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

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

Abdul Malik

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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 you for your interesting contribution on a highly topical subject. This especially since Indonesia is home to much of the remaining mangrove 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”

Reviewer 2:

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 interpret 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

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

10 **Abdul Malik^{1,2,*}, Rasmus Fensholt² and Ole Mertz²**

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18 Academic Editor:

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20

21 **Abstract:** Mangroves are recognized as a provider of a variety of products and essential
22 ecosystem services that contribute significantly to the livelihood of local communities.
23 However, over the past decades, mangroves in many tropical areas including the Takalar
24 district, South Sulawesi have degraded and decreased mainly due to conversion to shrimp
25 ponds. Currently, little is known about the economic benefits of commercialization of
26 shrimp ponds as compared to those derived from mangroves in the form of products and
27 services. Here, we estimate the Total Economic Value (TEV) of mangrove benefits in
28 order to compare it with the benefit value of commercial shrimp ponds. Market prices,
29 replacement costs, benefit transfer value and Cost-Benefit Analyses (CBA) have been
30 used for value determination and comparison. The results show that the per year TEV of
31 mangroves during the study period was IDR 41,464,146,576 (USD 4,364,647) or IDR
32 24,121,086 (USD 2,539) per hectare, (the highest value contribution derived from the
33 indirect use value (91%)), whereas the commercial shrimp ponds had a benefit value of
34 IDR 1,373,250,500 (USD 144,553) or IDR 19,902,181 (USD 2,095) per hectare. In

35 addition, the comparison of Net Present Value (NPV) between the benefit value of
36 mangroves and that of commercial shrimp ponds revealed that conversion of mangroves
37 into commercial shrimp ponds was not economically beneficial when the analysis was
38 expanded to cover the costs of environmental and forest rehabilitation.

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

42 1. Introduction

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

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

58 Although mangroves provide a variety of products and services, they have been under great
59 pressure due to decision making commonly based on assumptions of larger net benefits without
60 considering the loss of wider mangrove services [5] and natural capital stocks [6]. Mangrove
61 products and services are often undervalued or even ignored in the economy and by industry and
62 local inhabitants [7]. Consequently, nearly half of the total mangrove areas in the world have
63 been lost over the past decades, with the largest areas of decline in Asia [8,9,10]. In Indonesia
64 (which has the largest mangrove areas in the world), mangroves are threatened primarily by
65 aquaculture but also by overharvesting of timber, firewood collection, charcoal production and
66 conversion to other land uses such as agriculture, urbanization, mining and salt ponds
67 [10,11,12,13]. Mangrove areas are characterized by some of the most rapid loss rates of coastal
68 ecosystems in Indonesia; from 1980 to 2003, at least 1.1 million hectares of mangrove were lost,
69 with 75 % of these areas being converted to shrimp ponds [10,14]. High economic revenues
70 from the increase in exports and foreign trade in shrimp have become the main driving forces for
71 the expansion of shrimp ponds by clearing mangroves [12]. In 2012, for instance, shrimp exports
72 from Indonesia were valued at USD 1,304,149,000, of which 38 percent went to the United

73 States of America (USA), 29 percent to Japan, 9 percent to European countries and 24 percent to
74 other countries [15]. In South Sulawesi, the value of shrimp exports in 2011 reached USD
75 42,407,000 [13]. Since the early 1990s, Indonesia has become one of the major shrimp
76 producing and exporting countries in the world [16]. However, the expansion of shrimp export
77 which mostly comes from aquaculture production has triggered a heated debate in Indonesia as
78 well as in other exporting countries such as Thailand due to the significant consequences for
79 coastal areas [17,18].

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

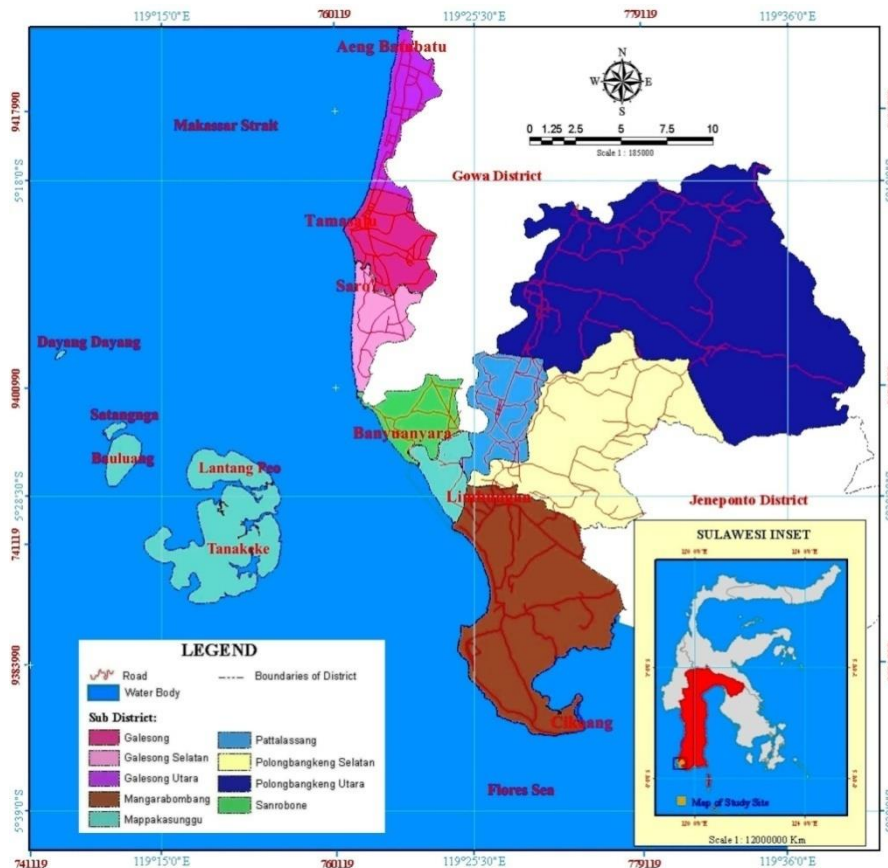
87 Economic valuations of mangroves have been conducted in many areas of the world [7].
88 However, little attention has been paid in the scientific literature to an economic valuation of
89 mangroves in areas threatened by commercial shrimp farming development in Indonesia and
90 other Asian countries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

98 **2. Study Area**

99 Takalar district is located in southern South Sulawesi, Indonesia (between latitude 5°12' -
100 5°38' and longitude 119°10' - 119°39', see figure 1), 45 km from Makassar city (the capital of
101 South Sulawesi). The district has a coastline of 74 km [22], occupied by mangroves, coral reefs,
102 sea grass, sandy beaches, rocky beaches, estuaries, shrimp ponds, rice fields and tourism and
103 residential areas. Most areas of Takalar are plain and coastal areas (including small islands) with
104 an altitude of 0 - 100 metres above sea level and the rest are hilly areas [23]. The district covers
105 566.51 km² and is divided into nine subdistricts (Galesong, South Galesong, North Galesong,
106 Mangarabombang, Mappakasunggu, Pattalassang, South Polongbengkeng, North
107 Polongbengkeng and Sanrobone). Mappakasunggu consists of a mainland part and small islands
108 (Tanakeke, Lantangpeo, Bauluang, Satangnga and DayangDayang). The population is 272,316
109 and the population density is 481 persons per km². Mean temperatures vary from 23°C - 33°C
110 and the monthly precipitation average over the past eight years (2004 – 2011) has been between

111 174 mm and 712 mm; the greatest amount of precipitation occurred in 2008 from November to
112 March [24].

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



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

139 3. Materials and Methods

140 The TEV of mangroves was calculated from monetary values of the DUV, IUUV and OV of
141 mangroves [26,4,27]. The DUV of mangroves was derived from benefit values of fishery
142 products (fish, crab and shrimp capture as well as seaweed farming) and forestry products

143 (firewood collection, charcoal production and Nypa palm crafting), which have been estimated
144 using market prices [4,27] and the following formulas:

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

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

- 146 • Firewood value (FwV)

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

- 147 • Charcoal value (CcV)

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

- 148 • Nypa palm crafting value (NpcV)

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

149 The IUV of mangroves is derived from benefit values of mangrove services such as coastline
150 protection, seawater intrusion prevention, provision of nursery grounds and supply of nutrients
151 for marine organisms. These benefit values were estimated using replacement costs [4,27]. The
152 coastline protection service was estimated by the cost of breakwater construction over a 10-year
153 project lifespan; the seawater intrusion prevention service was assessed by the cost of the water
154 supply needs of people if the availability of fresh water was reduced due to mangrove loss; the

155 provision of nursery grounds service was estimated by the construction cost of ponds for nursery
156 grounds for shrimp or fish. Finally, the supply of nutrients service was assessed by the value of

157 nutrient production (nitrogen and phosphate) from mangrove litter converted to the fertilizer
158 market price of Urea (NH₂)₂CO and SP-36 (Superphosphate, 36 percent P₂O₅), using the
159 following formulas:

- 160 • Coastline prevention value (CPV)

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

161 Coastal length = 74,000 m; Cost of breakwater construction with specification of length (1m),
162 width (11m) and height (2.5m) = IDR 1,530,880/m³ (USD 158/m³) [28].

- 163 • Seawater intrusion prevention value (SwIPV)

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

- 164 • Provision of nursery grounds value (PNGV)

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

- 165 • Supply of nutrients value (SNV)

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

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

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

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

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



- 173 • The benefit value of fisheries and forestry, medicines and mangrove services over a 10-year
 174 project period will decrease 5% – 20% (the decrease will begin in the second year of the
 175 project) with a subsequent decrease in mangrove ecosystem functions that provide products
 176 and services due to the expansion of shrimp ponds. In contrast, the costs of production will
 177 increase by 2% - 20% during such a project period.
- 178 • Several studies (e.g. [30,4,31,32]) have observed that shrimp production decreases
 179 successively after the fifth year due to the lower survival rate of shrimp. Hence, the
 180 production of shrimp over a 10-year project period also decreases by 5 – 20% and investment
 181 and production costs increase to sustain shrimp production.
- 182 • In accordance with the loan interest rate prevailing at financial institutions such as banks
 183 when the survey was conducted, a discount rate of 10% was used in the CBA.
- 184 • The environmental cost (water pollution cost) of shrimp ponds was adopted from Lan [33],
 185 who reported that the production of 360,000 tons of shrimp generates an environmental cost
 186 of USD 280 million (1 kg shrimp produced = USD 1.28), whereas the forest rehabilitation
 187 cost was estimated from seed provision, planting and maintenance costs. The forest
 188 rehabilitation cost was estimated from year 6 to year 10 (assuming normal shrimp pond
 189 production during the first 5 years). The formula for calculating the NPV is as follows: [27]
 190

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

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

191 Where:

192 NPV = Net Present Value

193 B = annual gross benefit; EB = annual extended benefit

194 C = annual gross cost; EC = annual extended cost

195 r = discount rate

196 i = each benefit or cost

197 t = period of time

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

199 4. Results and Discussion

200 4.1. DUV of mangroves

201 In past decades, people who lived around mangroves in this area were highly dependent on
 202 mangroves for various fishery and forestry products for domestic and commercial purposes. In
 203 fisheries, mangrove forest has benefits for the capture of fish, crab and shrimp as well as
 204 seaweed and shrimp farming, whereas in forestry, benefits connected with the collection of
 205 firewood, charcoal production and Nypa palm leaf crafting are generated. The results of the
 206 household survey showed that 43 households have been directly using mangrove for fish capture,

207 six for crab capture, six for shrimp capture and seven for seaweed farming. Eight households
 208 have been using mangrove for harvest firewood, four for charcoal production and three for Nypa
 209 palm leaf crafting. The production averages of fish, crab and shrimp capture and seaweed
 210 farming (*Eucheuma cottonii*) per household per year are 2,450 kg, 338 kg, 213 kg and 8,914 kg,
 211 respectively. The production of firewood, charcoal and handcrafts such as roofs, walls, floor
 212 mats, baskets and especially hats from Nypa palm leaves per household per year amounted to 60
 213 bundles (1 bundle = 100 stems with a length of 1 m and a diameter of 4 cm to 8 cm), 720 sacks
 214 (1 sack = 25 kg) and 6,750 units, respectively. The total of fish, crab and shrimp production was
 215 105,350 kg/year, 2,028 kg/year and 1,278 kg/year, respectively, whereas seaweed (*Eucheuma*
 216 *cottonii*) production was 62,398 kg per year. Harvested mangrove forests for firewood reached
 217 480 bundles per year, charcoal production was 2,160 sacks per year and handcrafting produced
 218 27,000 units per year. The highest benefit of DUV was obtained from fish production, earning
 219 IDR 498,850,000 (USD 52,511) per year, followed by seaweed farming for IDR 327,588,000
 220 (USD 19,402) per year. Thus, the total benefit of the DUV of mangrove ecosystem is IDR
 221 1,105,209,600 (USD 116,338) per year (Table 1).

222
 223 **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 (<i>Eucheuma cottonii</i>)	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

224
 225 A large number and variety of fish species and other marine species use the mangroves for
 226 nursery, spawning and feeding grounds and for migrating to the coral reef areas or offshore [34].
 227 The main fish, shrimp and crab species available for fishery in the mangrove area include small
 228 pelagic fish, snapper (*lates calcarifer*), milkfish (*Chanos chanos*), white shrimp (*Pennaeus*

229 *vannamei*) and mud crab (*Scylla sp.*). In seaweed farms on the seashore (near mangrove areas),
230 cultures of *Eucheuma cottonii* are developed. Furthermore, the harvest of mangroves for home
231 consumption and firewood and charcoal for commercial use are mostly derived from *Rhizophora*
232 *sp.*, whereas leaves of *Nypa fruticans* are used for handicrafts such as hats, floor mats, baskets,
233 roofs and walls. Even though fish capture is the dominant source of revenue for the local
234 population and the highest generator of net benefit per year (IDR 498,850,000 = USD 52,511),
235 the highest net benefit value per household per year (IDR 46,798,286 = USD 4,926) is derived
236 from seaweed farming. Over the last decades, clearing mangrove to expand shrimp ponds has
237 been widespread in this area, causing mangrove areas to decrease and degrade rapidly, which in
238 turn has led to a decrease in fish production and fishermen's income. Consequently, seaweed
239 farming has become an alternative livelihood strategy that has proven to be more profitable than
240 fishing [13].

241 4.2. IUV of mangroves

242 Besides providing a variety of products, mangrove forest supports ecological services by
243 protecting the coastline from exposure to waves, preventing seawater intrusion and providing
244 nursery grounds and supplying nutrients for marine organisms [35]. [36] stated that the stand of
245 *Kandelia candel* (six years old) can reduce waves with an offshore height of 1 m to 0.05 m when
246 they reach the shore. [37] and [38] revealed that abrasion and seawater intrusion occurred in
247 several places in the region where mangrove is absent. Abrasion was found along the coast in six
248 subdistricts of Takalar district (Mappakasunggu, Mangarabombang, Sanrobone, South Galesong,
249 Galesong and North Galesong), reaching 20-100 metres per year over the past five years.
250 Moreover, seawater intrusion into inland areas has made growth conditions difficult for local
251 crops such as banana. Furthermore, [39] and [40] found that 17 commercial fish species inhabit
252 and use mangroves as nursery grounds in Lamuru Estuary, Bone district, South Sulawesi while
253 27 commercial fish species do so in the Tongke-tongke mangrove forest area and Sinjai district.
254 In Selangor, Malaysia, [41] noted that many species of fish (119) and prawn (9) inhabit and use
255 mangrove as nursery and feeding grounds. In addition, [42] reported that the average production
256 of nitrogen and phosphate of mangrove litter in Sinjai district, South Sulawesi reached 497.98
257 kg/ha and 22.02 kg/ha, respectively. [43] report the availability of nutrients in the soil of the
258 Bhitarkanika National Park, India to be 2,907 kg/ha (nitrogen) and 28.11 kg/ha (phosphate).

