem services that contribute significantly to the livelihood of local communities. However, over the past decades, mangroves in many tropical areas including the Takalar district, South Sulawesi have degraded and decreased mainly due to conversion to aquaculture. Currently, little is known about the economic benefits of commercialization of aquaculture as compared to those derived from mangroves in the form of products and services. Here, we estimate the Total Economic Value (TEV) of mangrove benefits in order to compare it with the benefit value of commercial aquaculture. Market prices, replacement costs, benefit transfer value and Cost-Benefit Analyses (CBA) have been used for value determination and comparison. The results show that the per year TEV of mangroves ~~during the study period~~in the stud~~ied site~~y area (Takalar district, South Sulawesi) was in the range of ~~IDR 41,501,241,298 – 100,666,954,298 (USD~~4,370 ~~,368,582~~kUSD (USD x 1000) ~~(USDx1,000,000) –~~ to 1~~0,596,552~~0,597 kUSD~~)~~ or ~~IDR 38,165,377 – 72,584,058 (USD~~4 ~~,018~~kUSD ~~(USDx1,000) –~~ to ~~7,641~~8 kUSD ~~)~~per hectare ~~,~~ (the highest value contribution derived from the indirect use value (94%)), whereas the commercial aquaculture ~~in the studied area~~had a net benefit value of ~~IDR 2,163,910,500 (USD~~22~~7,780~~8 kUSD ~~)~~ or ~~IDR 31,361,022 (USD~~3 ~~,301~~kUSD ~~)~~per hectare. In addition, the comparison of Net Present Value (NPV) between the benefit value of mangroves and that of commercial aquaculture revealed that conversion of mangroves into commercial aquaculture was not economically beneficial when the analysis was expanded to cover the costs of environmental and forest rehabilitation.

Keywords: Economic valuation; mangroves; commercial aquaculture; Indonesia; South Sulawesi.

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1. Introduction

One of the crucial issues in development based on the use of natural resources is how to integrate economic development on the one hand with natural resources and environmental sustainability on the other in order to mitigate negative impacts and problems in future [1]. In principle, development should take place by utilizing the natural resources optimally [2]. In many countries, development is considered inevitable as a way to improve the welfare of communities. Unfortunately, failure to take into account the costs and benefits of the use of natural resources, which leads to negligence in decision-making, is still common and currently, we are facing an increasing scarcity of the resources necessary to support local livelihoods [3].

Mangroves, which are considered an important natural resource, occupy coastal and estuarine areas in many tropical places, provide goods and services for both direct use (e.g. timber, firewood, charcoal, Nypa palm leaves for crafting, wood chips, fisheries, food, medicines, material construction and tourism and recreational areas) and indirect use (e.g. coastline protection, prevention of seawater intrusion, provision of nursery and breeding grounds for fish, supply of nutrients for marine life, biodiversity maintenance and carbon sequestration) that have contributed significantly to community livelihoods [4].

Although mangroves provide a variety of products and services, they have been under great pressure due to decision making commonly based on assumptions of larger net benefits without considering the loss of wider mangrove services [5] and natural capital stocks [6]. Mangrove products and services are often undervalued [7,8] or even ignored in the economy and by industry and local inhabitants [9]. Consequently, nearly half of the total mangrove areas in the world have been lost over the past decades, with the largest areas of decline in Asia [10,11,12]. In Indonesia (which has the largest mangrove areas in the world), mangroves are threatened primarily by aquaculture but also by overharvesting of timber, firewood collection, charcoal production and conversion to other land uses such as agriculture, urbanization, mining and salt ponds [12,13,14,15]. Mangrove areas are characterized by some of the most rapid loss rates of coastal ecosystems in Indonesia; from 1980 to 2003, at least 1.1 million hectares of mangrove were lost, with 75 % of these areas being converted to shrimp ponds [12,16]. High economic revenues from the increase in exports and foreign trade in shrimp have become the main driving forces for the expansion of shrimp ponds by clearing mangroves [14]. In 2012, for instance, shrimp exports from Indonesia were valued at ~~USD~~ 1,304,149 ~~,000~~kUSD (USD x 1,000), of which 38 percent went to the United States of America (USA), 29 percent to Japan, 9 percent to European countries and 24 percent to other countries [17]. In South Sulawesi, the value of shrimp exports in 2011 reached ~~USD~~ 42,407~~,000~~ kUSD [15]. Since the early 1990s, Indonesia has become one of the major shrimp producing and exporting countries in the world [18]. However, the expansion of shrimp export which mostly comes from aquaculture production has triggered a heated debate in Indonesia as well as in other exporting countries such as Thailand due to the significant consequences for coastal areas [19,20].

Evaluation of the value of mangrove products and services affected by shrimp pond expansion is therefore important as a vehicle to integrate both ecological perspectives and economic considerations [21]. Such an evaluation will support reliable instruments that can be used to shift focus towards a green economy and guide policy makers to make sustainable decisions about mangrove utilization [4,2,22]. In addition, it is one way to increase knowledge and awareness among stakeholders of the importance of the mangrove ecosystem for sustainable and environmentally friendly economic development [23].

Economic valuations of mangroves have been conducted in many areas of the world [9]. However, little attention has been paid in the scientific literature to an economic valuation of mangroves in areas threatened by commercial aquaculture development in Indonesia and other Asian countries and to the discussion of the economic benefits of aquaculture as compared to mangroves as a provider of a variety of products and environmental services. This paper aims to estimate the TEV of mangrove, including estimations of Direct Use Value (DUV), Indirect Use Value (IUV) and Option Value (OV), to enable a direct comparison with the benefit value of commercial aquaculture for a case study area in southern South Sulawesi, Indonesia using the CBA method. Given the threat of aquaculture expansion, information from such analyses is critical as the net benefit value generated from mangroves is currently not considered by policy makers dealing with sustainable management of mangroves.

2. Study Area

Takalar district is located in southern South Sulawesi, Indonesia (between latitude 5°12’ - 5°38’ and longitude 119°10’- 119°39’, see figure 1), 45 km from Makassar city (the capital of South Sulawesi). The district has a coastline of 74 km [24], occupied by mangroves, coral reefs, sea grass, sandy beaches, rocky beaches, estuaries, aquaculture ponds, rice fields and tourism and residential areas. Most areas of Takalar are plain and coastal areas (including small islands) with an altitude of 0 - 100 metres above sea level and the rest are hilly areas [25]. The district covers 566.51 km^2 and is divided into nine sub districts (Galesong, South Galesong, North Galesong, Mangarabombang, Mappakasunggu, Pattalassang, South Polongbangkeng, North Polongbangkeng and Sanrobone). Mappakasunggu consists of a mainland part and small islands (Tanakeke, Lantangpeo, Bauluang, Satangnga and Dayang dayangan). The population is 272,316 and the population density is 481 persons per km^2. Mean temperatures vary from 23˚C - 33˚C and the monthly precipitation average over the past eight years (2004 – 2011) has been between 174 mm and 712 mm; the greatest amount of precipitation occurred in 2008 from November to March [26].