259 In this case study area, the net benefit values of these mangrove services have been estimated
260 using the replacement cost method. Annual values of prevention of coastline erosion and
261 seawater intrusion provided by mangroves were estimated to be IDR 11,328,512,000 (USD
262 1,192,475) or IDR 6,590,176 (USD 694) per hectare and IDR 11,307,700,000 (USD 1,190,288)
263 or IDR 6,578,069 (USD 692) per hectare, respectively. Provision of nursery grounds and supply
264 of nutrient services were estimated to amount to IDR 13,542,282,000 (USD 1,425,503) or IDR
265 7,878,000 (USD 892) per hectare and 1,616,554,476 (USD 170,164) or IDR 940,404 (USD 99)
266 per hectare, respectively. Thus, annually the aggregate benefit of IUV mangroves was IDR
267 37,795,048,476 (USD 3,978,426) or IDR 21,986,648 (USD 2,314) per hectare (Table 2). Some

268 studies have reported benefit values of such mangrove services and [31] estimated the cost of
 269 constructing breakwaters to prevent coastal erosion in Southern Thailand to be USD 3,679/Ha.
 270 [21] estimated the benefit value of preventing coastline erosion and supplying nursery grounds
 271 from mangroves in the Bohol Marine Triangle, Philippines to be USD 672/Ha/yr and USD 243
 272 Ha/yr, respectively. [32] calculated the annual benefit value of preventing seawater intrusion in
 273 Probolinggo district, East Java to be IDR 68,227,500 (USD 7,182) per hectare and [43]
 274 estimated each hectare of mangrove in the Bhitarkanika National Park, India to contain nutrient
 275 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

277 4.3. OV of mangroves

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

295

296

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

297

298 4.4. TEV and NPV of Mangroves

299 On the basis of the sum values of the DUV, IUV and OV, the annual benefit of the TEV of
 300 mangroves is estimated to be IDR 41,464,146,576 (USD 4,364,647) or IDR 24,121,086 (USD
 301 2,539) per hectare (Table 4). In addition, the NPVs per hectare for all three values (the DUV,
 302 IUV and OV) of mangroves benefits over a 10-year time period with a discount rate of 10%
 303 were IDR 4,579,584 (USD 482), IDR 171,757,468 (USD 18,080) and IDR 11,416,610 (USD
 304 1,202) (Table 5).

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

314

315

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

316

317

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

318 4.5. Benefit value of commercial shrimp farming and comparison to economic value of 319 mangroves

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

327 Interviews of 23 of shrimp farmers revealed that shrimp ponds in the study area have been
328 constructed (to an average extent of 3 hectares) by clearing mangrove forests. The types of
329 shrimp ponds found were monoculture of shrimp (3 ponds), monoculture of milkfish (3 ponds),
330 polyculture of shrimp and milkfish (9 ponds) and polyculture of milkfish and seaweed, mainly
331 from *Gracilaria sp.* (8 ponds). The total investment cost, including construction costs and
332 equipment, for all pond areas were IDR 543,549,500 (USD 57,216) (average cost per shrimp
333 pond is about IDR 23 million (USD 2,488)). Meanwhile, the total production cost, including
334 fixed costs (e.g. equipment depreciation costs and taxes) and variable costs (e.g. costs of labour,
335 seed, feed, fertilizer, fuel, etc.) for all pond areas was about IDR 406,600,000 (USD 42,800)
336 (average per shrimp pond IDR 17.6 million (USD 1.860)). Annually, shrimp production
337 generated on average 7,600 kg, milkfish production, 30,150 kg, and seaweed production, 34,350
338 kg (2 harvests per year). The market prices of shrimp, milkfish and seaweed (*Gracilaria sp.*)
339 were IDR 55,000 (USD 5.79) per kg, IDR 15,000 (USD 1.58) per kg and IDR 4,000 (USD 0.42)
340 per kg, respectively. Thus, annually the net benefit amounts to IDR 1,373,250,500 (USD
341 144,553) or IDR 19,902,181 (USD 2,095) per hectare and the NPV of the revenue of shrimp
342 ponds per hectare during the 10-year project period (with a discount rate of 10%) is estimated to
343 be IDR 15,052,424 (USD 1,584) (Table 6). This suggests that shrimp farming is financially
344 feasible and when compared to the NPV of the DUV and the OV of mangroves, the revenue is 3
345 and 1.3 times higher, respectively. However, when the comparison includes the NPV of the IUV
346 of mangroves, the economic benefit value of mangroves providing environmental services (e.g.
347 providing nursery grounds, protecting coastlines, preventing seawater intrusion, and supplying
348 nutrients) were far higher (11.4 times). However, when the estimation of the NPV of shrimp
349 farming is extended to include external costs (costs of environmental and forest rehabilitation or
350 social costs related to water pollution and loss of mangroves), the revenue of commercial shrimp
351 farming becomes negative (USD -459 per hectare) or no longer economically beneficial (Table 6
352 and Figure 2). It is often the case for shrimp farming in Indonesia that the expected levels of
353 shrimp production are met during the first five years, after which production starts to decline and
354 many shrimp farmers suffer from heavy economic losses, often leading to bankruptcy [49].
355 Consequently, many shrimp farms are abandoned as owners try to find new locations for
356 farming [30]; a general pattern also observed in other Asian countries as reported by [4] and [31].
357 Abandoned shrimp ponds are exposed to abrasion and the soil becomes very acidic, making it

358 difficult to use for other purposes [31]. In summary, degraded and decreased areas of mangroves,
 359 water pollution caused by waste ponds and the loss of nursery, feeding and spawning grounds of
 360 marine organisms have become visible evidence of the environmental impacts of shrimp farming
 361 development. If local environmental conditions are recoverable, the associated costs are very
 362 high and therefore, the economic benefit value of commercial shrimp farming in the long term
 363 becomes questionable, as also discussed by [50].

364 **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 (<i>Gracilaria sp.</i>)	Kg/yr	34,350	-
4	Market price			
	Shrimp	IDR/Kg	55,000	5.79
	Milkfish	IDR/Kg	15,000	1.58
	Seaweed (<i>Gracilaria sp.</i>)	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

365 Exchange rate: USD 1 = IDR 9,500

366

367

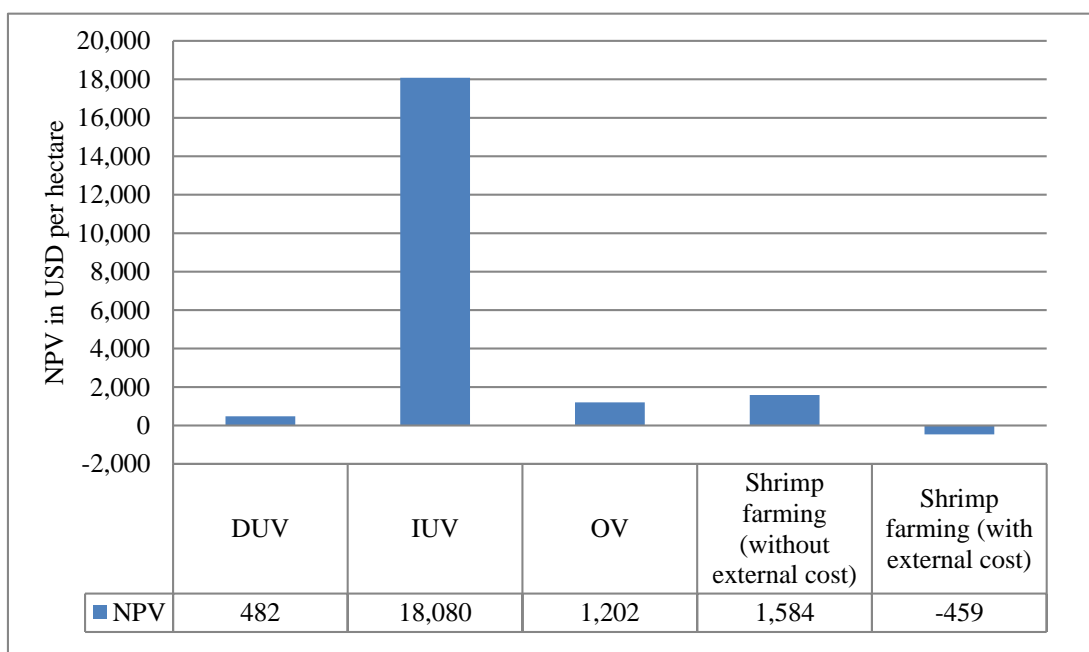
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373 **Figure 2.** Comparison of NPV of mangroves versus commercial shrimp farming.

374 **5. Conclusions**

375 This study has demonstrated that the annual TEV of mangrove benefits is IDR
376 41,464,146,576 (USD 4,364,647) or IDR 24,121,086 (USD 2,539) per hectare. The calculation
377 included the DUV of mangroves (the benefit value of fisheries and forestry products), the IUV
378 of mangroves (the benefit value of protecting the coastline, preventing seawater intrusion, acting
379 as a nursery ground and supplying nutrients), and the OV of mangroves (benefit value of
380 medicines). The highest contribution of the TEV of mangroves was derived from the IUV of
381 mangroves (91%). The benefit value of commercial shrimp farming amounts to IDR
382 1,373,250,500 (USD 144,553) or IDR 19,902,181 (USD 2,095) per hectare. In addition, the
383 NPVs per hectare for the DUV, IUV and OV and shrimp farming were IDR 4,579,584 (USD
384 482), IDR 171,757,468 (USD 18,080), IDR 11,416,610 (USD1,202) and IDR 15,052,424 (USD
385 1,584), respectively. The conversion of mangroves into commercial shrimp farms has a higher
386 beneficial value than the DUV and OV of mangroves and at a first glance seems to be financially
387 viable, but when the IUV of mangroves is included in the comparison, the benefit value of
388 mangroves is considerably higher. In addition, when the analysis of NPV was extended to
389 include the costs of environmental restoration (from water pollution) and forest rehabilitation,
390 the revenue of shrimp farming became negative or no longer economically beneficial. 

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399 **Author Contributions**

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

403 **Conflict of Interest**

404 The authors declare no conflict of interest.

405 **References**

- 406 1. Fauzi, A., *Economics of Natural Resources and Environment. Theory and Applications*. PT
407 Gramedia Pustaka Utama: Jakarta, Indonesia, 2004; p 259.
- 408 2. Suparmoko, M., *Neraca Sumberdaya Alam (Natural Resource Accounting)*. BPFE UGM:
409 Yogyakarta, Indonesia, 2005.
- 410 3. Rukmana, D., *Ekonomi Lingkungan dan Sumberdaya Alam*. Penerbit Arus Timur Makassar,
411 Indonesia, 2012.
- 412 4. Bann, C., *The economic valuation of mangroves _A manual for researchers*. Economy and
413 Environment Program for Southeast Asia (EEPSEA): Singapore. , 1998.
- 414 5. Barbier, E. B., Sustainable use of wetlands valuing tropical wetland benefits: economic
415 methodologies and applications. *The Geographical Journal* **1993**,159, 22-32.
- 416 6. Brander, L. M.; Wagtendonk, A. J.; Hussain, S. S.; McVittie, A.; Verburg, P. H.; Groot, R.
417 S. d.; Ploeg, S. v. d., Ecosystem service values for mangroves in Southeast Asia: A meta-
418 analysis and value transfer application. *Ecosystem Services* **2012**,1 (1), 62-69.
- 419 7. Vo, Q. T.; Kuenzer, C.; Vo, Q. M.; Moder, F.; Oppelt, N., Review of valuation methods for
420 mangrove ecosystem services. *Ecological Indicators* **2012**,23, 431-446.
- 421 8. Curran, S., Migration, Social Capital, and the Environment: Considering Migrant Selectivity
422 and Networks in Relation to Coastal Ecosystems *Population and Development Review*
423 **2002**,28, 89-125.
- 424 9. Giri, C.; Ochieng, E.; Tieszen, L. L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J.; Duke, N.,
425 Status and distribution of mangrove forests of the world using earth observation satellite
426 data. *Global Ecology and Biogeography* **2011**,20 (1), 154-159.
- 427 10. FAO *The World's Mangroves 1980 – 2005*; Food and Agriculture Organization (FAO):
428 Rome, Italy, 2007.
- 429 11. Onrizal, Perubahan Tutupan Hutan Mangrove di Pantai Timur Sumatera Utara Periode 1977
430 – 2006. *Jurnal Biologi Indonesia* **2010**,6 (2), 163-172.
- 431 12. Nurkin, B., Degradation of Mangrove Forests in South Sulawesi, Indonesia. *Hydrobiologia*
432 **1994**,285, 271-276.
- 433 13. Malik, A.; Fensholt, R.; Mertz, O., Consequences of Mangrove Forest Change in South
434 Sulawesi. REEC, under review.
- 435 14. Forest-Ministry-Indonesia, *Luas Mangrove per Propinsi di Indonesia In Noor Y.R., Khazali*
436 *M., Suryadiputra I N.N. Panduan Pengenalan Mangrove di Indonesia*. PHKA/WI-IP: Bogor,
437 Indonesia. , 2006; p 219.
- 438 15. WGMFDA. *Kelautan dan Perikanan dalam Angka 2013*; Working Group of Marine and
439 Fisheries Data Arrangement (WGMFDA). Centre of Data, Statistics and Information,
440 Ministry of Marine and Fisheries of Indonesia: Jakarta, Indonesia, 2013.
- 441 16. GlobeFish. Food Market: Shrimp Production <http://www.globefish.org>. (accessed May 5,
442 2013).
- 443 17. Barbier, E. B., Habitat-Fishery Linkages and Mangrove Loss in Thailand. *Contemporary*
444 *Economic Policy* **2003**,21 (1), 59-77.
- 445 18. Hogarth, P., *The Biology of Mangroves and Seagrass* 2ed.; Oxford University Press: New
446 York, 2007.

- 447 19. Chee, Y. E., An Ecological Perspective on the Valuation of Ecosystem Services. *Biological*
448 *Conservation* **2004**,120, 549-565.
- 449 20. Beaumont, N. J.; Austen, M. C.; Mangi, S. C.; Townsend, M., Economic valuation for the
450 conservation of marine biodiversity. *Marine pollution bulletin* **2008**,56 (3), 386-96.
- 451 21. Samonte-Tan, G. P. B.; White, A. T.; Tercero, M. A.; Diviva, J.; Tabara, E.; Caballes, C.,
452 Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines.
453 *Coastal Management* **2007**,35 (2-3), 319-338.
- 454 22. Ukkas, M. *Pemetaan Potensi/Zonasi Wilayah Pesisir dan Pulau-pulau Kecil Kabupaten*
455 *Takalar*; Laporan Penelitian. Universitas Hasanuddin: Makassar, Indonesia, 2001.
- 456 23. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2012.* ; Badan Pusat Statistik (BPS)
457 Kabupaten Takalar: Takalar, Indonesia, 2012.
- 458 24. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2004-2012.*; Badan Pusat Statistik
459 (BPS) Kabupaten Takalar: Takalar: Takalar, Indonesia, 2004-2012.
- 460 25. Malik, A.; Fensholt, R.; Mertz, O., Mangrove Exploitation Effects on Biodiversity and
461 Ecosystem Services. BIOC, under review.
- 462 26. Pearce, D.; Moran, D., *The Economic Value of Biodiversity.* Earthscan: UK, 1994.
- 463 27. UNEP, *Guidelines for conducting economic valuation of coastal ecosystem goods and*
464 *services.* UNEP/GEF/SCS Technical Publication 2007.
- 465 28. Mayudin, A., Kondisi Ekonomi Pasca Konversi Hutan Mangrove menjadi Lahan Tambak di
466 Kabupaten Pangkajene Kepulauan Propinsi Sulawesi Selatan. *Eksos* **2012**,8 (2), 90-104.
- 467 29. Sribianti, I., Valuasi Ekonomi Hutan Mangrove: Studi Kasus Valuasi Ekonomi Kawasan
468 Hutan Mangrove Malili Kabupaten Luwu Timur *Jurnal Sains & Teknologi* **2008**,8 (3), 186-
469 192.
- 470 30. Hong, P. N., Impact of Shrimp Culture Extension on Environmental and Biodiversity
471 resources in Marsh of Coastal Zone. *Journal of Fisheries* . **1995**,3, 6-9 and 25.
- 472 31. Sathirathai, S.; Barbier, E. B., Valuing Mangrove Conservation in Southern Thailand.
473 *Contemporary Economic Policy* **2001**,19 (2), 109-122.
- 474 32. Harahab, N., *Penilaian Ekonomi Ekosistem Hutan Mangrove dan Aplikasinya dalam*
475 *Perencanaan Wilayah Pesisir.* Graha Ilmu Publisher: Yogyakarta, Indonesia, 2010.
- 476 33. Lan, T. D., Coastal aquaculture and shrimp farming in North Vietnam and environmental
477 cost estimation. *Aquatic Ecosystem Health & Management* **2009**,12 (3), 235-242.
- 478 34. Setyawan, A. D.; Winarno, K., Pemanfaatan Langsung Ekosistem Mangrove di Jawa
479 Tengah dan Penggunaan Lahan di Sekitarnya; Kerusakan dan Upaya Restorasinya.
480 *Biodiversitas* **2006**,7 (3), 282-291.
- 481 35. Ong, J. E.; Gong, W. K., *Structure, Function and Management of Mangrove Ecosystems*
482 International Society for Mangrove Ecosystems (ISME) Okinawa, Japan, and International
483 Tropical Timber Organization (ITTO Yokohama, Japan.: 2013.
- 484 36. Mazda, Y.; Magi, M.; Kogo, M.; Hong, P. N., Mangroves as a coastal protection from
485 waves in the Tong King delta, Vietnam. *Mangroves and Salt Marshes* **1997**,1 (2), 127-135.