The selected study area represents one of the hot spots of mangrove rich environments in Indonesia. However, the region is ~~characterised by~~being amongst the largest producers of aquaculture product in South Sulawesi [27] and ~~in past decades,~~ mangrove ~~s~~forest ~~in this area have~~ has degraded and decreased in past decades, mainly due to the intensification of ~~conversion to~~ aquaculture. About 2,593 hectares (77.4%) of the total mangrove forest area has been changed to aquaculture, mainly on Tanakeke Island and in Banyuanyara village. Currently, the total extent of intact mangrove forest is 1,719 hectares and covers the sub districts of Mappakasunggu, Mangarabombang, Pattallassang, Sanrobone, Galesong, South Galesong and North Galesong [15]. Mangroves in this region are dominated by saplings and seedlings and comprise 10 species (*Avicennia alba, Bruguiera gymnorrhiza, Ceriops tagal, Excoecaria agallocha, Lumnitzera racemosa, Nypa fruticans, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa* and *Sonneratia alba*). The most dominant species has been *Rhizophora mucronata*, followed by *Sonneratia alba*. The Diameter at Breast High (DBH) of mangrove trees is between 6.37 cm and 23.57 cm and the diameter size classes of 10 – 15 cm are dominant, followed by 15 – 20 cm [28].

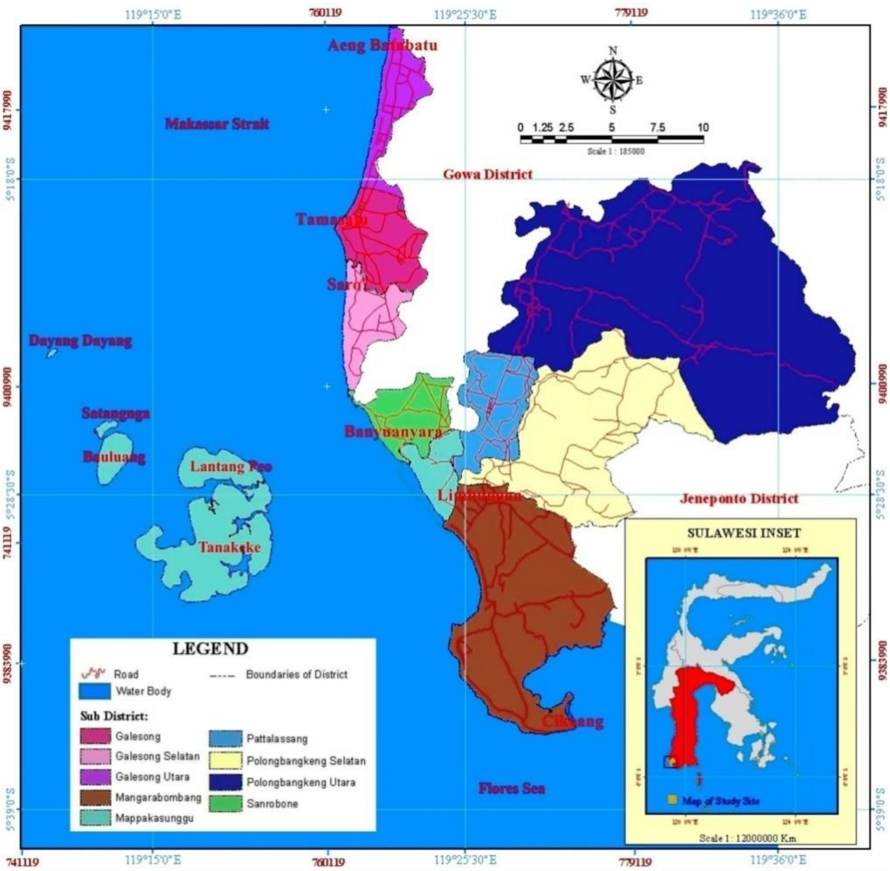

Figure 1. Map of the Takalar District Study Area, South Sulawesi, Indonesia

3. Materials and Methods

3.1. Data Collection

Household Surveys

Data on direct use of mangrove products and aquaculture were produce from household surveys by use of questionnaires. ~~93~~Ninety-three households were selected by a Purposive Sampling method [29] and all households had a direct relation to, and dependence on mangrove forests (fishermen, shrimp farmers, firewood collectors, charcoal producers and Nypa palm crafters). The survey was conducted in 10 areas covering the islands of Lantangpeo, Tanakeke, Bauluang and Satanga (sub-district of Mappakasunggu), and the villages of Laikang (sub-district of Mangarabombang), Limbungan (sub-district of Pattallassang), Banyuanyara (sub-district of Sanrobone), Sa'ro (sub-district of South Galesong), Tamasaju (sub-district of Galesong) and Aeng Batu-batu (sub-district of North Galesong) (Figure 1). The areas were selected based on the criteria that mangrove forests should be present and utilized by communities for fishery and forestry production.

3.2. Data Analysis

3.2.1. Economic Valuation of Mangrove

The TEV of mangroves was calculated from monetary values of the DUV, IUV and OV of mangroves [30,4,31], and TEV values are reported in percentage. The DUV of mangroves was derived from benefit values of fishery products (fish, crab and shrimp capture) and forestry products (firewood collection, charcoal production and Nypa palm crafting), which have been estimated using market prices [4,31] and the following formulas:

- Fish, crab and shrimp capture values (FV;CV; SV)

  FV; CV; SV = Production (kg/yr) x Price (~~IDR~~USD/kg) – Production cost (~~IDR~~USD) (1)

- Firewood value (FwV)

  FwV = Wood collection (bundle/yr) x Price (~~IDR~~USD/bundle) – Production cost (~~IDR~~USD) (1 bundle = 100 stems with a length of 1 m and a diameter of 4 to 8 cm) (2)

- Charcoal value (CcV)

  CcV = Production (sack/yr) x Price (~~IDR~~USD/sack) – Production cost (~~IDR~~USD) (1 sack = 25kg) (3)

- Nypa palm crafting value (NpcV)

  NpcV = Production (piece/yr) x Price (~~IDR~~USD/piece) – Production cost (~~IDR~~USD) (4)

The IUV of mangroves is derived from benefit values of mangrove services such as coastline protection, seawater intrusion prevention, provision of nursery grounds and carbon sequestration. These benefit values were estimated using replacement costs and benefit transfer methods [4,31]. The coastline protection service was estimated by the cost of breakwater construction over a 10-year project lifespan; the seawater intrusion prevention service was assessed by the cost of the water supply needs of people if the availability of fresh water was reduced due to mangrove loss; the provision of nursery grounds service was estimated by foregone benefit from fishery according to the KKP-Indonesia (Ministry of Marine and Fisheries of Indonesia) [32], who reported the average loss volume of fish catch in South Sulawesi include Takalar district of 1,211 tons per year during the period 2003 - 2011. Finally, carbon sequestration was estimated by using transferring rates of carbon storage of mangrove (100 - 200 tons C/ha) from Ong [33]. The price of carbon credits (USD 5.5/tCO_2) is based on Diaz et al. [34]. Calculation of IUV is conducted using the following formulas:

- Coastline prevention value (CPV)

CPV = coastal length (m) x cost of breakwater construction (USDIDR) (5)

Coastal length = 74,000 m; The cost of breakwater construction has been reported to range between IDR 1,530,880/m^3(USD158 USD/m^3)[35] and IDR 8,312,500/m^3(USD 875 USD/m^3) [36].