- 486 37. Hajramurni, A. Abrasion speed in Takalar hits 100 meters a year.
487 <http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a->
488 [year.html](http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html) (accessed March 13, 2013).
- 489 38. Halim, A. Kerusakan Mangrove Memiskinkan Warga.
490 <http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga>
491 (accessed March 13, 2013).
- 492 39. Pirzanet, A. M.; Gunarto; Daud, R.; Utoyo; Kabangnga, N. *Pemantapan Budidaya Kepiting*
493 *Bakau untuk Mengantisipasi Dampak Penangkapan di perairan Sungai Lamuru, Kabupaten*
494 *Bone*; Balai Penelitian Perikanan Pantai: Maros, Indonesia, 1999.
- 495 40. Gunarto, Konservasi mangrove sebagai pendukung sumberdaya hayati perikanan pantai
496 *Jurnal Litbang Pertanian* **2004**,23 (1).
- 497 41. Sasekumar, A.; Chong, V. C.; Leh, M. U.; D’Cruz, R., Mangroves as a Habitat for Fish and
498 Prawns. *Hyrobiologia* **1992**,247, 195-207.
- 499 42. Asbar. Optimalisasi Pemanfaatan Kawasan Pesisir untuk Pengembangan Budidaya Tambak
500 Berkelanjutan di KabupatenSinjai, Sulawesi Selatan. Dissertation, Bogor Agricultural
501 University, Bogor, Indonesia, 2007.
- 502 43. Hussain, S. A.; Badola, R., Valuing mangrove ecosystem services: linking nutrient retention
503 function of mangrove forests to enhanced agroecosystem production. *Wetlands Ecology and*
504 *Management* **2008**,16 (6), 441-450.
- 505 44. Prakash, M.; Sivakumar, T., A study on antibacterial activity of mangrove plant *Excoecaria*
506 *agallocha L.* *International Journal of Current Microbiology and Applied Sciences* **2013**, 2
507 (8), 260-262.
- 508 45. Bandaranayake, W. M., Traditional and medicinal uses of mangroves. *Mangroves and Salt*
509 *Marshes* **1998**,2, 133-148.
- 510 46. Frost, R., Dwindling Indian Sundarban Mangrove: The Way Out. *Science and Culture*
511 **2010**,76 (7–8), 275-282.
- 512 47. Jusoff, K.; Taha, D., Managing Sustainable Mangrove Forests in Peninsular Malaysia.
513 *Journal of Sustainable Development* **2008**,1 (1).
- 514 48. Purnomo, A., *Pemilihan Lokasi Tambak Udang Berwawasan Lingkungan*. Pusat Penelitian
515 dan Pengembangan Perikanan: Jakarta, Indonesia, 1992; p 40.
- 516 49. MAP-Indonesia *Kajian Risilian (Situational and contextual field assessment and analysis-*
517 *Restoring Coastal Livelihood Project)*; Mangrove Action Project (MAP) Indonesia:
518 Sulawesi Selatan, Indonesia, 2011.
- 519 50. Sigit, R. R. Ekonomi Lingkungan: Pilih Mangrove atau Tambak.
520 <http://www.mongabay.co.id/2013/10/25/ekonomi-lingkungan-pilih-mangrove-atau-tambak/>
521 (accessed January 5, 2013).

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523

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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 feel 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
> make major revisions before it is processed further. Please find your
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> manuscript found at the above link for your revisions, as the
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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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> *1.449*! -----

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 be 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
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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
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> 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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> the editors and reviewers.

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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
> -- Nathan Li MDPI Branch Office, Beijing Forests Editorial Office
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> *1,449*! -----
>

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

Shrimp production

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)

Milkfish production:

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 = $60,300 \times 15,000 = \text{IDR } 904,500,000$ (USD 95,210)

Seaweed production (Gracilaria):

Average of pond area = 3ha

Total area of pond = $8 \times 3\text{ha} = 24$ ha

Seaweed harvest per year = 2 times

Production per hectare per year = $1,431 \text{ kg} \times 2 = 2,862$ kg/ha/yr

Total production of seaweed per year = $24 \times 2862 = 68,700$ 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 = $34,350 \times 4,000 = \text{IDR } 1,374,000,000$ (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 thank 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 foregone 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 needed 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:

Milkfish production:

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

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 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).

Economic Valuation of Mangroves for Comparison with Commercial ~~Shrimp Farming~~ Aquaculture Ponds 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. 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

35 value contribution derived from the indirect use value (91.94%), whereas the commercial
36 ~~shrimp aquaculture ponds~~ had a net benefit value of IDR 2,163,910,500 (USD 227,780) or
37 IDR 31,361,022 (USD 3,301) ~~IDR 1,373,250,500 (USD 144,553) or IDR 19,902,181 (USD~~
38 ~~2,095)~~ per hectare. In addition, the comparison of Net Present Value (NPV) between the
39 benefit value of mangroves and that of commercial ~~shrimp ponds~~ aquaculture revealed that
40 conversion of mangroves into commercial ~~shrimp aquaculture ponds~~ was not economically
41 beneficial when the analysis was expanded to cover the costs of environmental and forest
42 rehabilitation.

43 **Keywords:** Economic valuation; mangroves; commercial shrimp farming; Indonesia;
44 South Sulawesi.
45

46 1. Introduction

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

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

62 Although mangroves provide a variety of products and services, they have been under great
63 pressure due to decision making commonly based on assumptions of larger net benefits without
64 considering the loss of wider mangrove services [5] and natural capital stocks [6]. Mangrove
65 products and services are often undervalued [7,8] or even ignored in the economy and by industry
66 and local inhabitants [9]. Consequently, nearly half of the total mangrove areas in the world have
67 been lost over the past decades, with the largest areas of decline in Asia [10,11,12]. In Indonesia
68 (which has the largest mangrove areas in the world), mangroves are threatened primarily by
69 aquaculture but also by overharvesting of timber, firewood collection, charcoal production and
70 conversion to other land uses such as agriculture, urbanization, mining and salt ponds
71 [12,13,14,15]. Mangrove areas are characterized by some of the most rapid loss rates of coastal
72 ecosystems in Indonesia; from 1980 to 2003, at least 1.1 million hectares of mangrove were lost,

73 with 75 % of these areas being converted to shrimp ponds [12,16]. High economic revenues from
74 the increase in exports and foreign trade in shrimp have become the main driving forces for the
75 expansion of shrimp ponds by clearing mangroves [14]. In 2012, for instance, shrimp exports from
76 Indonesia were valued at USD 1,304,149,000, of which 38 percent went to the United States of
77 America (USA), 29 percent to Japan, 9 percent to European countries and 24 percent to other
78 countries [17]. In South Sulawesi, the value of shrimp exports in 2011 reached USD 42,407,000
79 [15]. Since the early 1990s, Indonesia has become one of the major shrimp producing and
80 exporting countries in the world [18]. However, the expansion of shrimp export which mostly
81 comes from aquaculture production has triggered a heated debate in Indonesia as well as in other
82 exporting countries such as Thailand due to the significant consequences for coastal areas [19,20].

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

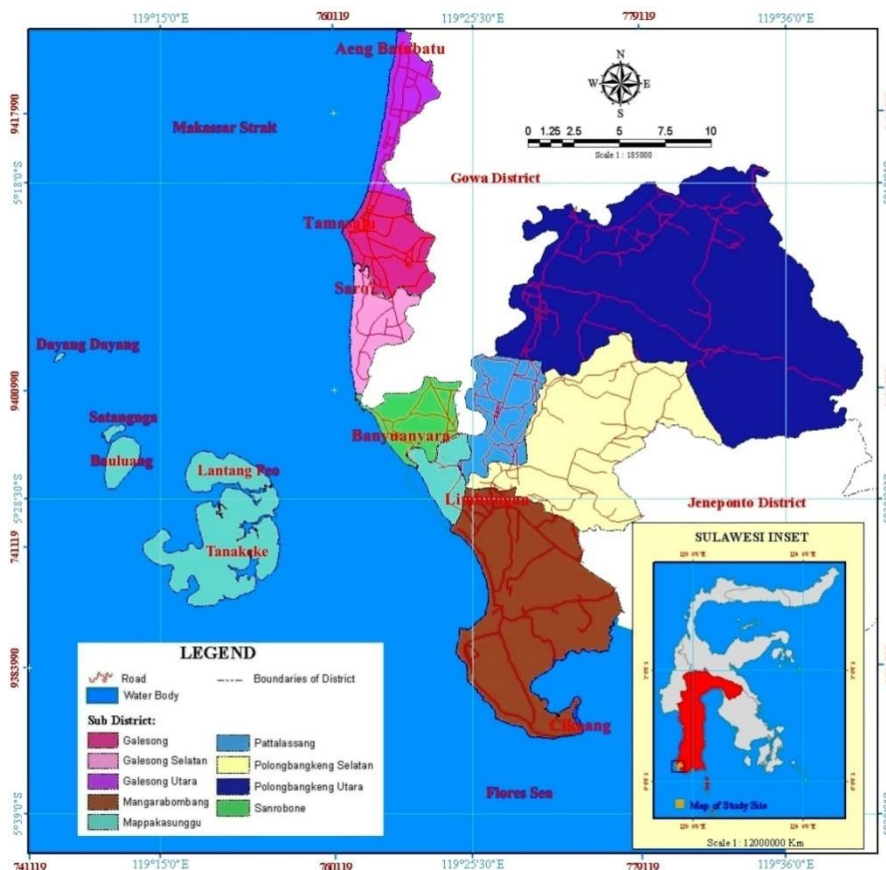
90 Economic valuations of mangroves have been conducted in many areas of the world [9].
91 However, little attention has been paid in the scientific literature to an economic valuation of
92 mangroves in areas threatened by commercial ~~shrimp farming aquaculture pond~~ development in
93 Indonesia and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

102 2. Study Area

103 Takalar district is located in southern South Sulawesi, Indonesia (between latitude 5°12' - 5°38'
104 and longitude 119°10' - 119°39', see figure 1), 45 km from Makassar city (the capital of South
105 Sulawesi). The district has a coastline of 74 km [24], occupied by mangroves, coral reefs, sea
106 grass, sandy beaches, rocky beaches, estuaries, aquaculture ponds, rice fields and tourism and
107 residential areas. Most areas of Takalar are plain and coastal areas (including small islands) with
108 an altitude of 0 - 100 metres above sea level and the rest are hilly areas [25]. The district covers
109 566.51 km² and is divided into nine sub districts (Galesong, South Galesong, North Galesong,
110 Mangarabombang, Mappakasunggu, Pattalassang, South Polongbangkeng, North
111 Polongbangkeng and Sanrobone). Mappakasunggu consists of a mainland part and small islands

112 (Tanakeke, Lantangpeo, Bauluang, Satangnga and Dayang Dayang). The population is 272,316
 113 and the population density is 481 persons per km². Mean temperatures vary from 23°C - 33°C and
 114 the monthly precipitation average over the past eight years (2004 – 2011) has been between 174
 115 mm and 712 mm; the greatest amount of precipitation occurred in 2008 from November to March
 116 [26].

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



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

147
148 **3. Materials and Methods**

149 **3.1. Data Collection**

150 **Households Surveys**

151 Data on direct use of mangrove products and aquaculture were produce from household surveys
152 by using of questionnaires. 93 households were administrated, who were selected by a Purposive
153 Sampling method [29]. These and all households all had a direct relation to, and dependence on
154 mangrove forests ,such as (fishermen, shrimp farmers, firewood collectors, charcoal producers
155 and Nypa palm crafters). Thise survey iswas conducted in ten10 areas covering the islands of
156 Lantangpeo, Tanakeke, Bauluang and Satanga (sub-district of Mappakasunggu), and the villages
157 of Laikang (sub-district of Mangarabombang), Limbungan (sub-district of Pattalassang),
158 Banyuanyara (sub-district of Sanrobone), Sa'ro (sub-district of South Galesong), Tamasaju (sub-
159 district of Galesong) and Aeng Batu-batu (sub-district of North Galesong) (Figure 1). Thus, The
160 areas were selected based on the criteria that mangrove forests should be present and utilized by
161 communities for fishery and forestry production.

162 **3.2. Data Analysis-Data**

163 **3.2.1. Economic Valuation of Mangrove**

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

170 • Fish, crab and shrimp capture and seaweed farming values (FV;CV; SV; SFV)
$$\text{FV; CV; SV ; SFV} = \text{Production (unit/kg/yr) x } \frac{\text{price-Price (IDR/kgunit)}}{\text{Production cost (IDR)}} \quad (1)$$

171 • Firewood value (FwV)
$$\text{FwV} = \text{Wood collection (unit/bundle/yr) x } \frac{\text{price-Price (IDR/unitbundle)}}{\text{Production cost (IDR) (1 bundle = 100 stems with a length of 1 m and a diameter of 4 cm to 8 cm)}} \quad (2)$$

172 • Charcoal value (CcV)
$$\text{CcV} = \text{Production (unitsack/yr) x } \frac{\text{Price (IDR/sackunit)}}{\text{Production cost (IDR) (1 sack = 25kg)}} \quad (3)$$

173 • Nypa palm crafting value (NpcV)
$$\text{NpcV} = \text{Production (Unitpiece/yr) x } \frac{\text{Price (IDR/unitpiece)}}{\text{Production cost (IDR)}} \quad (4)$$

174 The IUV of mangroves is derived from benefit values of mangrove services such as coastline
175 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 grounds for 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/tCO₂) 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 (NH₂)₂CO and SP-36 (Superphosphate, 36 percent P₂O₅). Calculation of IUUV is conducted using the following formulas:

- Coastline prevention value (CPV)

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

Coastal length = 74,000 m; The cost of breakwater construction has been reported to range between with specification of length (1m), width (11m) and height (2.5m) = IDR 1,530,880/m³ (USD 158/m³) [35] according to South Sulawesi's Public Work Agency and IDR 8,312,500/m³ (USD 875/m³) [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)

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

- Supply of nutrients value (SNV)

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

- Carbon sequestration value (CSV)

$$CSV = \text{carbon sequestration rate (100 - 200 ton C/ha)} \times \text{total area of mangrove (1,719 ha)} \times \text{price of carbon market (USD 5.5/ton CO}_2\text{)} \quad (8)$$

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 (ASpV) was calculated using the formulas:

$$\text{Total area of aquaculture ponds (ha)} = \text{number of farmers (23 farmers)} \times \text{area of aquaculture pond per farmer (3 ha)} \quad (9)$$

$$\text{Investment cost} = \text{cost construction (IDR/ha)} + \text{farming equipment (IDR/unit)} \times \text{total area of aquaculture pond (ha)} \quad (10)$$

$$\text{Production cost} = \text{fixed cost (e.g. equipment depreciation) (IDR/unit)} + \text{variable cost (fry, feed, fertilizer, fuel, etc) (IDR/unit)} \times \text{total area of aquaculture pond (ha)} \quad (11)$$

$$\text{Benefit of ApV} = \text{production (kg/ha/yr)} \times \text{price (IDR/kg)} \times \text{total area of aquaculture pond (ha)} \quad (12)$$

$$\text{Net Benefit of ApV} = \text{benefit of ApV (IDR/yr)} - (\text{investment cost} + \text{production cost}) \quad (13)$$

$$\text{Net benefit/ha/yr of ApV} = \text{net benefit of ApV (IDR/yr)} / \text{total area of aquaculture pond (ha)}$$
$$\text{SpV} = \text{Production (unit/yr)} \times \text{Price (IDR/unit)} - \text{Production cost (IDR)}$$

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 into commercial aquaculture pond is economically feasible as financial. To facilitate, CBA is used to determine the NPV of internal costs and benefits of commercial aquaculture pond. Based on Malik et al. [15], the project life of aquaculture pond is 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 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 ~~the~~ exploitation of mangrove for fishery and forestry products ~~is has been ongoing-occurred induring~~ past several decades. ~~However,~~ the most intensive exploitation ~~is conducted~~ has occurred 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]

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

$$NPV = \sum_{i=1}^n \frac{(Bit + EBit) - (Cit - ECit)}{(1+r)^t} \text{ (Extended CBA)} \quad (4015)$$

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.

$$\text{Environmental cost of shrimp ponds} = \frac{\text{shrimp production (kg/ha/yr)} \times \text{USD 1.28} \times \text{total area of shrimp ponds (ha)}}{\text{total area of shrimp ponds (ha)}} \quad (16)$$

$$\text{Forest rehabilitation cost} = \frac{\text{seed provision cost (IDR/ha)} + \text{planting cost (IDR/ha)} + \text{maintenance cost (IDR/ha)} \times \text{total area of shrimp ponds (ha)}}{\text{total area of shrimp ponds (ha)}} \quad (17)$$

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 ~~1,105,209,677~~ 777,621,600 (USD ~~116,338~~ 81,855) per year (Table 1).

Table 1. DUV of mangroves

No	Products	Household users (n= 77 <u>70</u>)	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/ Haha/ <u>aha/</u> yr)	Net use value (USD/ Haha/ <u>aha/</u> 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 (<i>Eucheuma cottonii</i>)	7	327,588,000	46,798,286	34,483	4,926	190,569	20
Sub Total of DUV =			915,288 <u>587,700,000</u>	96,346 <u>61,863</u>	532,454 <u>34,185</u>	56 <u>36</u>		

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		116,3388		642,93845	6848
			<u>777,621,600</u>		<u>1,855</u>		<u>2,369</u>	

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

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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 ~~4,9262,936~~) 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. IUUV 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 ~~estimated~~ 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~~ 692,277/ha) ~~per hectare~~, respectively. ~~The value of coastline protection services is dominated 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/yr. [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)
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<u>1</u>	<u>Coastline protection</u>	<u>11,328,512,000</u>	<u>1,192,475</u>	<u>6,590,176</u>	<u>694</u>
<u>2</u>	<u>Seawater intrusion</u>	<u>11,307,700,000</u>	<u>1,190,284</u>	<u>6,578,060</u>	<u>692</u>
		<u>(IDR/yr)</u>	<u>(USD/yr)</u>	<u>(IDR/ha/yr)</u>	<u>(USD/ha/yr)</u>
<u>1</u>	<u>Coastline protection</u>	<u>11,328,512,000 –</u>	<u>1,192,475 –</u>	<u>6,590,176 –</u>	<u>694 – 3,767</u>
<u>3</u>	<u>Provision of nursery</u>	<u>13,542,282,000</u>	<u>1,425,503</u>	<u>7,878,000</u>	<u>829</u>
		<u>61,512,500,000</u>	<u>6,475,000</u>	<u>35,783,886</u>	
<u>2</u>	<u>Seawater intrusion</u>	<u>4,523,080,000</u>	<u>476,114</u>	<u>2,631,227</u>	<u>277</u>
<u>4</u>	<u>Supply of nutrients</u>	<u>1,616,554,476</u>	<u>170,164</u>	<u>940,404</u>	<u>99</u>
	<u>(nitrogen and phosphate)</u>				
<u>3</u>	<u>Provision of nursery</u>	<u>13,326,364,198</u>	<u>1,402,775</u>	<u>21,775,105</u>	<u>2,292</u>
	<u>Total of IUUV =</u>	<u>37,795,048,476</u>	<u>3,978,426</u>	<u>21,986,648</u>	<u>2,314</u>
<u>4</u>	<u>Carbon sequestration</u>	<u>8,981,775,000 –</u>	<u>945,450 –</u>	<u>5,225,000 –</u>	<u>550 – 1,100</u>
		<u>17,963,500,000</u>	<u>1,890,895</u>	<u>10,449,971</u>	
	<u>Total of IUUV =</u>	<u>38,159,731,198 –</u>	<u>4,016,814 –</u>	<u>36,221,508 –</u>	<u>3,813 – 7,436</u>
		<u>97,325,444,198</u>	<u>10,244,784</u>	<u>70,640,189</u>	

363

364

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

365 3.3.4.3. OV of mangroves

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

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

384

385

Table 3. OV of mangroves

No	Option value	Total use Value (USD/yr)	Total use value (IDR/yr)	Total use value (IDR/Haha/yr)	Total use value (USD/Haha/yr)
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1	Medicines	269,883	2,563,888,500	1,491,500	157
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Exchange rate : USD 1 = IDR 9,500 ; Total area of mangrove = 1,719 Ha

386

387 **3.4.4.4. TEV and NPV of Mangroves**

388 On the basis of the sum values of the DUV, IUV and OV, the annual benefit of the TEV of
 389 mangroves is estimated to be IDR 41,464,146,576501,241,298 – 100,666,954,298 (USD
 390 4,364,64768,582 – 10,596,552) or IDR 24,121,08638,165,377 – 72,584,058 (USD 2,5394,018 –
 391 7,641) per hectare (Table 4). In addition, the NPVs per hectare for all three values (the DUV, IUV
 392 and OV) of mangroves benefits over a 10-year time period with a discount rate of 10% were IDR
 393 4,579,5842,572,943 (USD 482271), IDR 171,757,468126,260,406 – 322,024,022 (USD
 394 18,08013,291 – 33,897) and IDR 118,48316,225,610 (USD 1,202893) (Table 5).

395 The largest benefit value of mangroves (9194%) and the highest NPV are derived from the
 396 IUV, including the values of coastline protection, seawater intrusion prevention, and nutrient and
 397 nursery ground provision and carbon sequestration.

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

405

406

Table 4. TEV of mangroves

No.	Economic use value	Use value (IDR/yr)	Use value (IDR/USD/yr)	Use value (IDR/Ha/yr)	Use value (IDR/USD/Ha/yr)	%
1	DUV	<u>1,105,209,600</u> <u>777</u> <u>,621,600</u>	<u>116,338</u> <u>81,88</u> <u>5</u>	<u>642,938</u> <u>452,3</u> <u>69</u>	<u>6848</u> <u>23</u>	
2	IUV	<u>37,795,048,476</u> <u>38</u> <u>,159,731,198</u> – <u>97,325,444,198</u>	<u>3,978,426</u> <u>4,1</u> <u>06,814</u> – <u>10,244,784</u>	<u>21,986,648</u> <u>36,</u> <u>221,508</u> – <u>70,640,189</u>	<u>2,314</u> <u>3,813</u> – <u>7,436</u>	<u>91</u> <u>94</u>
3	OV	2,563,888,500	269,883	1,491,500	157	<u>64</u>
	TEV	<u>41,464,146,576</u> <u>50</u> <u>1,241,298</u> – <u>100,666,954,298</u>	<u>4,364,647</u> <u>8,5</u> <u>82</u> – <u>10,596,552</u>	<u>24,121,086</u> <u>38,</u> <u>165,377</u> – <u>72,584,058</u>	<u>2,539</u> <u>4,018</u> – <u>7,641</u>	100

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

407

408

409

Table 5. NPV of mangroves

NPV	DUV	IUV	OV
NPV (IDR)	7,872,304,104	295,251,087,549	217,041,638,583
	4,422,889,286		19,625,152,186
NPV (IDR/Haha)	4,579,584,257	171,757,468	126,260,406
	2,943		11,416,610
NPV (USD/Haha)	482,271	13,291	18,080
			33,897

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 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.

Interviews of 23 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 annual harvests, shrimp production generated on average 7,600,422 kg, milkfish production, 30,150,700 kg/ha/yr, and seaweed production, 34,350,862 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 (USD 144,553,227,780) or IDR 19,902,181,361,022/ha (USD 2,095,330,1/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 (41.49.3 times - 23.89) as also reported by Rönnbäck and do not

covered most of the benefit value of these services [7]. However, 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 -4591,282/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	30,150,670	-
	Seaweed (<i>Gracilaria sp.</i>)	Kg/ha/yr	34,350,862	-
4	Market price			
	Shrimp	IDR/Kg	55,000	5.79
	Milkfish	IDR/Kg	15,000	1.58
	Seaweed (<i>Gracilaria sp.</i>)	IDR/Kg	4,000	0.42
			2,323,400,000	3,11
5	Benefit of ApV	IDR/yr	4,060,000	244,568
			1,373,250,500	2,16
6	Net benefit of ApV	IDR/yr	3,920,500	144,553
	Net benefit/per Haha/yr of ApV	IDR/Haha/yr	19,902,181	31,361,
			022	2,0953,301
6	NPV without external cost:			

7	NPV without external cost:		25,875,117,657,930	
	NPV-NPV	IDR	,220,762	2,723,696,918
			15,052,424,13,481,	
	NPV	IDR/Haha	460	1,584,1,419
87	NPV with external cost:		-7,491,812,355-	
	NPV	IDR	840,662,415	-788,61-88,491
			-4,358,239-	
	NPV	IDR/Haha	12,183,513	-459-1,282

Exchange rate: USD 1 = IDR 9,500

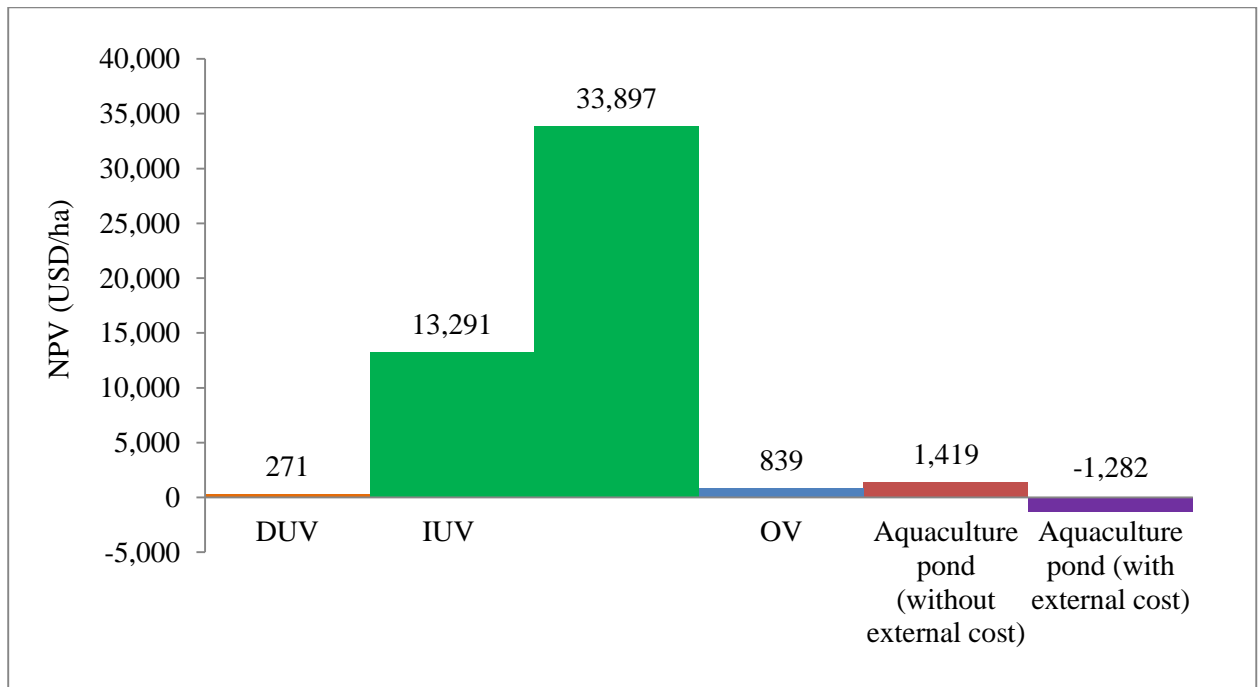


Figure 2. Comparison of NPV of mangroves versus commercial ~~shrimp farming~~ aquaculture pond.

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

477 mangroves (the benefit value of protecting the coastline, preventing seawater intrusion, acting as
478 a nursery ground and ~~supplying nutrients~~ carbon sequestration), and the OV of mangroves (benefit
479 value of medicines material). The highest contribution of the TEV of mangroves was derived from
480 the IUV of mangroves (~~91~~94%). The net benefit value of commercial ~~shrimp farming~~ aquaculture
481 pond—amounts to IDR ~~1,373,250,500~~ 2,163,910,500 (USD ~~144,553~~ 227,780) or IDR
482 ~~19,902,181~~ 31,361,022 (USD ~~2,095~~ 3,301) per hectare. In addition, the NPVs per hectare for the
483 DUV, IUV and OV and ~~shrimp farming~~ aquaculture pond—were IDR ~~4,579,584~~ 2,572,943 (USD
484 ~~482~~ 271), IDR ~~171,757,468~~ 126,260,406 – 322,024,022 (USD ~~18,080~~ 13,291 – 33,897), IDR
485 ~~11,416,610~~ 8,483,225 (USD ~~1,202~~ 893) and IDR ~~15,052,424~~ 13,481,460 (USD ~~1,584~~ 1,419),
486 respectively. The conversion of mangroves into commercial ~~shrimp farms~~ aquaculture pond has a
487 higher beneficial value than the DUV and OV ~~and OV~~ of mangroves and at a first glance seems
488 to be financially viable, but when the IUV ~~of mangroves~~ is included in the comparison, the benefit
489 value of mangroves is considerably higher. In addition, when the analysis of NPV was extended
490 to include the costs of environmental ~~restoration (from water pollution)~~ and forest rehabilitation,
491 the revenue of ~~shrimp farming~~ aquaculture pond became negative or no longer economically
492 beneficial.

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501 **Author Contributions**

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

505 **Conflict of Interest**

506 The authors declare no conflict of interest.

507 **References**

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

- 512 3. Rukmana, D., *Ekonomi Lingkungan dan Sumberdaya Alam*. Penerbit Arus Timur Makassar,
513 Indonesia, 2012.
- 514 4. Bann, C., *The economic valuation of mangroves _A manual for researchers*. Economy and
515 Environment Program for Southeast Asia (EEPSEA): Singapore 1998
- 516 5. Barbier, E. B., Sustainable use of wetlands valuing tropical wetland benefits: economic
517 methodologies and applications. *The Geographical Journal* **1993**, *159*, 22-32.
- 518 6. Brander, L. M.; Wagtendonk, A. J.; Hussain, S. S.; McVittie, A.; Verburg, P. H.; Groot, R. S.
519 d.; Ploeg, S. v. d., Ecosystem service values for mangroves in Southeast Asia: A meta-analysis
520 and value transfer application. *Ecosystem Services* **2012**, *1* (1), 62-69.
- 521 7. Rönnbäck, P., The ecological basis for economic value of seafood production supported by
522 mangrove ecosystems. *Ecological Economics* **1999**, *29*, 235-252.
- 523 8. Barbier, E. B.; Koch, E. W.; Silliman, B. R.; Hacker, S. D.; Wolanski, E.; Primavera, J.;
524 Granek, E. F.; Polasky, S.; Aswani, S.; Cramer, L. A.; Stoms, D. M.; Kennedy, C. J.; Bael,
525 D.; Kappel, C. V.; Perillo, G. M. E.; Reed, D. J., Coastal Ecosystem-Based Management with
526 Nonlinear Ecological Functions and Values *Science* **2008**, *319*, 321-323.
- 527 9. Vo, Q. T.; Kuenzer, C.; Vo, Q. M.; Moder, F.; Oppelt, N., Review of valuation methods for
528 mangrove ecosystem services. *Ecological Indicators* **2012**, *23*, 431-446.
- 529 10. Curran, S., Migration, Social Capital, and the Environment: Considering Migrant Selectivity
530 and Networks in Relation to Coastal Ecosystems *Population and Development Review* **2002**,
531 *28*, 89-125.
- 532 11. Giri, C.; Ochieng, E.; Tieszen, L. L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J.; Duke, N.,
533 Status and distribution of mangrove forests of the world using earth observation satellite data.
534 *Global Ecology and Biogeography* **2011**, *20* (1), 154-159.
- 535 12. FAO *The World's Mangroves 1980 – 2005*; Food and Agriculture Organization (FAO):
536 Rome, Italy, 2007.
- 537 13. Onrizal, Perubahan Tutupan Hutan Mangrove di Pantai Timur Sumatera Utara Periode 1977
538 – 2006. *Jurnal Biologi Indonesia* **2010**, *6* (2), 163-172.
- 539 14. Nurkin, B., Degradation of Mangrove Forests in South Sulawesi, Indonesia. *Hydrobiologia*
540 **1994**, *285*, 271-276.
- 541 15. Malik, A.; Fensholt, R.; Mertz, O., Consequences of Mangrove Forest Change in South
542 Sulawesi. REEC, under review.
- 543 16. Forest-Ministry-Indonesia, *Luas Mangrove per Propinsi di Indonesia In Noor Y.R., Khazali*
544 *M., Suryadiputra I.N.N. Panduan Pengenalan Mangrove di Indonesia*. PHKA/WI-IP: Bogor,
545 Indonesia. , 2006; p 219.
- 546 17. WGMFDA. *Kelautan dan Perikanan dalam Angka 2013*; Working Group of Marine and
547 Fisheries Data Arrangement (WGMFDA). Centre of Data, Statistics and Information,
548 Ministry of Marine and Fisheries of Indonesia: Jakarta, Indonesia, 2013.
- 549 18. GlobeFish. Food Market: Shrimp Production <http://www.globefish.org>. (accessed May 5,
550 2013).
- 551 19. Barbier, E. B., Habitat-Fishery Linkages and Mangrove Loss in Thailand. *Contemporary*
552 *Economic Policy* **2003**, *21* (1), 59-77.
- 553 20. Hogarth, P., *The Biology of Mangroves and Seagrass* 2ed.; Oxford University Press: New
554 York, 2007.
- 555 21. Chee, Y. E., An Ecological Perspective on the Valuation of Ecosystem Services. *Biological*
556 *Conservation* **2004**, *120*, 549-565.
- 557 22. Beaumont, N. J.; Austen, M. C.; Mangi, S. C.; Townsend, M., Economic valuation for the
558 conservation of marine biodiversity. *Marine pollution bulletin* **2008**, *56* (3), 386-96.
- 559 23. Samonte-Tan, G. P. B.; White, A. T.; Tercero, M. A.; Diviva, J.; Tabara, E.; Caballes, C.,
560 Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines.
561 *Coastal Management* **2007**, *35* (2-3), 319-338.