- Seawater intrusion prevention value (SwIPV)

SwIPV = household population x number of water supply (gallon/day) x Price (IDRUSD/gallon) x 365 days (6)

- Provision of nursery grounds value (PNGV)

PNGV = loss volume of fish catch (kg/yr) x fish price (IDRUSD/kg) / total loss of mangrove area during the period 2003 - 2011 (612 ha) from Malik et al. [15] (7)

- Carbon sequestration value (CSV)

CSV = carbon sequestration rate (100 - 200 tonC/ha) x total area of mangrove (1,719 ha) x price of carbon market (USD 5.5/tonCO_2) (8)

The OV of mangroves was calculated using the benefit transfer value method [4,31,23]. The benefit values of medicinal material from mangrove ecosystems was estimated by transferring the available value from Sribianti [37], who studied in East Luwu district, Indonesia. The annual benefit was IDR1,500,000 (USD157 USD) per hectare [37].

3.2.2. Commercial Aquaculture

The economic value of aquaculture (AV) was calculated using the formulas:

Total area of aquaculture (ha) = number of farmers (23 farmers) x area of aquculture per farmer (3 ha) (9)

Investment cost = cost construction (IDRUSD/ha) + farming equipment (IDRUSD/unit) x total area of aquaculture (ha) (10)

Production cost = fixed cost (e.g. equipment depreciation) (IDRUSD/unit) + variable cost (fry, feed, fertilizer, fuel, etc) (IDRUSD/unit) x total area of aquaculture (ha) (11)

Benefit of AV = production (kg/ha/yr) x price (IDRUSD/kg) x total area of aquaculture (ha) (12)

Net Benefit/yr of AV = benefit of AV (IDRUSD/yr) – (investment cost + production cost) (IDRUSD/yr) (13)

Net benefit/ha/yr of AV = net benefit of AV (IDRUSD/yr) / total area of aquaculture (ha) (14)

3.2.3. Cost-Benefit Analysis (CBA)

CBA is conducted to compare economic value of mangrove with commercial aquaculture, to address assess whether converting mangrove forest into commercial aquaculture is economically feasible. CBA is used to determining the NPV of internal costs and benefits of commercial aquaculture. Based on Malik et al. [15], tThe project life span of aquaculture was found to be five years on average in this the study area [15]. Several studies (e.g. [38,4,36,39]) have observed that shrimp production decreases successively after the fifth year due to the lower survival rate of shrimp. Hence, the production of shrimp over a 10-year project period also decreases by 5 – 20% and investment and production costs increase to sustain shrimp production [39]. However, aquaculture involves external costs including environmental cost (water pollution cost) related to the high salinity content of the water released from the ponds, agrochemical runoff and forest rehabilitation cost for land degradation [36]. Thus, CBA is required to including also the NPV of external cost. The value of environmental cost was adopted from Lan [40], who reported that the production of 360,000 tons of shrimps generates an environmental cost of ~~USD~~ 280 million USD (1 kg shrimp produced = USD 1.28), whereas the forest rehabilitation cost was estimated from seed provision, planting and maintenance costs [39]. The forest rehabilitation cost was estimated from year 6 to year 10.

Furthermore, CBA is required to determine the NPV of mangroves from fishery and forestry, medicines and mangrove services over a 10-year project period using the cost and benefit values of each products and services based on an average age of the present mangrove (17 years) [28] and duration of exploitation of mangrove by local communities. Whereas the exploitation of mangrove for fishery and forestry products has been ongoing during past several decades, the most intensive exploitation has occured over the past 20 years [15]. A discount rate of 10% was used in the CBA reflecting the predominant cost of the loan interest rate at financial institutions when the survey was conducted [41;39]. The formula for calculating the NPV is as follows: [31]

$$\mathrm{NPV} = \sum_{i=1}^{n} \frac{\mathrm{Bit}-\mathrm{Cit}}{(1+r)^{t}} \text{ (Ordinary CBA)}$$

$$\mathrm{NPV} = \sum_{i=1}^{n} \frac{(\mathrm{Bit}+\mathrm{EBit})-(\mathrm{Cit}-\mathrm{ECit})}{(1+r)^{t}} \text{ (Extended CBA)} \tag{15}$$

Where:

NPV = Net Present Value
B = annual gross benefit; EB = annual extended benefit
C = annual gross cost; EC = annual extended cost
r = discount rate
i = each benefit or cost
t = period of time

Criteria: NPV > 0: financially feasible; NPV = 0: impasse; and NPV <0: not financially feasible.

Environmental cost = shrimp production (kg/ha/yr) x USD 1.28 x total area of shrimp ponds (ha) (16)

Forest rehabilitation cost = seed provision cost (~~IDR~~USD/ha) + planting cost (~~IDR~~USD/ha) + maintenance cost (~~IDR~~USD/ha) x total area of aquaculture (ha) (17)

4. Results and Discussion

4.1. DUV of mangroves

In past decades, people who lived around mangroves in this area were highly dependent on mangroves for various fishery and forestry products for domestic and commercial purposes. In fisheries, mangrove forest has benefits for the capture of fish, crab and shrimp as well as aquaculture, whereas in forestry, benefits related to the collection of firewood, charcoal production and Nypa palm leaf crafting are generated.

The results of the household survey showed that 43 households have been directly using mangrove for fish capture, six for crab capture, and six for shrimp capture. They are using traditional fishing gear such as fishing rods, fishing nets, fish/crab traps and scoop. Annually, fish capture is conducted during 8 months (February - September), when sea conditions are good, whereas the remaining 4 months (October - January; characterized by high waves and strong winds) are used to rest, repair boats and fishing gear or engage in alternative work [15]. Eight households have been using mangrove for harvest firewood, three for charcoal production and four for Nypa palm leaf crafting. The production averages of fish, crab and shrimp capture per household per year are 2,450 kg, 338 kg, and 213 kg, respectively. The production of firewood, charcoal and handcrafts such as roofs, walls, floor mats, baskets and especially hats from Nypa palm leaves per household per year amounted to 60 bundles, 720 sacks and 6,750 pieces, respectively. The total of fish, crab and shrimp production was 105,350 kg/year, 2,028 kg/year and 1,278 kg/year, respectively. Harvested mangrove forests for firewood reached 480 bundles per year, charcoal production was 2,160 sacks per year and handcrafting produced 27,000 pieces per year.