- 562 24. Ukkas, M. *Pemetaan Potensi/Zonasi Wilayah Pesisir dan Pulau-pulau Kecil Kabupaten*
563 *Takalar*; Laporan Penelitian. Universitas Hasanuddin: Makassar, Indonesia, 2001.
- 564 25. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2012.* ; Badan Pusat Statistik (BPS)
565 Kabupaten Takalar: Takalar, Indonesia, 2012.
- 566 26. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2004-2012.*; Badan Pusat Statistik (BPS)
567 Kabupaten Takalar: Takalar: Takalar, Indonesia, 2004-2012.
- 568 27. BPS-Sulsel, *Sulawesi Selatan Dalam Angka 2012.* Badan Pusat Statistik Sulawesi Selatan
569 (BPS-Sulsel): Sulawesi Selatan, Indonesia, 2012.
- 570 28. Malik, A.; Fensholt, R.; Mertz, O., Mangrove Exploitation Effects on Biodiversity and
571 Ecosystem Services. BIOC, under review.
- 572 29. Patton, M., *Qualitative Evaluation and Research Methods.* Sage: Beverly Hills, CA, 1990
573 p532.
- 574 30. Pearce, D.; Moran, D., *The Economic Value of Biodiversity.* Earthscan: UK, 1994.
- 575 31. UNEP, *Guidelines for conducting economic valuation of coastal ecosystem goods and*
576 *services.* UNEP/GEF/SCS Technical Publication 2007.
- 577 32. KKP-Indonesia, *Statistical Data of Marine and Fisheries* Kementerian Kelautan dan
578 Perikanan (KKP) Indonesia <http://statistik.kkp.go.id/> (Accessed 1 March 2013): Jakarta,
579 Indonesia, 2012.
- 580 33. Ong, J. E., Mangroves – a carbon source or sink. *Chemosphere* **1993**, 27, 1097-1107.
- 581 34. Diaz, D.; Hamilton, K.; Johnson, E., *Forest Carbon Market 2011: From Canopy to Currency.*
582 Forest Trend Ecosystem Marketplace: Washington DC 2011; p 93.
- 583 35. Mayudin, A., Kondisi Ekonomi Pasca Konversi Hutan Mangrove menjadi Lahan Tambak di
584 Kabupaten Pangkajene Kepulauan Propinsi Sulawesi Selatan. *Eksos* **2012**, 8 (2), 90-104.
- 585 36. Sathirathai, S.; Barbier, E. B., Valuing Mangrove Conservation in Southern Thailand.
586 *Contemporary Economic Policy* **2001**, 19 (2), 109-122.
- 587 37. Sribianti, I., Valuasi Ekonomi Hutan Mangrove: Studi Kasus Valuasi Ekonomi Kawasan
588 Hutan Mangrove Malili Kabupaten Luwu Timur *Jurnal Sains & Teknologi* **2008**, 8 (3), 186-
589 192.
- 590 38. Hong, P. N., Impact of Shrimp Culture Extension on Environmental and Biodiversity
591 resources in Marsh of Coastal Zone. *Journal of Fisheries* . **1995**, 3, 6-9 and 25.
- 592 39. Harahab, N., *Penilaian Ekonomi Ekosistem Hutan Mangrove dan Aplikasinya dalam*
593 *Perencanaan Wilayah Pesisir.* Graha Ilmu Publisher: Yogyakarta, Indonesia, 2010.
- 594 40. Lan, T. D., Coastal aquaculture and shrimp farming in North Vietnam and environmental cost
595 estimation. *Aquatic Ecosystem Health & Management* **2009**, 12 (3), 235-242.
- 596 41. Gunawardena, M.; Rowan, J. S., Economic Valuation of a Mangrove Ecosystem Threatened
597 by Shrimp Aquaculture in Sri Lanka. *Environmental management* **2005**, 4, 535-550
- 598 42. Setyawan, A. D.; Winarno, K., Pemanfaatan Langsung Ekosistem Mangrove di Jawa Tengah
599 dan Penggunaan Lahan di Sekitarnya; Kerusakan dan Upaya Restorasinya. *Biodiversitas*
600 **2006**, 7 (3), 282-291.
- 601 43. Ong, J. E.; Gong, W. K., *Structure, Function and Management of Mangrove Ecosystems*
602 International Society for Mangrove Ecosystems (ISME) Okinawa, Japan, and International
603 Tropical Timber Organization (ITTO Yokohama, Japan.: 2013.
- 604 44. Mazda, Y.; Magi, M.; Kogo, M.; Hong, P. N., Mangroves as a coastal protection from waves
605 in the Tong King delta, Vietnam. *Mangroves and Salt Marshes* **1997**, 1 (2), 127-135.
- 606 45. Hajramurni, A. Abrasion speed in Takalar hits 100 meters a year.
607 [http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-](http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html)
608 [year.html](http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html) (accessed March 13, 2013).
- 609 46. Halim, A. Kerusakan Mangrove Memiskinkan Warga.
610 [http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiski](http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga)
611 [nkan.Warga](http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga) (accessed March 13, 2013).

- 612 47. Pirzanet, A. M.; Gunarto; Daud, R.; Utoyo; Kabangnga, N. *Pemantapan Budidaya Kepiting*
613 *Bakau untuk Mengantisipasi Dampak Penangkapan di perairan Sungai Lamuru, Kabupaten*
614 *Bone*; Balai Penelitian Perikanan Pantai: Maros, Indonesia, 1999.
- 615 48. Gunarto, Konservasi mangrove sebagai pendukung sumberdaya hayati perikanan pantai
616 *Jurnal Litbang Pertanian* **2004**, 23 (1).
- 617 49. Sasekumar, A.; Chong, V. C.; Leh, M. U.; D’Cruz, R., Mangroves as a Habitat for Fish and
618 Prawns. *Hyrobiologia* **1992**, 247, 195-207.
- 619 50. Salem, M. E.; Mercer, D. E., The Economic Value of Mangrove: A Meta-Analysis.
620 *Sustainability* **2012**, 4, 359-383.
- 621 51. Jusoff, K.; Taha, D., Managing Sustainable Mangrove Forests in Peninsular Malaysia.
622 *Journal of Sustainable Development* **2008**, 1 (1).
- 623 52. Prakash, M.; Sivakumar, T., A study on antibacterial activity of mangrove plant *Excoecaria*
624 *agallocha L.* *International Journal of Current Microbiology and Applied Sciences* **2013**, 2 (8),
625 260-262.
- 626 53. Bandaranayake, W. M., Traditional and medicinal uses of mangroves. *Mangroves and Salt*
627 *Marshes* **1998**, 2, 133-148.
- 628 54. Frost, R., Dwindling Indian Sundarban Mangrove: The Way Out. *Science and Culture* **2010**,
629 76 (7–8), 275-282.
- 630 55. MAP-Indonesia *Kajian Risilian (Situational and contextual field assessment and analysis-*
631 *Restoring Coastal Livelihood Project)*; Mangrove Action Project (MAP) Indonesia: Sulawesi
632 Selatan, Indonesia, 2011.
- 633 56. Sigit, R. R. Ekonomi Lingkungan: Pilih Mangrove atau Tambak.
634 <http://www.mongabay.co.id/2013/10/25/ekonomi-lingkungan-pilih-mangrove-atau-tambak/>
635 (accessed January 5, 2013).

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

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



35 ~~IDR 24,121,086 (USD 2,539)~~ per hectare, (the highest value contribution derived from 
36 the indirect use value (9194%)), whereas the commercial ~~shrimp-aquaculture ponds~~ had a
37 net benefit value of IDR 2,163,910,500 (USD 227,780) or IDR 31,361,022 (USD 3,301)
38 ~~IDR 1,373,250,500 (USD 144,553) or IDR 19,902,181 (USD 2,095)~~ per hectare. In
39 addition, the comparison of Net Present Value (NPV) between the benefit value of
40 mangroves and that of commercial ~~shrimp-pondsaquaculture~~ revealed that conversion of
41 mangroves into commercial ~~shrimp-aquaculture ponds~~ was not economically beneficial
42 when the analysis was expanded to cover the costs of environmental and forest
43 rehabilitation.

44 **Keywords:** Economic valuation; mangroves; commercial ~~shrimp-farmingaquaculture~~;
45 Indonesia; South Sulawesi.
46

47 1. Introduction

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

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

63 Although mangroves provide a variety of products and services, they have been under great
64 pressure due to decision making commonly based on assumptions of larger net benefits without
65 considering the loss of wider mangrove services [5] and natural capital stocks [6]. Mangrove
66 products and services are often undervalued [7,8] or even ignored in the economy and by
67 industry and local inhabitants [9]. Consequently, nearly half of the total mangrove areas in the
68 world have been lost over the past decades, with the largest areas of decline in Asia [10,11,12].
69 In Indonesia (which has the largest mangrove areas in the world), mangroves are threatened
70 primarily by aquaculture but also by overharvesting of timber, firewood collection, charcoal
71 production and conversion to other land uses such as agriculture, urbanization, mining and salt
72 ponds [12,13,14,15]. Mangrove areas are characterized by some of the most rapid loss rates of

73 coastal ecosystems in Indonesia; from 1980 to 2003, at least 1.1 million hectares of mangrove
74 were lost, with 75 % of these areas being converted to shrimp ponds [12,16]. High economic
75 revenues from the increase in exports and foreign trade in shrimp have become the main driving
76 forces for the expansion of shrimp ponds by clearing mangroves [14]. In 2012, for instance,
77 shrimp exports from Indonesia were valued at USD 1,304,149,000, of which 38 percent went to
78 the United States of America (USA), 29 percent to Japan, 9 percent to European countries and
79 24 percent to other countries [17]. In South Sulawesi, the value of shrimp exports in 2011
80 reached USD 42,407,000 [15]. Since the early 1990s, Indonesia has become one of the major
81 shrimp producing and exporting countries in the world [18]. However, the expansion of shrimp
82 export which mostly comes from aquaculture production has triggered a heated debate in
83 Indonesia as well as in other exporting countries such as Thailand due to the significant
84 consequences for coastal areas [19,20].

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

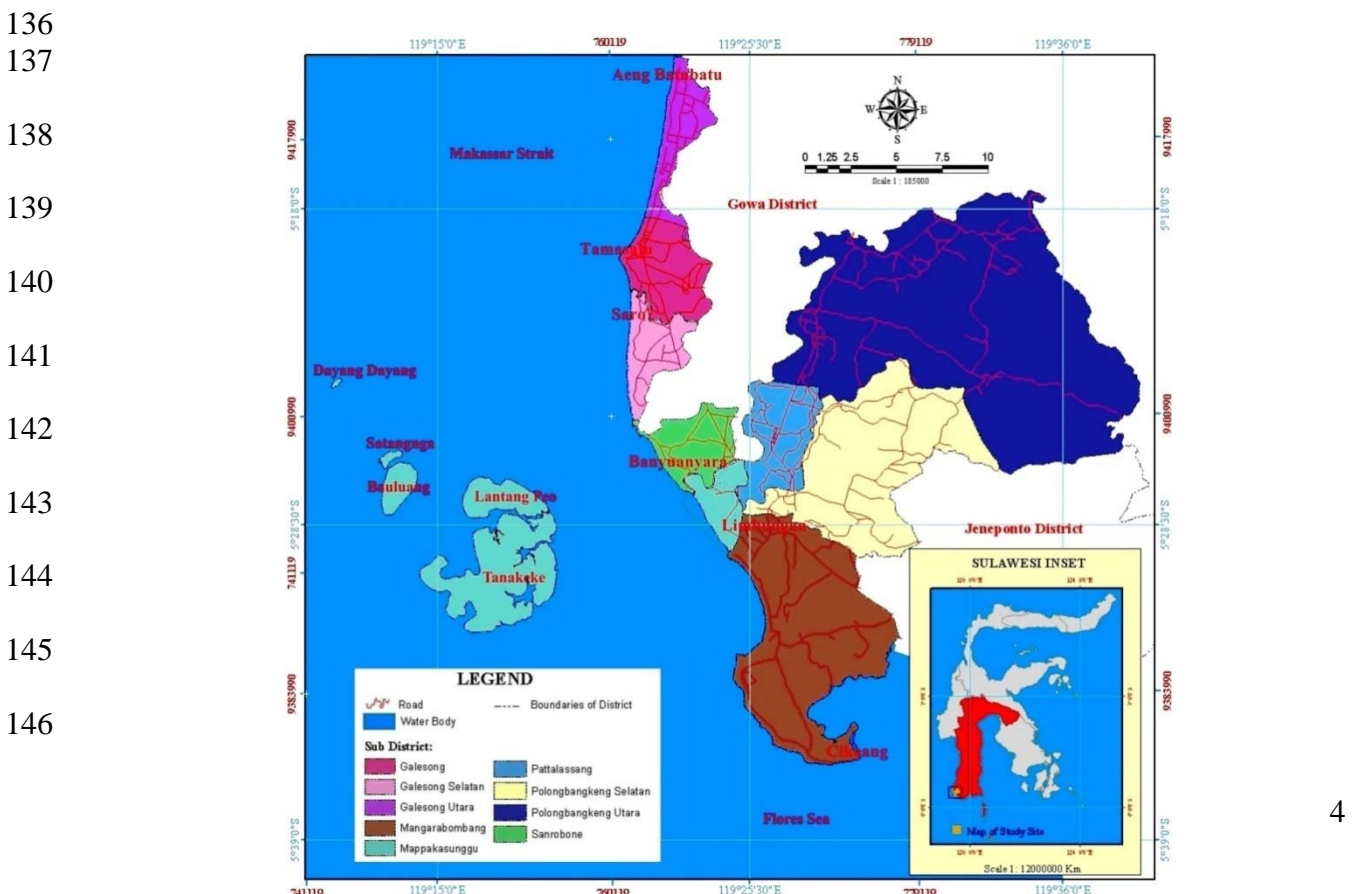
92 Economic valuations of mangroves have been conducted in many areas of the world [9].
93 However, little attention has been paid in the scientific literature to an economic valuation of
94 mangroves in areas threatened by commercial [shrimp farmingaquaculture pond](#) development in
95 Indonesia and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

104 2. StudyArea

105 Takalar district is located in southern South Sulawesi, Indonesia (between latitude 5°12' -
106 5°38' and longitude 119°10' - 119°39', see figure 1), 45 km from Makassar city (the capital of
107 South Sulawesi). The district has a coastline of 74 km [24], occupied by mangroves, coral reefs,
108 sea grass, sandy beaches, rocky beaches, estuaries, aquaculture ponds, rice fields and tourism
109 and residential areas. Most areas of Takalar are plain and coastal areas (including small islands)
110 with an altitude of 0 - 100 metres above sea level and the rest are hilly areas [25]. The district
111 covers 566.51 km² and is divided into nine sub districts (Galesong, South Galesong, North

112 Galesong, Mangarabombang, Mappakasunggu, Pattalassang, South Polongbangkeng, North
 113 Polongbangkeng and Sanrobone). Mappakasunggu consists of a mainland part and small islands
 114 (Tanakeke, Lantangpeo, Bauluang, Satangnga and Dayang Dayang). The population is 272,316
 115 and the population density is 481 persons per km². Mean temperatures vary from 23°C - 33°C
 116 and the monthly precipitation average over the past eight years (2004 – 2011) has been between
 117 174 mm and 712 mm; the greatest amount of precipitation occurred in 2008 from November to
 118 March [26].

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



147

148

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

150

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 using 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). Thise survey iswas conducted in ten10 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, tThe 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 theand 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)

$$FV; CV; SV; SFV = \text{Production (unit/kg/yr)} \times \text{price-Price (IDR/kgunit)} - \text{Production cost (IDR)} \quad (1)$$

- Firewood value (FwV)

$$FwV = \text{Wood collection (unitbundle/yr)} \times \text{price-Price (IDR/unitbundle)} - \text{Production cost (IDR)} \quad (2)$$

(1 bundle = 100 stems with a length of 1 m and a diameter of 4 cm to 8 cm)

- Charcoal value (CcV)

$$CcV = \text{Production (unitsack/yr)} \times \text{Price (IDR/sackunit)} - \text{Production cost (IDR)} \quad (3)$$

(1 sack = 25 kg)

- Nypa palm crafting value (NpcV)

$$\text{NpcV} = \text{Production (Unit/piece/yr)} \times \text{Price (IDR/unitpiece)} - \text{Production cost (IDR)} \quad (4)$$

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 sequestrationsupply 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/tCO₂) is based on Diaz et al. [34]the supply of nutrientservice was assessedby the value of nutrient production (nitrogen and phosphate) from mangrove litter converted to the fertilizer market price of Urea (NH₂)₂CO and SP-36 (Superphosphate, 36 percent P₂O₅). Calculation of IUV is conducted using the following formulas:

- Coastline prevention value (CPV)

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

Coastal length = 74,000 m; The cCost of breakwater construction has been reported to range between withspecification oflength (1m), width (11m) and height (2.5m) =IDR 1,530,880/m³ (USD 158/m³) [35] according to South Sulawesi'sPublic Work Agency and -IDR 8,312,500/m³ (USD 875/m³) [36]according to Thailand's Harbour Department of the Ministry of Communications and Transport.

- Seawater intrusion prevention value (SwIPV)

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

- Provision of nursery grounds value (PNGV)

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

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

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

- Carbon sequestration value (CSV)

$$\text{CSV} = \text{carbon sequestration rate (100 - 200 ton C/ha)} \times \text{total area of mangrove (1,719 ha)} \times \text{price of carbon market (USD 5.5/ton CO}_2\text{)} \quad (8)$$

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

210 3.2.2. Commercial of Aquaculture Pond

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

$$\text{Total area of aquaculture ponds (ha)} = \text{number of farmers (23 farmers)} \times \text{area of aquaculture pond-per farmer (3 ha)} \quad (9)$$

$$\text{Investment cost} = \text{cost construction (IDR/ha)} + \text{farming equipment (IDR/unit)} \times \text{total area of aquaculture pond (ha)} \quad (10)$$

$$\text{Production cost} = \text{fixed cost (e.g. equipment depreciation) (IDR/unit)} + \text{variable cost (fry, feed, fertilizer, fuel, etc) (IDR/unit)} \times \text{total area of aquaculture-pond (ha)} \quad (11)$$

$$\text{Benefit of A~~p~~V} = \text{production (kg/ha/yr)} \times \text{price (IDR/kg)} \times \text{total area of aquaculture pond (ha)} \quad (12)$$

$$\text{Net Benefit/yr of A~~p~~V} = \text{benefit of A~~p~~V (IDR/yr)} - (\text{investment cost} + \text{production cost}) \text{ (IDR/yr)} \quad (13)$$

$$\text{Net benefit/ha/yr of A~~p~~V} = \text{net benefit of A~~p~~V (IDR/yr)} / \text{total area of aquaculture pond (ha)} \quad (14)$$

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

212 3.2.3. Cost-Benefit Analysis (CBA)

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

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

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

235 forest rehabilitation cost was estimated from seed provision, planting and maintenance costs [39].
 236 The forest rehabilitation cost was estimated from year 6 to year 10.

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

244 A discount rate of 10% was used in the CBA reflecting the predominant cost of the loan
 245 interest rate ~~prevailing~~ at financial institutions ~~such as banks~~ when the survey was conducted
 246 [41;39].

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

249 The environmental cost (water pollution cost) of shrimp ponds was adopted from Lan, who
 250 reported that the production of 360,000 tons of shrimp generates an environmental cost of
 251 USD280 million (1 kg shrimp produced = USD1.28), whereas the forest rehabilitation cost was
 252 estimated from seed provision, planting and maintenance costs. The forest rehabilitation cost
 253 was estimated from year 6 to year 10 (assuming normal shrimp pond production during the first
 254 5 years). The formula for calculating the NPV is as follows: [31]
 255

$$NPV = \sum_{i=1}^n \frac{Bit-Cit}{(1+r)^t} \quad (\text{Ordinary CBA}) \quad (4015)$$

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

256 Where:

257 NPV = Net Present Value

258 B = annual gross benefit; EB = annual extended benefit

259 C = annual gross cost; EC = annual extended cost

260 r = discount rate

261 i = each benefit or cost

262 t = period of time

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

$$\text{Environmental cost} = \text{shrimp production (kg/ha/yr)} \times \text{USD 1.28} \times \text{total area of shrimp ponds (ha)} \quad (16)$$

$$\text{Forest rehabilitation cost} = \text{seed provision cost (IDR/ha)} + \text{planting cost (IDR/ha)} + \text{maintenance cost (IDR/ha)} \times \text{total area of aquaculture (ha)} \quad (17)$$

264

265 **4. Results and Discussion**

266 **4.1. DUV of mangroves**

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

272 The results of the household survey showed that 43 households have been directly using
 273 mangrove for fish capture, six for crab capture, and six for shrimp capture ~~and seven for seaweed~~
 274 ~~farming~~. They are using a traditional of fishing gear such as fishing rods, fishing nets, fish/crab
 275 traps and scoop. Annually, fish capture is conducted during 8 months (February - September),
 276 when sea conditions are good, whereas the remaining 4 months (October - ~~and~~ January);:
 277 characterized by ~~when there are~~ high waves and strong winds); are used to rest, repair boats and
 278 fishing gear or engage in alternative work [15]. Eight households have been using mangrove for
 279 harvest firewood, three for charcoal production and four for Nypa palm leaf crafting. The
 280 production averages of fish, crab and shrimp capture ~~and seaweed farming (Eucheumacottonii)~~
 281 per household per year are 2,450 kg, 338 kg, and 213 kg ~~and 8,914kg~~, respectively. The
 282 production of firewood, charcoal and handicrafts such as roofs, walls, floor mats, baskets and
 283 especially hats from Nypa palm leaves per household per year amounted to 60 bundles ~~(1 bundle~~
 284 ~~= 100 stems with a length of 1 m and a diameter of 4 cm to 8 cm)~~, 720 sacks ~~(1 sack = 25kg)~~ and
 285 6,750 ~~units/pieces~~, respectively. The total of fish, crab and shrimp production was 105,350
 286 kg/year, 2,028 kg/year and 1,278 kg/year, respectively, ~~whereas seaweed (Eucheumacottonii)~~
 287 ~~production was 62,398 kg per year~~. Harvested mangrove forests for firewood reached 480
 288 bundles per year, charcoal production was 2,160 sacks per year and handicrafting produced
 289 27,000 ~~units/pieces~~ per year.

290 The highest benefit of DUV was obtained from fish production, earning IDR 498,850,000
 291 (USD 52,511) per year, followed by ~~seaweed farming~~charcoal production for IDR
 292 ~~327,588,000~~83,685,600 (USD ~~49,4028,809~~) per year. Thus, the total benefit of the DUV of
 293 mangrove ecosystem is IDR ~~4,105,209,6777,621,600~~ (USD ~~446,33881,855~~) per year (Table 1).
 294



295 **Table 1. DUV of mangroves**

No	Products	House- hold users (n=7770)	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/ Haha / yr)	Net use value (USD/ Haha / 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 (<i>Eucheuma cottonii</i>)	7	327,588,000	46,798,286	34,483	4,926	190,569	20
Sub Total of DUV =			915,288,587,7		96,34661		532,45434	5636
			00,000		.863		1.885	
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		116,3388		642,93845	6848
			777,621,600		1,855		2,369	

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

297

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

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

315 4.2. IUUV of mangroves

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

323 (Mappakasunggu, Mangarabombang, Sanrobone, South Galesong, Galesong and North
324 Galesong), reaching 20-100 metres per year over the past five years. Moreover, seawater
325 intrusion into inland areas has made growth conditions difficult for local crops such as banana.
326 Furthermore, [Pirzanet et al. \[47\]](#) and [Gunarto \[48\]](#) found that 17 commercial fish species inhabit
327 and use mangroves as nursery grounds in Lamuru Estuary, Bone district, South Sulawesi while
328 27 commercial fish species do so in the Tongke-tongke mangrove forest area and Sinjai district.
329 In Selangor, Malaysia, [Sasekumar et al. \[49\]](#) noted that many species of fish (119) and prawn (9)
330 inhabit and use mangrove as nursery and feeding grounds. [In addition, Ong \[33\] reported that](#)
331 [mangrove above ground could store 100 – 200 ton C/ha above ground, whereas below ground](#)
332 [carbon can reach to 700 ton C/1 m soil thickness/ha \(with an estimated carbon sink rate of 1.5](#)
333 [ton C/ha/yr\).](#)

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

338 In this case study area, the net benefit values of these mangrove services have been estimated
339 using the replacement cost [and benefit transfer methods.](#) Annual values of prevention of
340 coastline erosion and seawater intrusion provided by mangroves were estimated to be IDR
341 11,328,512,000 (USD 1,192,475) [to 61,512,500,000 \(USD 6,475,000\)](#) or IDR 6,590,176/ha
342 [\(USD 694/ha\) to 35,783,886/ha \(USD 3,767/ha\) per hectare](#) and IDR
343 [11,307,700,000, 523,080,000 \(USD 1,190,284,476, 114\) or IDR 6,578,0692,631,227/ha \(USD](#)
344 [692277/ha\) per hectare, respectively. The value of coastline protection services is dominated](#)
345 [of by the TEV of mangrove. This finding is similar in Thailand as reported by Barbier et al. \[8\].](#)
346 Provision of nursery ground [sand supply of nutrient service were was](#) estimated to amount to
347 IDR 13,542,282,326,364,198,000 (USD 1,425,503,140,275) or IDR 7,878,000,21,775,105/ha
348 [\(USD 8922,292/ha\). Furthermore, carbon sequestration service was estimated to per hectare and](#)
349 [IDR 1,616,554,4768,981,775,000 – IDR 17,963,500,000 \(USD 170,164,945,450 – USD](#)
350 [1,890,895\) or IDR 940,404,5,225,000/ha – IDR 10,449,971/ha \(USD 99550/ha – USD 1,100/ha\)](#)
351 [per hectare, respectively.](#) Thus, annually the aggregate benefit of IUV mangroves was IDR
352 [37,795,048,47638,159,731,198 – IDR 97,325,444,198 \(USD 3,978,4264,016,814 – USD](#)
353 [10,244,784\) or IDR 21,986,64836,221,508/ha – IDR 70,640,189/ha \(USD 2,3143,813/ha – USD](#)
354 [7,436/ha\) per hectare \(Table 2\).](#)

355 Some studies have reported benefit values of such mangrove services and [Sathirathai and](#)
356 [Barbier \[36\]](#) estimated the cost of constructing breakwaters to prevent coastal erosion in
357 Southern Thailand to be USD 3,679/Haha. [Samonte-Tan et al. \[23\]](#) estimated the benefit value of
358 preventing coastline erosion and supplying nursery grounds from mangroves in the Bohol
359 Marine Triangle, Philippines to be USD 672/Haha/yr and USD 243/Haha/yr, respectively.
360 [Harahab \[39\]](#) calculated the annual benefit value of preventing seawater intrusion in Probolinggo
361 district, East Java to be IDR 68,227,500/ha/yr (USD 7,182/ha/yr) [per hectare. In addition, and](#)
362 [estimated each hectare of mangrove in the Bhitarkanika National Park, India to contain nutrient](#)
363 [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	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 – 3,767
2	Seawater intrusion prevention	4,523,080,000	476,114	2,631,227	277
3	Provision of nursery grounds	13,542,282,000	1,425,503	7,878,000	829
4	Supply of nutrients	1,616,554,476	170,164	940,404	99
4	Carbon sequestration (nitrogen and phosphate)	8,981,775,000 –	945,450 –	5,225,000 –	550 – 1,100
Total of IUV =		37,995,848,476	3,978,426	21,988,848	2,314
Total of IUV =		38,159,731,198 –	4,016,814 –	36,221,508 –	3,813 – 7,436
		97,325,444,198	10,244,784	70,640,189	

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 Haha) 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].

392
393



Table 3. OV of mangroves

No	Option value	Total use Value (USD/yr)	Total use value (IDR/yr)	Total use value (IDR/Haha/y r)	Total use value (USD/Haha/ 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 Haha

394

395 **4.5.4.4. TEV and NPV of Mangroves**



396 On the basis of the sum values of the DUV, IUV and OV, the annual benefit of the TEV of
397 mangroves is estimated to be IDR 41,464,146,576501,241,298 – 100,666,954,298 (USD
398 4,364,64768,582 – 10,596,552) or IDR 24,121,08638,165,377 – 72,584,058 (USD 2,5394,018 –
399 7,641) per hectare (Table 4). In addition, the NPVs per hectare for all three values (the DUV,
400 IUV and OV) of mangroves benefits over a 10-year time period with a discount rate of 10%
401 were IDR 4,579,5842,572,943 (USD 482271), IDR 171,757,468126,260,406 – 322,024,022
402 (USD 18,08013,291 – 33,897) and IDR 118,48316,225 610(USD 1,202893) (Table 5).

403 The largest benefit value of mangroves (9194%) and the highest NPV are derived from the
404 IUV, including the values of coastline protection, seawater intrusion prevention, and nutrient and
405 nursery ground provision and carbon sequestration.