The highest benefit of DUV was obtained from fish production, earning ~~IDR 498,850,000 (USD~~5~~2,511~~3 kUSD ~~)~~(USD x 1,000) per year, followed by charcoal production for ~~IDR 83,685,600 (USD~~9 kUSD~~8,809)~~ per year (numbers rounded to the nearest thousand in text as compared to table values throughout the paper for improved readebility). Thus, the total benefit of the DUV of mangrove ecosystem is ~~IDR 777,621,600 (USD~~8~~1,855~~2 kUSD~~)~~ per year (Table 1).

Table 1. The Direct Use Value (DUV) of mangrove ~~s~~in the Takalar district, South Sulawesi

No.	Products	Household users (n=70)	Net use value (USD/yr)	Net use value/household (USD/yr)	Net use value (USD/ha/yr)
Fishery products					
1	Fish capture	43	52,511	1,221	31
2	Crab capture	6	6,531	1,088	4
3	Shrimp capture	6	2,822	470	2
	Sub Total of DUV =		61,863		36
Foresty products					
1	Firewood	8	3,379	422	2
2	Charcoal	3	8,809	2,936	5
3	Nypa palm crafting	4	7,804	1,951	5
	Sub Total DUV =		19,992		12
	Total of DUV =		81,855		48

Total area of mangrove = 1,719 ha

A large number and variety of fish species and other marine species use the mangroves fornursery, spawning and feeding grounds [42]. The main fish, shrimp and crab species available for fishery in the mangrove area include small pelagic fish, snapper (*lates calcarifer*), milkfish (*Chanos chanos*), white shrimp (*Pennaeus vannamei*) and mud crab (*Scylla sp*.). Furthermore, the harvest of mangroves for home consumption and firewood and charcoal for commercial use are mostly derived from *Rhizophora sp*., whereas leaves of *Nypa fruticans* are used for handcrafts such as hats, floor mats, baskets, roofs and walls.

Even though fish capture is the dominant source of revenue for the local population and the highest generator of net benefit per year (~~IDR 498,850,000 = USD~~5~~2,511~~3 kUSD), the highest net benefit value per household per year (~~IDR 27,895,200 = USD2,936~~3 kUSD) is derived from charcoal production. Over the last decades, clearing mangrove to expand shrimp ponds has been wide spread in this area, causing mangrove areas to decrease and degrade rapidly, which in turn has led to a decrease in fish production and fishermen's income [15].

4.2. IUV of mangroves

Besides providing a variety of products, mangrove forest supports ecological services by protecting the coastline from exposure to waves, preventing seawater intrusion and providing nursery grounds and carbon sequestration [43]. Mazda et al. [44] stated that the stand of *Kandelia candel* (six years old) can reduce waves with an offshore height of 1 m to 0.05 m when they reach the shore. Hajramurni [45] and Halim [46] revealed that abrasion and seawater intrusion occurred in several places in the region where mangrove is absent. Abrasion was found along the coast in six sub districts of Takalar district (Mappakasunggu, Mangarabombang, Sanrobone, South Galesong, Galesong and North Galesong), reaching 20 - 100 metres per year over the past five years. Moreover, seawater intrusion into inland areas has made growth conditions difficult for local crops such as banana. Furthermore, Pirzanet et al. [47] and Gunarto [48] found that 17 commercial fish species inhabit and use mangroves as nursery grounds in Lamuru Estuary, Bone district, South Sulawesi while 27 commercial fish species do so in the Tongke-tongke mangrove forest area and Sinjai district. In Selangor, Malaysia, Sasekumar et al. [49] noted that many species of fish (119) and prawn (9) inhabit and use mangrove as nursery and feeding grounds. In addition, Ong [33] reported that mangrove could store 100 – 200 ton C/ha above ground, whereas below ground carbon can reach 700 ton C/1 m soil thickness/ha (with an estimated carbon sink rate of 1.5 ton C/ha/yr).

In this case study area, the net benefit values of these mangrove services have been estimated using the replacement cost and benefit transfer methods. Annual values of prevention of coastline erosion and seawater intrusion provided by mangroves were estimated to be ~~to be~~in the range of ~~IDR 11,328,512,000 (USD~~1,192 ~~,475~~kUSD ~~)~~to ~~61,512,500,000 (USD~~ 6,475 kUSD ~~,000)~~or ~~IDR 6,590,176/ha (USD~~694 USD/ha~~)~~ to ~~35,783,886/ha (USD~~ 3,767 USD/ha ~~)~~and ~~IDR 4,523,080,000 (USD~~476 kUSD~~,114)~~ or ~~IDR 2,631,227/ha (USD~~277 USD/ha~~)~~, respectively. ~~The value of coastline protection services is dominatedbythe TEV of mangrove.This finding is similar in Thailand as reported by Barbier et al.[8].~~Provision of nursery ground service was estimated to

~~amount to~~~~IDR 13,326,364,198 (USD~~1,403 ~~2,775~~kUSD~~)~~ or ~~IDR 21,775,105/ha (USD~~2,292 USD/ha~~)~~. Furthermore, carbon sequestration services ~~was~~ were estimated to be in the range of ~~to IDR 8,981,775,000 IDR 17,963,500,000 (USD~~945 kUSD ~~,450 to~~ to ~~USD~~ 1,891 ~~0,895~~kUSD~~)~~ or ~~IDR 5,225,000/ha – IDR 10,449,971/ha (USD~~550 USD/ha ~~–~~to ~~– USD~~ 1,100 USD/ha~~)~~. Thus, annually the aggregate benefit of IUV mangroves was in the range of ~~IDR 38,159,731,198 – IDR 97,325,444,198 (USD~~4,017 ~~m~~kUSD ~~,016,814~~to ~~– USD~~ 10,245 ~~m~~kUSD ~~,244,784)~~or ~~IDR 36,221,508/ha – IDR 70,640,189/ha (USD~~3,813 USD/ha to ~~– USD~~ 7,436 USD/ha ~~)~~(Table 2).

Some studies have reported benefit values of such mangrove services and Sathirathai and Barbier [36] estimated the cost of constructing breakwaters to prevent coastal erosion in Southern Thailand to be ~~USD~~ 3,679 USD/ha. Samonte-Tan et al. [23] estimated the benefit value of preventing coastline erosion and supplying nursery grounds from mangroves in the Bohol Marine Triangle, Philippines to be ~~USD~~672 USD/ha/yr and ~~USD~~243 USD/ha/yr, respectively. Harahab [39] calculated the annual benefit value of preventing seawater intrusion in Probolinggo district, East Java to be ~~IDR 68,227,500/ha/yr (~~USD 7 ~~,182~~kUSD/ha/yr~~)~~. In addition, Salem and Mercer [50] summarized the range of economic value of mangrove from coastal protection and carbon sequestration services ~~of~~is ~~USD~~ 10.45 ~~–~~to 8,044 USD/ha/yr and ~~USD~~ 39.89 ~~–~~to ~~USD~~ 4,265 USD/ha/yr, respectively.