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

413

414

Table 4. TEV of mangroves



No.	Economic usevalue	Use value (IDR/yr)	Use value (IDRUSD/yr)	Use value (IDR/Haha/y r)	Use value (IDRUSD/Ha ha/yr)	%
1	DUV	1,105,209,600777 .621,600	116,33881,88 5	642,938452,3 69	6848	23
2	IUV	37,795,048,47638 .159,731,198 – 97,325,444,198	3,978,4264,1 06,814 – 10,244,784	21,986,64836, 221,508 – 70,640,189	2,3143,813 – 7,436	941
3	OV	2,563,888,500	269,883	1,491,500	157	64
	TEV	41,464,146,57650	4,364,6478,5	24,121,08638,	2,5394,018 –	100

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

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

415
416
417

Table 5. NPV of mangroves



NPV	DUV	IUV	OV	
NPV (IDR)	<u>7,872,304,104</u>	<u>295,251,087,549</u>	<u>217,041,638,583</u>	<u>19,625,152,186</u>
	<u>4,422,889,286</u>	<u>-553,559,294,612</u>		<u>82,664,597</u>
NPV (IDR/ Haha)	<u>4,579,584</u>	<u>171,757,468</u>	<u>126,260,406 –</u>	<u>8,483,225</u>
	<u>2,943</u>	<u>322,024,022</u>		<u>10</u>
NPV (USD/ Haha)	<u>482271</u>	<u>13,291</u>	<u>-18,080</u>	<u>1,202893</u>

418 **4.6.4.5. Benefit value of commercial ~~shrimp farming~~ aquaculture pond and**
419 **comparison to economic value of mangroves**

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


427 Interviews of 23 ~~of shrimp aquaculture~~ farmers revealed that ~~shrimp aquaculture~~ ponds in the
428 study area have been constructed (to an average extent of 3 hectares) by clearing mangrove
429 forests. The types of ~~shrimp aquaculture~~ ponds found were monoculture of shrimp (3 ponds),
430 monoculture of milkfish (3 ponds), polyculture of shrimp and milkfish (9 ponds) and polyculture
431 of milkfish and seaweed, mainly from *Gracilaria sp.* (8 ponds). The total investment cost,
432 including construction costs and equipment, for all pond areas were IDR 543,549,500 (USD
433 57,216) (average cost per shrimp pond is about IDR 23 million (USD 2,488)). Meanwhile, the
434 total production cost, including fixed costs (e.g. equipment depreciation costs and taxes) and
435 variable costs (e.g. costs of labour, seed, feed, fertilizer, fuel, etc.) for all pond areas was about
436 IDR 406,600,000 (USD 42,800) (average per ~~shrimp~~ pond IDR 17.6 million (USD 1.860)). Two
437 aAnnual harvestsly, shrimp production generated on average 7,600422 kg/ha/yr, milkfish
438 production, 30,1506,700 kg/ha/yr, and seaweed production, 34,3502,862 kg/ha/yr (2 harvests per
439 year). The market prices of shrimp, milkfish and seaweed (*Gracilaria sp.*) were IDR 55,000
440 (USD 5.79) per kg, IDR 15,000 (USD 1.58) per kg and IDR 4,000 (USD 0.42) per kg,
441 respectively. Thus, annually the net benefit amounts to IDR 1,373,250,5002,163,910,500 (USD
442 144,553227,780) or IDR 19,902,18131,361,022/ha (USD 2,0953,301/ha) per hectare and the
443 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 34.5 and 1.34 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 covered most of the benefit value of these services~~[7]. However, wWhen 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 ~~-459663/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].

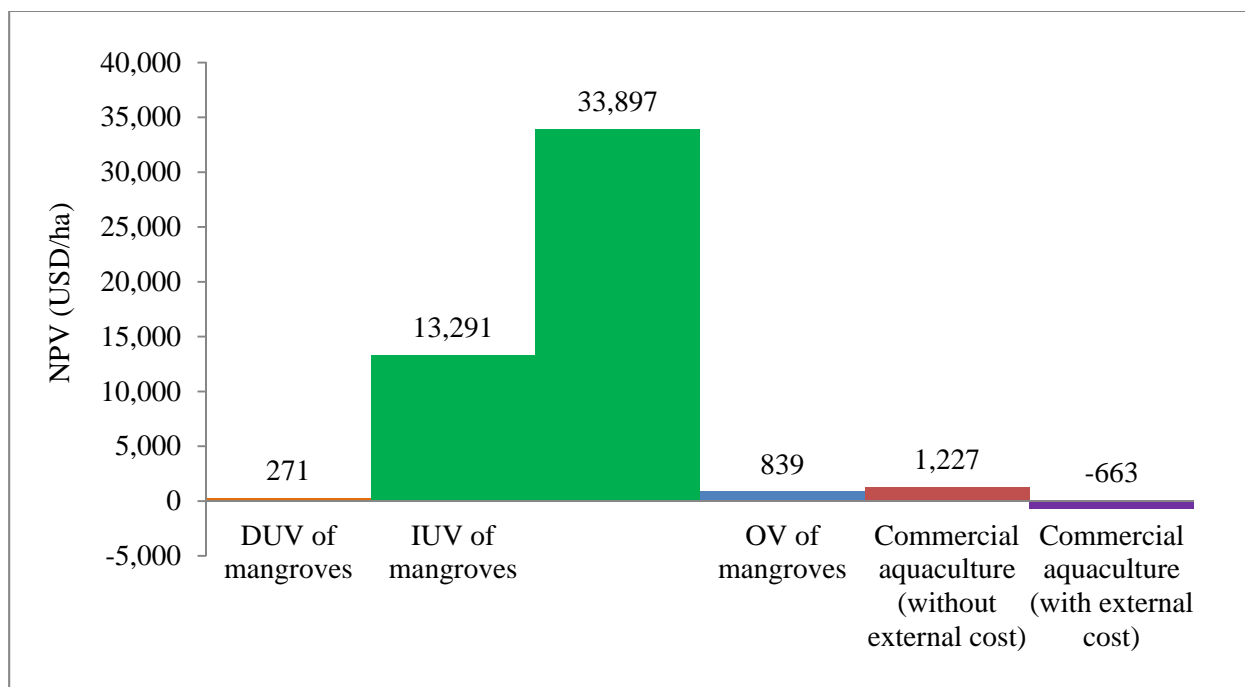
In summary, degraded and decreased areas of mangroves, water pollution caused by waste ponds and the loss of nursery, feeding and spawning grounds of marine organisms have become visible evidence of the environmental impacts of ~~shrimp farming~~aquaculture pond development. If local environmental conditions 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	<u>7,600</u> <u>422</u>	-
	Milkfish	Kg/ha/yr	<u>30,150</u> <u>6,700</u>	-
	Seaweed (<i>Gracilaria sp.</i>)	Kg/ha/yr	<u>34,350</u> <u>2,862</u>	-
4	Market price			
	Shrimp	IDR/Kg	55,000	5.79
	Milkfish	IDR/Kg	15,000	1.58

	Seaweed (<i>Gracilaria sp.</i>)	IDR/Kg	4,000	0.42
			<u>2,323,400,000</u>	<u>3,11</u>
5	Benefit of ApV	IDR/yr	<u>4,060,000</u>	<u>244,568</u>
			<u>1,373,250,500</u>	<u>2,16</u>
6	Net benefit of ApV	IDR/yr	<u>3,910,500</u>	<u>144,553</u>
	Net benefit/perHaha/yr of ApV	IDR/Haha/yr	<u>19,902,181</u>	<u>31,361,</u>
6	NPV without external cost:		<u>022</u>	<u>2,095</u>
7	NPV without external cost:		<u>25,875,117,657</u>	<u>804</u>
	NPV-NPV	IDR	<u>,260,088</u>	<u>2,723,696</u>
			<u>15,052,424</u>	<u>11,655,</u>
	NPV	IDR/Haha	<u>943</u>	<u>1,584</u>
8	NPV with external cost:		<u>-7,491,812,355-</u>	
	NPV	IDR	<u>434,647,387</u>	<u>-788,61-45,752</u>
			<u>-4,358,239-</u>	
	NPV	IDR/Haha	<u>6,299,237</u>	<u>-459-663</u>

Exchange rate: USD 1 = IDR 9,500



479 **Figure 2.** Comparison of NPV of mangroves versus commercial [shrimp farming aquaculture](#)

480 [pond.](#)

482 **5. Conclusions**

483 This study has demonstrated that the annual TEV of mangrove benefits is IDR
484 [41,464,146,576](#) [41,501,241,298](#) – [100,666,954,298](#) (USD [4,364,647](#) [4,368,582](#) – [10,596,552](#)) or
485 IDR [24,121,086](#) [38,165,377](#) – [72,584,058](#) (USD [2,539](#) [4,018](#) – [7,641](#)) per hectare. The calculation
486 included the DUV of mangroves (the benefit value of fisheries and forestry products), the IUV
487 of mangroves (the benefit value of protecting the coastline, preventing seawater intrusion, acting
488 as a nursery ground and [supplying nutrients carbon sequestration](#)), and the OV of mangroves
489 (benefit value of medicines [material](#)). The highest contribution of the TEV of mangroves was
490 derived from the IUV of mangroves ([91](#)[94](#)%). The [net](#) benefit value of commercial [shrimp](#)
491 [farming aquaculture pond](#) amounts to IDR [1,373,250,500](#) [2,163,910,500](#) (USD [144,553](#) [227,780](#))
492 or IDR [19,902,181](#) [31,361,022](#) (USD [2,095](#) [3,301](#)) per hectare. In addition, the NPVs per hectare
493 for the DUV, IUV and OV and [shrimp farming aquaculture pond](#) were IDR [4,579,584](#) [2,572,941](#)
494 (USD [482](#) [271](#)), IDR [171,757,468](#) [126,260,406](#) – [322,024,022](#) (USD [18,080](#) [13,291](#) – [33,897](#)),
495 IDR [11,416,610](#) [8,483,225](#) (USD [1,202](#) [893](#)) and IDR [15,052,424](#) [11,655,943](#) (USD [1,584](#) [1,227](#)),
496 respectively. The conversion of mangroves into commercial [shrimp farms aquaculture pond](#) has a
497 higher beneficial value than the DUV and OV of mangroves and at a first glance seems to be
498 financially viable, but when the IUV of mangroves is included in the comparison, the [benefit](#)
499 value of mangroves is considerably higher. In addition, when the analysis of NPV was extended
500 to include the costs of environmental [restoration \(from water pollution\)](#) and forest rehabilitation,
501 the revenue of [shrimp farming aquaculture pond](#) became negative or no longer economically
502 beneficial.

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511 **Author Contributions**

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

515 **Conflict of Interest**

516 The authors declare no conflict of interest.

517 **References**

- 518 1. Fauzi, A., *Economics of Natural Resources and Environment. Theory and Applications*. PT
519 Gramedia Pustaka Utama: Jakarta, Indonesia, 2004; p 259.
- 520 2. Suparmoko, M., *Neraca Sumberdaya Alam (Natural Resource Accounting)*. BPFE UGM:
521 Yogyakarta, Indonesia, 2005.
- 522 3. Rukmana, D., *Ekonomi Lingkungan dan Sumberdaya Alam*. Penerbit Arus Timur Makassar,
523 Indonesia, 2012.
- 524 4. Bann, C., *The economic valuation of mangroves _A manual for researchers*. Economy and
525 Environment Program for Southeast Asia (EEPSEA): Singapore 1998
- 526 5. Barbier, E. B., Sustainable use of wetlands valuing tropical wetland benefits: economic
527 methodologies and applications. *The Geographical Journal* **1993**,*159*, 22-32.
- 528 6. Brander, L. M.; Wagtendonk, A. J.; Hussain, S. S.; McVittie, A.; Verburg, P. H.; Groot, R.
529 S. d.; Ploeg, S. v. d., Ecosystem service values for mangroves in Southeast Asia: A meta-
530 analysis and value transfer application. *Ecosystem Services* **2012**,*1* (1), 62-69.
- 531 7. Rönnbäck, P., The ecological basis for economic value of seafood production supported by
532 mangrove ecosystems. *Ecological Economics* **1999**, *29*, 235-252.
- 533 8. Barbier, E. B.; Koch, E. W.; Silliman, B. R.; Hacker, S. D.; Wolanski, E.; Primavera, J.;
534 Granek, E. F.; Polasky, S.; Aswani, S.; Cramer, L. A.; Stoms, D. M.; Kennedy, C. J.; Bael,
535 D.; Kappel, C. V.; Perillo, G. M. E.; Reed, D. J., Coastal Ecosystem-Based Management
536 with Nonlinear Ecological Functions and Values *Science* **2008**,*319*, 321-323.
- 537 9. Vo, Q. T.; Kuenzer, C.; Vo, Q. M.; Moder, F.; Oppelt, N., Review of valuation methods for
538 mangrove ecosystem services. *Ecological Indicators* **2012**,*23*, 431-446.
- 539 10. Curran, S., Migration, Social Capital, and the Environment: Considering Migrant Selectivity
540 and Networks in Relation to Coastal Ecosystems *Population and Development Review*
541 **2002**,*28*, 89-125.
- 542 11. Giri, C.; Ochieng, E.; Tieszen, L. L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J.; Duke, N.,
543 Status and distribution of mangrove forests of the world using earth observation satellite
544 data. *Global Ecology and Biogeography* **2011**,*20* (1), 154-159.
- 545 12. FAO *The World's Mangroves 1980 – 2005*; Food and Agriculture Organization (FAO):
546 Rome, Italy, 2007.
- 547 13. Onrizal, Perubahan Tutupan Hutan Mangrove di Pantai Timur Sumatera Utara Periode 1977
548 – 2006. *Jurnal Biologi Indonesia* **2010**,*6* (2), 163-172.
- 549 14. Nurkin, B., Degradation of Mangrove Forests in South Sulawesi, Indonesia. *Hydrobiologia*
550 **1994**,*285*, 271-276.
- 551 15. Malik, A.; Fensholt, R.; Mertz, O., Consequences of Mangrove Forest Change in South
552 Sulawesi. REEC, under review.
- 553 16. Forest-Ministry-Indonesia, *Luas Mangrove per Propinsi di Indonesia In Noor Y.R., Khazali*
554 *M., Suryadiputra I N.N. Panduan Pengenalan Mangrove di Indonesia*. PHKA/WI-IP: Bogor,
555 Indonesia. , 2006; p 219.

- 556 17. WGMFDA. *Kelautan dan Perikanan dalam Angka 2013*; Working Group of Marine and
557 Fisheries Data Arrangement (WGMFDA). Centre of Data, Statistics and Information,
558 Ministry of Marine and Fisheries of Indonesia: Jakarta, Indonesia, 2013.
- 559 18. GlobeFish. Food Market: Shrimp Production <http://www.globefish.org>. (accessed May 5,
560 2013).
- 561 19. Barbier, E. B., Habitat-Fishery Linkages and Mangrove Loss in Thailand. *Contemporary*
562 *Economic Policy* **2003**,21 (1), 59-77.
- 563 20. Hogarth, P., *The Biology of Mangroves and Seagrass* 2ed.; Oxford University Press: New
564 York, 2007.
- 565 21. Chee, Y. E., An Ecological Perspective on the Valuation of Ecosystem Services. *Biological*
566 *Conservation* **2004**,120, 549-565.
- 567 22. Beaumont, N. J.; Austen, M. C.; Mangi, S. C.; Townsend, M., Economic valuation for the
568 conservation of marine biodiversity. *Marine pollution bulletin* **2008**,56 (3), 386-96.
- 569 23. Samonte-Tan, G. P. B.; White, A. T.; Tercero, M. A.; Diviva, J.; Tabara, E.; Caballes, C.,
570 Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines.
571 *Coastal Management* **2007**,35 (2-3), 319-338.
- 572 24. Ukkas, M. *Pemetaan Potensi/Zonasi Wilayah Pesisir dan Pulau-pulau Kecil Kabupaten*
573 *Takalar*; Laporan Penelitian. Universitas Hasanuddin: Makassar, Indonesia, 2001.
- 574 25. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2012*. ; Badan Pusat Statistik (BPS)
575 Kabupaten Takalar: Takalar, Indonesia, 2012.
- 576 26. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2004-2012*.; Badan Pusat Statistik
577 (BPS) Kabupaten Takalar: Takalar: Takalar, Indonesia, 2004-2012.
- 578 27. BPS-Sulsel, *Sulawesi Selatan Dalam Angka 2012*. Badan Pusat Statistik Sulawesi Selatan
579 (BPS-Sulsel): Sulawesi Selatan, Indonesia, 2012.
- 580 28. Malik, A.; Fensholt, R.; Mertz, O., Mangrove Exploitation Effects on Biodiversity and
581 Ecosystem Services. BIOC, under review.
- 582 29. Patton, M., *Qualitative Evaluation and Research Methods*. Sage: Beverly Hills, CA, 1990
583 p532.
- 584 30. Pearce, D.; Moran, D., *The Economic Value of Biodiversity*. Earthscan: UK, 1994.
- 585 31. UNEP, *Guidelines for conducting economic valuation of coastal ecosystem goods and*
586 *services*. UNEP/GEF/SCS Technical Publication 2007.
- 587 32. KKP-Indonesia, *Statistical Data of Marine and Fisheries* Kementerian Kelautan dan
588 Perikanan (KKP) Indonesia <http://statistik.kkp.go.id/> (Accessed 1 March 2013): Jakarta,
589 Indonesia, 2012.
- 590 33. Ong, J. E., Mangroves – a carbon source or sink. *Chemosphere* **1993**,27, 1097-1107.
- 591 34. Diaz, D.; Hamilton, K.; Johnson, E., *Forest Carbon Market 2011: From Canopy to*
592 *Currency*. Forest Trend Ecosystem Marketplace: Washington DC 2011; p 93.
- 593 35. Mayudin, A., Kondisi Ekonomi Pasca Konversi Hutan Mangrove menjadi Lahan Tambak di
594 Kabupaten Pangkajene Kepulauan Propinsi Sulawesi Selatan. *Eksos* **2012**,8 (2), 90-104.
- 595 36. Sathirathai, S.; Barbier, E. B., Valuing Mangrove Conservation in Southern Thailand.
596 *Contemporary Economic Policy* **2001**,19 (2), 109-122.
- 597 37. Sribianti, I., Valuasi Ekonomi Hutan Mangrove: Studi Kasus Valuasi Ekonomi Kawasan
598 Hutan Mangrove Malili Kabupaten Luwu Timur *Jurnal Sains & Teknologi* **2008**,8 (3), 186-
599 192.
- 600 38. Hong, P. N., Impact of Shrimp Culture Extension on Environmental and Biodiversity
601 resources in Marsh of Coastal Zone. *Journal of Fisheries* . **1995**,3, 6-9 and 25.
- 602 39. Harahab, N., *Penilaian Ekonomi Ekosistem Hutan Mangrove dan Aplikasinya dalam*
603 *Perencanaan Wilayah Pesisir*. Graha Ilmu Publisher: Yogyakarta, Indonesia, 2010.
- 604 40. Lan, T. D., Coastal aquaculture and shrimp farming in North Vietnam and environmental
605 cost estimation. *Aquatic Ecosystem Health & Management* **2009**,12 (3), 235-242.