Table 2. The Inderect Use Value (IUV) of mangrove ~~s~~in the Takalar district, South Sulawesi

No.	Services	Use value (USD/yr)	Use value (USD/ha/yr)
1	Coastline protection	1,192,475 – 6,475,000	694 – 3,767
2	Sea water intrusion prevention	476,114	277
3	Provision of nursery grounds	1,402,775	2,292
4	Carbon sequestration	945,450 – 1,890,895	550 – 1,100
	Total of IUV =	4,016,814 – 10,244,784	3,813 – 7,436

~~Exchange rate: USD1 = IDR 9,500;~~ Total area of mangrove = 1,719 ha

4.3. OV of mangroves

The ~~benefit values of mangrove as medicine is the~~ option value (OV) of mangrove ~~, which~~includes the future potential use of mangrove as a pharmaceutical resource [51]. Most mangrove plants have medicinal importance, such as *Avecennia sp.*, *Bruguiera sp.*, *Ceriops sp.*, *Excoecaria sp.*, *Rhizophora sp.*, *Sonneratia sp.* and *Xylocarpus sp.* [52,53]. Frost [54] reported that communities living in mangrove areas in Indian Sundarban have used *Rhizophora sp.*, *Excoecaria sp.* and *Bruguiera sp.* to treat angina, leprosy, and diarrhea and blood pressure, respectively. Jusoff and Taha [51] reported that the tree bark of *Rhizophora sp.* is commonly used to treat fractures, cure diarrhea and stop hemorrhages. In addition, Prakash and Sivakumar [52] stated that dried plant samples of *Excoecaria agallocha* prevent pathogenic bacteria. Mangroves are furthermore a rich source of steroids, triterpenes, saponins, flavonoids, alkaloids and tannins [53].

By transferring benefit values of medicine material of mangroves in East Luwu district Indonesia [37], the estimation of the annual benefit value of medicinal material in this area was ~~IDR 2,563,888,500(USD269~~270 kUSD~~,883)~~ (mangrove extent of 1,719 ha) or ~~IDR 1,491,500 (USD~~157 USD~~)~~ per hectare (Table 3). However, over the past decades mangroves in the study area have degraded, leading to depletion of their composition and diversity [28]. Nonetheless, the economic value of medicinal material in this area is quite high and many species commonly used for medicine are available, such as *Avicennia sp.*, *Bruguiera sp.*, *Ceriops sp.*, *Excoecaria sp.*, *Sonneratia sp.*, and especially *Rhizophora sp.* [28].

Table 3. The Option Value (OV) of mangrove ~~s~~in the Takalar district, South Sulawesi

No	Option value	Total use value (USD/yr)	Total use value (USD/ha/yr)
1	Medicines	269,883	157

4.4. TEV and NPV of Mangroves

On the basis of the sum values of the DUV, IUV and OV, the annual benefit of the TEV of mangroves ~~is~~ varies ~~estimated to~~in the range ~~of varies~~ between ~~be~~~~IDR 41,501,241,298 – 100,666,954,298 (USD~~ 4,370 ~~68,582~~kUSD ~~–~~and 10,59~~6,552~~7 kUSD~~)~~ or ~~IDR 38,165,377 – 72,584,058 (USD~~4 ~~,018~~kUSD/ha ~~–~~and 8 ~~7,641~~kUSD~~)~~/ha ~~per hectare~~(Table 4). In addition, the NPVs per hectare for all three values (~~the~~ DUV, IUV and OV) of mangroves benefits (over a 10-year time period with a discount rate of 10%) were ~~IDR 2,572,943 (USD~~ 271 USD (DUV)~~)~~, ~~,IDR 126,260,406 – 322,024,022 (USD~~in the range between 13 kUSD ~~,291~~and ~~–~~34 kUSD (IUV), ~~3,897)~~and ~~IDR 8,483,225(USD~~893 USD (OV), respectively ~~)~~(Table 5).

The largest benefit value of mangroves (94%) and the highest NPV are derived from the IUV, including the values of coastline protection, seawater intrusion prevention, nursery ground provision and carbon sequestration. The value of coastline protection services ~~is~~dominates ~~dominated by~~~~in~~ the TEV of mangrove in the current study. This finding is similar to observations from ~~in~~ Thailand as reported by Barbier et al. [8].

This suggests that the ecological functioning of mangrove has an important role in supporting local people's livelihoods [7]. Currently, there is a lack of awareness in local communities concerning the value of such benefits. People are driven by urgent needs and quick and real benefits that can be easily obtained by exploiting mangroves; they may tend to disregard the sustainability and the greater benefit value provided by this resource. In addition, the lower values of the DUV and OV as compared to the IUV suggest that the mangroves have been degraded and have decreased, thereby impacting fishery and forestry production.

Table 4. The Total Economic Value (TEV) of mangrove ~~s~~in the Takalar district, South Sulawesi

No.	Economic use value	Use value (USD/yr)	Use value (USD/ha/yr)	%
1	DUV	81,885	48	2
2	IUV	4,106,814 – 10,244,784	3,813 – 7,436	94
3	OV	269,883	157	4
	TEV	4,368,582 – 10,596,552	4,018 – 7,641	100

Total area of mangrove = 1,719 ha

Table 5. The Net Present Value (NPV) of mangrove ~~s~~in the Takalar district, South Sulawesi

NPV	DUV	IUV	OV
NPV (~~IDR~~USD)	~~4,422,889,286~~ 465,567	~~217,041,638,583~~22,846,488 – ~~553,559,294,612~~58,269,399	~~14,582,664,597~~1,535,017
~~NPV (IDR/ha)~~	~~2,572,943~~	~~126,260,406 – 322,024,022~~	~~8,483,225~~
NPV (USD/ha)	271	13,291 – 33,897	893

Total area of mangrove = 1,719 ha

4.5. Benefit value of commercial aquaculture and comparison to economic value of mangroves

Interviews of 23 aquaculture farmers revealed that aquaculture ponds in the study area have been constructed (to an average extent of 3 hectares) by clearing mangrove forests. The types of aquaculture ponds found were monoculture of shrimp (3 ponds), monoculture of milkfish (3 ponds), polyculture of shrimp and milkfish (9 ponds) and polyculture of milkfish and seaweed, mainly from *Gracilaria sp*. (8 ponds). The total investment cost, including construction costs and equipment, for all pond areas were ~~IDR 543,549,500 (USD~~57 ~~,216~~kUSD~~)~~ (average cost per ~~shrimp~~ pond is about ~~IDR 23 million (USD~~2,488 USD~~)~~). Meanwhile, the total production cost, including fixed costs (e.g. equipment depreciation costs and taxes) and variable costs (e.g. costs of labour, seed, feed, fertilizer, fuel, etc.) for all pond areas was about ~~IDR 406,600,000 (USD~~43 ~~2,800~~kUSD ~~)~~(average per pond ~~IDR 17.6 million (USD~~1.860 USD~~)~~). Two annual harvests, shrimp production generated on average 422 kg/ha/yr, milkfish production, 6,700 kg/ha/yr, and seaweed production, 2,862 kg/ha/yr. The market prices of shrimp, milkfish and seaweed (*Gracilaria sp.*) were ~~IDR 55,000 (USD~~5.79~~)~~ USD/~~ per~~ kg, ~~IDR 15,000 (USD~~1.58 USD/~~) per~~ kg and ~~IDR 4,000 (USD~~0.42 USD/~~) per~~ kg, respectively. Thus, annually the net benefit amounts to ~~IDR 2,163,910,500 (USD~~228 kUSD~~7,780)~~ or ~~IDR 31,361,022/ha (USD~~3,301 USD/ha~~)~~ and the NPV of the revenue of aquaculture ponds per hectare during the 10-year project period (with a discount rate of 10%) is estimated to be ~~IDR 11,655,943(USD~~1,227 USD~~)~~ (Table 6).

This suggests that aquaculture is financially feasible and when compared to the NPV of the DUV and the OV of mangroves, the revenue is 4.5 and 1.4 times higher, respectively. However, when the comparison includes the NPV of the IUV of mangroves, the economic benefit value of mangroves providing environmental services (e.g. providing nursery grounds, protecting coastlines, preventing seawater intrusion, and carbon sequestration) were far higher (varies between 10.8 and– 27.6 times) as also reported by Rönnbäck [7]. When 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 becomes negative (USD -663/ha) or no longer economically beneficial (Table 6 and Figure 2).

In Indonesia, generally the expected levels of shrimp production are met during the first five years, after which production starts to decline and many shrimp farmers suffer from heavy economic losses, often leading to bankruptcy [55]. Consequently, many shrimp farms are abandoned as owners try to find new locations for farming [38]; a general pattern also observed in other Asian countries as reported by Bann [4] and Sathirathai and Barbier [36]. Abandoned shrimp ponds are exposed to abrasion and transforms into wastelands of limited value for other productive use such as agriculture due to very acidic and poor soil quality [36].

In summary, degraded and decreased areas of mangroves, water pollution caused by waste ponds and the loss of nursery, feeding and spawning grounds of marine organisms have become visible evidence of the environmental impacts of aquaculture development. If local environmental conditions are recoverable, the associated costs are very high and therefore, the economic benefit value of commercial aquaculture in the long term becomes questionable, as also discussed by [56].

Table 6. Benefit value of commercial aquaculture in the Takalar district, South Sulawesi

No	Description	Unit	Value
1	Investment	~~IDR~~USD	57,216~~543,549,500~~
2	Production cost	~~IDR~~USD/yr	42,800~~406,600,000~~
3	Production		
	Shrimp	Kg/ha/yr	422
	Milkfish	Kg/ha/yr	6,700
	Seaweed (*Gracilaria sp.*)	Kg/ha/yr	2,862
4	Market price		
	Shrimp	~~IDR~~USD/Kg	5.79~~55,000~~
	Milkfish	~~IDR~~USD/Kg	1.58~~15,000~~
	Seaweed (*Gracilaria sp.*)	~~IDR~~USD/Kg	0.42~~4,000~~
5	Benefit of AV	~~IDR~~USD/yr	327,796~~3,114,060,000~~
	Net benefit of AV	~~IDR~~USD/yr	227,780~~2,163,910,500~~
	Net benefit/ha/yr of AV	~~IDR~~USD/ha/yr	3,301~~31,361,022~~
6	NPV without external cost:		
	NPV	~~IDR~~USD	84,659~~804,260,088~~
	NPV	~~IDR~~USD/ha	1,227~~11,655,943~~
7	NPV with external cost:		
	NPV	~~IDR~~USD	-45,752~~-434,647,387~~
	NPV	~~IDR~~USD/ha	-663~~-6,299,237~~

~~Exchange rate: USD 1 = IDR 9,500~~

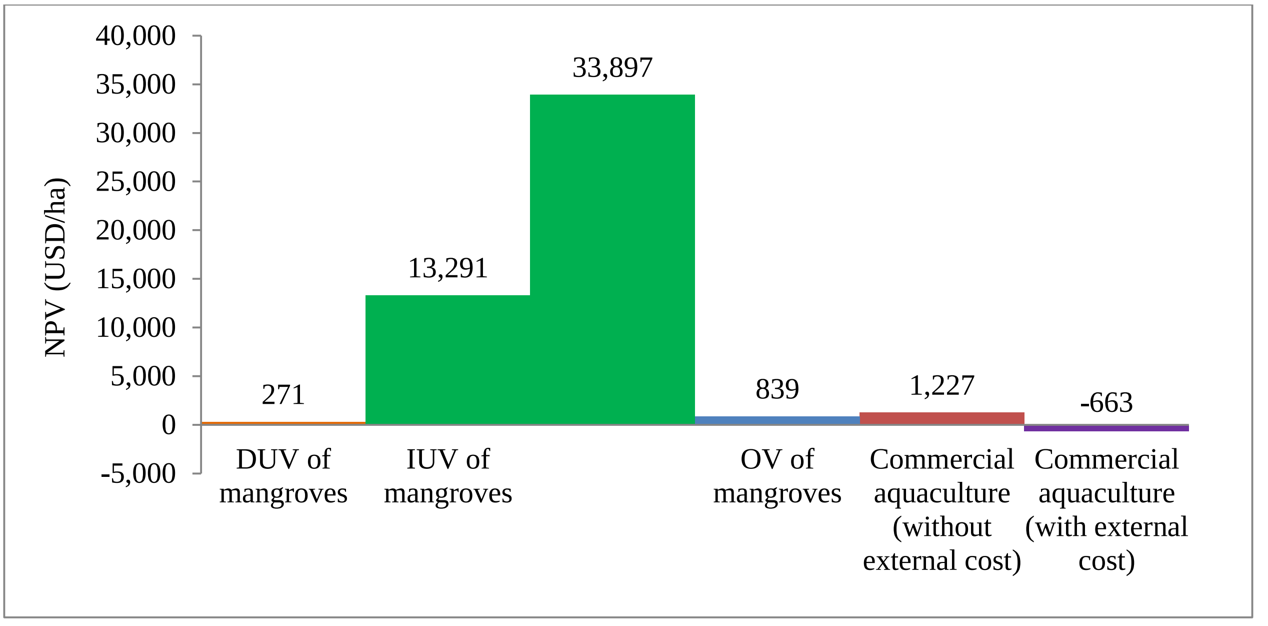

Figure 2. Comparison of the Net Present Value (NPV) of mangrove~~s~~ versus commercial aquaculture in the Takalar district, South Sulwesi.

5. Conclusions

~~This study has demonstrated thatthe annual TEV of mangrovebenefitsisIDR 41,501,241,298 – 100,666,954,298 (USD4,368,582 – 10,596,552) or IDR 38,165,377 – 72,584,058 (USD4,018 – 7,641) per hectare. The calculationincluded the DUV of mangroves (the benefit value of fisheries and forestry products), the IUV of mangroves (the benefit value of protecting the coastline, preventing seawater intrusion, acting as a nursery ground and carbon sequestration), and the OV of mangroves (benefit value of medicine). The highest contribution of the TEV of mangroves was derived from the IUV of mangroves (94%). The net benefit value of commercialaquaculture amounts to IDR 2,163,910,500 (USD227,780)or IDR 31,361,022 (USD3,301) per hectare. In addition, the NPVs per hectare for the DUV, IUV and OV and aquaculture were IDR 2,572,943 (USD271), IDR 126,260,406 – 322,024,022 (USD13,291 – 33,897), IDR 8,483,225 (USD893) and IDR 11,655,943 (USD1,227), respectively.~~ This study has demonstrated that the economic benefit value of mangrove ~~is economically beneficial rather than~~exceeds the economic benefit value of commercial aquaculture in the Takalar district, South Sulawesi. The highest contribution of the TEV (Total Economic Value) of mangroves was found to be derived from the IUV (Indirect Use Value) of mangroves (the benefit value of protecting the coastline, preventing seawater intrusion, acting as a nursery ground and carbon sequestration). T~~Although t~~The conversion of mangroves into commercial aquaculture ~~has~~was found to have a higher beneficial value than the DUV (Direct Use Value; the benefit value of fisheries and forestry products) and OV (Option Value; benefit value of medicine) of mangroves and at a first glance seems to be financially viable~~,~~. However, ~~but~~ when the IUV of mangroves is included in the comparison, the ~~benefit~~ value of mangroves is considerably higher. In addition, when the analysis of NPV (Net Present Value) was extended to include also the costs of environmental and forest rehabilitation, the revenue of aquaculture became negative ~~or~~ and thereby no longer economically beneficial.

The comparison of mangrove and commercial aquaculture economic benefit values ~~and commercial aquaculture~~ is essential in policy making ~~dealing with~~targeting sustainable management of mangroves. The approach, as presented in this study, ~~due to this information~~can be used ~~as consideration how~~ to put monetary values on ~~the~~ mangrove forest and aquaculture including ~~and allocation and formulation of~~also the ~~cost to account for the~~ environmental costs related to aquaculture development thereby providing a balanced economic valuation of conversion of mangrove forest into aquaculture.

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Author Contributions

Abdul Malik led the design of the study, conducted the field work and data analysis used for the economic valuation and wrote the first draft of the paper, with subsequent improvements by the co-authors.

Conflict of Interest

The authors declare no conflict of interest.

References

1. Fauzi, A., *Economics of Natural Resources and Environment. Theory and Applications*. PT Gramedia Pustaka Utama: Jakarta, Indonesia, 2004; p 259.
2. Suparmoko, M., *Neraca Sumberdaya Alam (Natural Resource Accounting)*. BPFE UGM: Yogyakarta, Indonesia, 2005.
3. Rukmana, D., *Ekonomi Lingkungan dan Sumberdaya Alam*. Penerbit Arus Timur Makassar, Indonesia, 2012.
4. Bann, C., *The economic valuation of mangroves _A manual for researchers*. Economy and Environment Program for Southeast Asia (EEPSEA): Singapore 1998
5. Barbier, E. B., Sustainable use of wetlands valuing tropical wetland benefits: economic methodologies and applications. *The Geographical Journal* **1993,***159*, 22-32.

6. Brander, L. M.; Wagtendonk, A. J.; Hussain, S. S.; McVittie, A.; Verburg, P. H.; Groot, R. S. d.; Ploeg, S. v. d., Ecosystem service values for mangroves in Southeast Asia: A meta-analysis and value transfer application. *Ecosystem Services* **2012,***1* (1), 62-69.
7. Rönnbäck, P., The ecological basis for economic value of seafood production supported by mangrove ecosystems. *Ecological Economics* **1999,** *29*, 235-252.
8. Barbier, E. B.; Koch, E. W.; Silliman, B. R.; Hacker, S. D.; Wolanski, E.; Primavera, J.; Granek, E. F.; Polasky, S.; Aswani, S.; Cramer, L. A.; Stoms, D. M.; Kennedy, C. J.; Bael, D.; Kappel, C. V.; Perillo, G. M. E.; Reed, D. J., Coastal Ecosystem-Based Management with Nonlinear Ecological Functions and Values *Science* **2008,***319*, 321-323.
9. Vo, Q. T.; Kuenzer, C.; Vo, Q. M.; Moder, F.; Oppelt, N., Review of valuation methods for mangrove ecosystem services. *Ecological Indicators* **2012,***23*, 431-446.
10. Curran, S., Migration, Social Capital, and the Environment: Considering Migrant Selectivity and Networks in Relation to Coastal Ecosystems *Population and Development Review* **2002,***28*, 89-125.
11. Giri, C.; Ochieng, E.; Tieszen, L. L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J.; Duke, N., Status and distribution of mangrove forests of the world using earth observation satellite data. *Global Ecology and Biogeography* **2011,***20* (1), 154-159.
12. FAO *The World's Mangroves 1980 – 2005*; Food and Agriculture Organization (FAO): Rome, Italy, 2007.
13. Onrizal, Perubahan Tutupan Hutan Mangrove di Pantai Timur Sumatera Utara Periode 1977 – 2006. *Jurnal Biologi Indonesia* **2010,***6* (2), 163-172.
14. Nurkin, B., Degradation of Mangrove Forests in South Sulawesi, Indonesia. *Hydrobiologia* **1994,***285*, 271-276.
15. Malik, A.; Fensholt, R.; Mertz, O., Consequences of Mangrove Forest Change in South Sulawesi. REEC, under review.
16. Forest-Ministry-Indonesia, *Luas Mangrove per Propinsi di Indonesia In Noor Y.R., Khazali M., Suryadiputra I N.N. Panduan Pengenalan Mangrove di Indonesia*. PHKA/WI-IP: Bogor, Indonesia. , 2006; p 219.
17. WGMFDA. *Kelautan dan Perikanan dalam Angka 2013*; Working Group of Marine and Fisheries Data Arrangement (WGMFDA). Centre of Data, Statistics and Information, Ministry of Marine and Fisheries of Indonesia: Jakarta, Indonesia, 2013.
18. GlobeFish. Food Market: Shrimp Production http://www.globefish.org. (accessed May 5, 2013).
19. Barbier, E. B., Habitat-Fishery Linkages and Mangrove Loss in Thailand. *Contemporary Economic Policy* **2003,***21* (1), 59-77.
20. Hogarth, P., *The Biology of Mangroves and Seagrass* 2ed.; Oxford University Press: New York, 2007.
21. Chee, Y. E., An Ecological Perspective on the Valuation of Ecosystem Services. *Biological Conservation* **2004,***120*, 549-565.
22. Beaumont, N. J.; Austen, M. C.; Mangi, S. C.; Townsend, M., Economic valuation for the conservation of marine biodiversity. *Marine pollution bulletin* **2008,***56* (3), 386-96.
23. Samonte-Tan, G. P. B.; White, A. T.; Tercero, M. A.; Diviva, J.; Tabara, E.; Caballes, C., Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines. *Coastal Management* **2007,***35* (2-3), 319-338.
24. Ukkas, M. *Pemetaan Potensi/Zonasi Wilayah Pesisir dan Pulau-pulau Kecil Kabupaten Takalar*; Laporan Penelitian. Universitas Hasanuddin: Makassar, Indonesia, 2001.
25. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2012.* ; Badan Pusat Statistik (BPS) Kabupaten Takalar: Takalar, Indonesia, 2012.
26. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2004-2012.*; Badan Pusat Statistik (BPS) Kabupaten Takalar: Takalar: Takalar, Indonesia, 2004-2012.

27. BPS-Sulsel, *Sulawesi Selatan Dalam Angka 2012*. Badan Pusat Statistik Sulawesi Selatan (BPS-Sulsel): Sulawesi Selatan, Indonesia, 2012.
28. Malik, A.; Fensholt, R.; Mertz, O., Mangrove Exploitation Effects on Biodiversity and Ecosystem Services. BIOC, under review.
29. Patton, M., *Qualitative Evaluation and Research Methods*. Sage: Baverly Hills, CA, 1990 p532.
30. Pearce, D.; Moran, D., *The Economic Value of Biodiversity*. Earthscan: UK, 1994.
31. UNEP, *Guidelines for conducting economic valuation of coastal ecosystem goods and services*. UNEP/GEF/SCS Technical Publication 2007.
32. KKP-Indonesia, *Statistical Data of Marine and Fisheries* Kementerian Kelautan dan Perikanan (KKP) Indonesia http://statistik.kkp.go.id/ (Accessed 1 March 2013): Jakarta, Indonesia, 2012.
33. Ong, J. E., Mangroves – a carbon source or sink. *Chemosphere* **1993,***27*, 1097-1107.
34. Diaz, D.; Hamilton, K.; Johnson, E., *Forest Carbon Market 2011: From Canopy to Currency*. Forest Trend Ecosystem Marketplace: Washington DC 2011; p 93.
35. Mayudin, A., Kondisi Ekonomi Pasca Konversi Hutan Mangrove menjadi Lahan Tambak di Kabupaten Pangkajene Kepulauan Propinsi Sulawesi Selatan. *Eksos* **2012,***8* (2), 90-104.
36. Sathirathai, S.; Barbier, E. B., Valuing Mangrove Conservation in Southern Thailand. *Contemporary Economic Policy* **2001,***19* (2), 109-122.
37. Sribianti, I., Valuasi Ekonomi Hutan Mangrove: Studi Kasus Valuasi Ekonomi Kawasan Hutan Mangrove Malili Kabupaten Luwu Timur *Jurnal Sains & Teknologi* **2008,***8* (3), 186-192.
38. Hong, P. N., Impact of Shrimp Culture Extension on Environmental and Biodiversity resources in Marsh of Coastal Zone. *Journal of Fisheries* . **1995,***3*, 6-9 and 25.
39. Harahab, N., *Penilaian Ekonomi Ekosistem Hutan Mangrove dan Aplikasinya dalam Perencanaan Wilayah Pesisir*. Graha Ilmu Publisher: Yogyakarta, Indonesia, 2010.
40. Lan, T. D., Coastal aquaculture and shrimp farming in North Vietnam and environmental cost estimation. *Aquatic Ecosystem Health & Management* **2009,***12* (3), 235-242.
41. Gunawardena, M.; Rowan, J. S., Economic Valuation of a Mangrove Ecosystem Threatened by Shrimp Aquaculture in Sri Lanka. *Environmental management* **2005,***4*, 535-550
42. Setyawan, A. D.; Winarno, K., Pemanfaatan Langsung Ekosistem Mangrove di Jawa Tengah danPenggunaan Lahan di Sekitarnya; Kerusakan dan Upaya Restorasinya. *Biodiversitas* **2006,***7* (3), 282-291.
43. Ong, J. E.; Gong, W. K., *Structure, Function and Management of Mangrove Ecosystems* International Society for Mangrove Ecosystems (ISME) Okinawa, Japan, and International Tropical Timber Organization (ITTO Yokohama, Japan.: 2013.
44. Mazda, Y.; Magi, M.; Kogo, M.; Hong, P. N., Mangroves as a coastal protection from waves in the Tong King delta, Vietnam. *Mangroves and Salt Marshes* **1997,***1* (2), 127-135.
45. Hajramurni, A. Abrasion speed in Takalar hits 100 meters a year. http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html (accessed March 13, 2013).
46. Halim, A. Kerusakan Mangrove Memiskinkan Warga. http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga (accessed March 13, 2013).
47. Pirzanet, A. M.; Gunarto; Daud, R.; Utoyo; Kabangnga, N. *Pemantapan Budidaya Kepiting Bakau untuk Mengantisipasi Dampak Penangkapan di perairan Sungai Lamuru, Kabupaten Bone*; Balai Penelitian Perikanan Pantai: Maros, Indonesia, 1999.
48. Gunarto, Konservasi mangrove sebagai pendukung sumberdaya hayati perikanan pantai *Jurnal Litbang Pertanian* **2004,***23* (1).

49. Sasekumar, A.; Chong, V. C.; Leh, M. U.; D'Cruz, R., Mangroves as a Habitat for Fish and Prawns. *Hyrobiologia* **1992,***247*, 195-207.
50. Salem, M. E.; Mercer, D. E., The Economic Value of Mangrove: A Meta-Analysis. *Sustainability* **2012,***4*, 359-383.
51. Jusoff, K.; Taha, D., Managing Sustainable Mangrove Forests in Peninsular Malaysia. *Journal of Sustainable Development* **2008,***1* (1).
52. Prakash, M.; Sivakumar, T., A study on antibacterial activity of mangrove plant Excoecaria agallocha L. *International Journal of Current Microbiology and Applied Sciences* **2013,** *2* (8), 260-262.
53. Bandaranayake, W. M., Traditional and medicinal uses of mangroves. *Mangroves and Salt Marshes* **1998,***2*, 133-148.
54. Frost, R., Dwindling Indian Sundarban Mangrove: The Way Out. *Science and Culture* **2010,***76* (7–8), 275-282.
55. MAP-Indonesia *Kajian Risilian (Situational and contextual field assessment and analysis-Restoring Coastal Livelihood Project)*; Mangrove Action Project (MAP) Indonesia: Sulawesi Selatan, Indonesia, 2011.
56. Sigit, R. R. Ekonomi Lingkungan: Pilih Mangrove atau Tambak. http://www.mongabay.co.id/2013/10/25/ekonomi-lingkungan-pilih-mangrove-atau-tambak/ (accessed January 5, 2013).

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Received: 20 June 2015
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