- 606 41. Gunawardena, M.; Rowan, J. S., Economic Valuation of a Mangrove Ecosystem Threatened
607 by Shrimp Aquaculture in Sri Lanka. *Environmental management* **2005**,*4*, 535-550
- 608 42. Setyawan, A. D.; Winarno, K., Pemanfaatan Langsung Ekosistem Mangrove di Jawa
609 Tengah dan Penggunaan Lahan di Sekitarnya; Kerusakan dan Upaya Restorasinya.
610 *Biodiversitas* **2006**,*7* (3), 282-291.
- 611 43. Ong, J. E.; Gong, W. K., *Structure, Function and Management of Mangrove Ecosystems*
612 International Society for Mangrove Ecosystems (ISME) Okinawa, Japan, and International
613 Tropical Timber Organization (ITTO Yokohama, Japan.: 2013.
- 614 44. Mazda, Y.; Magi, M.; Kogo, M.; Hong, P. N., Mangroves as a coastal protection from
615 waves in the Tong King delta, Vietnam. *Mangroves and Salt Marshes* **1997**,*1* (2), 127-135.
- 616 45. Hajramurni, A. Abrasion speed in Takalar hits 100 meters a year.
617 [http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-](http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html)
618 [year.html](http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html) (accessed March 13, 2013).
- 619 46. Halim, A. Kerusakan Mangrove Memiskinkan Warga.
620 [http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiski](http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga)
621 [nkan.Warga](http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga) (accessed March 13, 2013).
- 622 47. Pirzanet, A. M.; Gunarto; Daud, R.; Utoyo; Kabangnga, N. *Pemantapan Budidaya Kepiting*
623 *Bakau untuk Mengantisipasi Dampak Penangkapan di perairan Sungai Lamuru, Kabupaten*
624 *Bone*; Balai Penelitian Perikanan Pantai: Maros, Indonesia, 1999.
- 625 48. Gunarto, Konservasi mangrove sebagai pendukung sumberdaya hayati perikanan pantai
626 *Jurnal Litbang Pertanian* **2004**,*23* (1).
- 627 49. Sasekumar, A.; Chong, V. C.; Leh, M. U.; D'Cruz, R., Mangroves as a Habitat for Fish and
628 Prawns. *Hyrobiologia* **1992**,*247*, 195-207.
- 629 50. Salem, M. E.; Mercer, D. E., The Economic Value of Mangrove: A Meta-Analysis.
630 *Sustainability* **2012**,*4*, 359-383.
- 631 51. Jusoff, K.; Taha, D., Managing Sustainable Mangrove Forests in Peninsular Malaysia.
632 *Journal of Sustainable Development* **2008**,*1* (1).
- 633 52. Prakash, M.; Sivakumar, T., A study on antibacterial activity of mangrove plant *Excoecaria*
634 *agallocha* L. *International Journal of Current Microbiology and Applied Sciences* **2013**, *2*
635 (8), 260-262.
- 636 53. Bandaranayake, W. M., Traditional and medicinal uses of mangroves. *Mangroves and Salt*
637 *Marshes* **1998**,*2*, 133-148.
- 638 54. Frost, R., Dwindling Indian Sundarban Mangrove: The Way Out. *Science and Culture*
639 **2010**,*76* (7-8), 275-282.
- 640 55. MAP-Indonesia *Kajian Risilian (Situational and contextual field assessment and analysis-*
641 *Restoring Coastal Livelihood Project)*; Mangrove Action Project (MAP) Indonesia:
642 Sulawesi Selatan, Indonesia, 2011.
- 643 56. Sigit, R. R. Ekonomi Lingkungan: Pilih Mangrove atau Tambak.
644 <http://www.mongabay.co.id/2013/10/25/ekonomi-lingkungan-pilih-mangrove-atau-tambak/>
645 (accessed January 5, 2013).

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

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21 **Abstract:** Mangroves are recognized as a provider of a variety of products and essential
22 ecosystem services that contribute significantly to the livelihood of local communities.
23 However, over the past decades, mangroves in many tropical areas including the Takalar
24 district, South Sulawesi have degraded and decreased mainly due to conversion to
25 aquaculture. Currently, little is known about the economic benefits of commercialization
26 of aquaculture as compared to those derived from mangroves in the form of products and
27 services. Here, we estimate the Total Economic Value (TEV) of mangrove benefits in order
28 to compare it with the benefit value of commercial aquaculture. Market prices, replacement
29 costs, benefit transfer value and Cost-Benefit Analyses (CBA) have been used for value
30 determination and comparison. The results show that the per year TEV of mangroves
31 ~~during the study period in the studied sitey area~~ (Takalar district, South Sulawesi) was in
32 ~~the range of IDR 41,501,241,298—100,666,954,298 (USD4,370,368,582kUSD (USD x~~
33 ~~1000) (USDx1,000,000)—to 10,596,5520,597 kUSD}~~ or ~~IDR 38,165,377—72,584,058~~
34 ~~(USD4,018kUSD (USDx1,000)—to 7,6418 kUSD)~~per hectare, (the highest value
35 contribution derived from the indirect use value (94%)), whereas the commercial

36 aquaculture [in the studied area](#) had a net benefit value of ~~IDR 2,163,910,500 (USD 227,7808~~
37 ~~kUSD)~~ or ~~IDR 31,361,022 (USD 3,304kUSD)~~ per hectare. In addition, the comparison of
38 Net Present Value (NPV) between the benefit value of mangroves and that of commercial
39 aquaculture revealed that conversion of mangroves into commercial aquaculture was not
40 economically beneficial when the analysis was expanded to cover the costs of
41 environmental and forest rehabilitation.

42 **Keywords:** Economic valuation; mangroves; commercial aquaculture; Indonesia; South
43 Sulawesi.
44

45 1. Introduction

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

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

61 Although mangroves provide a variety of products and services, they have been under great
62 pressure due to decision making commonly based on assumptions of larger net benefits without
63 considering the loss of wider mangrove services [5] and natural capital stocks [6]. Mangrove
64 products and services are often undervalued [7,8] or even ignored in the economy and by industry
65 and local inhabitants [9]. Consequently, nearly half of the total mangrove areas in the world have
66 been lost over the past decades, with the largest areas of decline in Asia [10,11,12]. In Indonesia
67 (which has the largest mangrove areas in the world), mangroves are threatened primarily by
68 aquaculture but also by overharvesting of timber, firewood collection, charcoal production and
69 conversion to other land uses such as agriculture, urbanization, mining and salt ponds
70 [12,13,14,15]. Mangrove areas are characterized by some of the most rapid loss rates of coastal
71 ecosystems in Indonesia; from 1980 to 2003, at least 1.1 million hectares of mangrove were lost,
72 with 75 % of these areas being converted to shrimp ponds [12,16]. High economic revenues from
73 the increase in exports and foreign trade in shrimp have become the main driving forces for the

74 expansion of shrimp ponds by clearing mangroves [14]. In 2012, for instance, shrimp exports from
75 Indonesia were valued at ~~USD-1,304,149,000~~USD (USD x 1,000), of which 38 percent went to
76 the United States of America (USA), 29 percent to Japan, 9 percent to European countries and 24
77 percent to other countries [17]. In South Sulawesi, the value of shrimp exports in 2011 reached
78 ~~USD-42,407,000~~kUSD [15]. Since the early 1990s, Indonesia has become one of the major shrimp
79 producing and exporting countries in the world [18]. However, the expansion of shrimp export
80 which mostly comes from aquaculture production has triggered a heated debate in Indonesia as
81 well as in other exporting countries such as Thailand due to the significant consequences for
82 coastal areas [19,20].

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

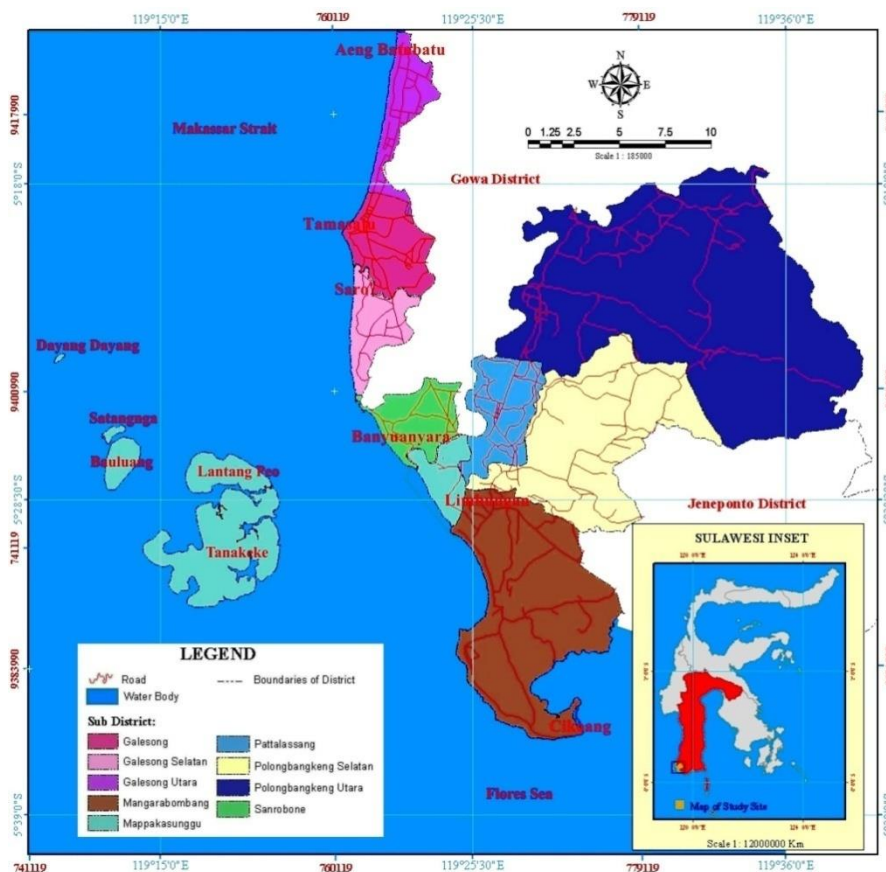
90 Economic valuations of mangroves have been conducted in many areas of the world [9].
91 However, little attention has been paid in the scientific literature to an economic valuation of
92 mangroves in areas threatened by commercial aquaculture development in Indonesia and other
93 Asian countries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

101 2. Study Area

102 Takalar district is located in southern South Sulawesi, Indonesia (between latitude 5°12' - 5°38'
103 and longitude 119°10' - 119°39', see figure 1), 45 km from Makassar city (the capital of South
104 Sulawesi). The district has a coastline of 74 km [24], occupied by mangroves, coral reefs, sea
105 grass, sandy beaches, rocky beaches, estuaries, aquaculture ponds, rice fields and tourism and
106 residential areas. Most areas of Takalar are plain and coastal areas (including small islands) with
107 an altitude of 0 - 100 metres above sea level and the rest are hilly areas [25]. The district covers
108 566.51 km² and is divided into nine sub districts (Galesong, South Galesong, North Galesong,
109 Mangarabombang, Mappakasunggu, Pattalassang, South Polongbangkeng, North
110 Polongbangkeng and Sanrobone). Mappakasunggu consists of a mainland part and small islands
111 (Tanakeke, Lantangpeo, Bauluang, Satangnga and Dayang dayangan). The population is 272,316
112 and the population density is 481 persons per km². Mean temperatures vary from 23°C - 33°C and

113 the monthly precipitation average over the past eight years (2004 – 2011) has been between 174
114 mm and 712 mm; the greatest amount of precipitation occurred in 2008 from November to March
115 [26].

116 The selected study area represents one of the hot spots of mangrove rich environments in
117 Indonesia. However, the region is ~~characterised by being~~ amongst the largest producers of
118 aquaculture product in South Sulawesi [27] and ~~in past decades,~~ mangrove ~~sforest in this area have~~
119 ~~has~~ degraded and decreased ~~in past decades,~~ mainly due to ~~the intensification of conversion to~~
120 aquaculture. About 2,593 hectares (77.4%) of the total mangrove forest area has been changed to
121 aquaculture, mainly on Tanakeke Island and in Banyuanyara village. Currently, the total extent of
122 intact mangrove forest is 1,719 hectares and covers the sub districts of Mappakasunggu,
123 Mangarabombang, Pattallassang, Sanrobone, Galesong, South Galesong and North Galesong [15].
124 Mangroves in this region are dominated by saplings and seedlings and comprise 10 species
125 (*Avicennia alba*, *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Excoecaria agallocha*, *Lumnitzera*
126 *racemosa*, *Nypa fruticans*, *Rhizophora apiculata*, *Rhizophora mucronata*, *Rhizophora stylosa* and
127 *Sonneratia alba*). The most dominant species has been *Rhizophora mucronata*, followed by
128 *Sonneratia alba*. The Diameter at Breast High (DBH) of mangrove trees is between 6.37 cm and
129 23.57 cm and the diameter size classes of 10 – 15 cm are dominant, followed by 15 – 20 cm [28].



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

144 **3. Materials and Methods**

145 3.1. Data Collection

146 Household Surveys

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

158 3.2. Data Analysis

159 3.2.1. Economic Valuation of Mangrove

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

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

$$\text{FV; CV; SV} = \text{Production (kg/yr)} \times \text{Price (IDR/USD/kg)} - \text{Production cost (IDR/USD)} \quad (1)$$

- 166 • Firewood value (FwV)

$$\text{FwV} = \text{Wood collection (bundle/yr)} \times \text{Price (IDR/USD/bundle)} - \text{Production cost (IDR/USD)} \quad (2)$$

(IDR/USD) (1 bundle = 100 stems with a length of 1 m and a diameter of 4 to 8 cm)

- 167 • Charcoal value (CcV)

$$\text{CcV} = \text{Production (sack/yr)} \times \text{Price (IDR/USD/sack)} - \text{Production cost (IDR/USD)} \quad (3)$$

sack = 25kg)

- 168 • Nypa palm crafting value (NpcV)

$$\text{NpcV} = \text{Production (piece/yr)} \times \text{Price (IDR/USD/piece)} - \text{Production cost (IDR/USD)} \quad (4)$$

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

180 credits (USD 5.5/tCO₂) is based on Diaz et al. [34]. Calculation of IUV is conducted using the
181 following formulas:

- 182 • Coastline prevention value (CPV)

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

183 Coastal length = 74,000 m; The cost of breakwater construction has been reported to range
184 between ~~IDR 1,530,880/m³~~ (USD 158 USD/m³) [35] and ~~IDR 8,312,500/m³~~ (USD 875 USD/m³)
185 [36].

- 186 • Seawater intrusion prevention value (SwIPV)

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

- 187 • Provision of nursery grounds value (PNGV)

$$\text{PNGV} = \text{loss volume of fish catch (kg/yr)} \times \text{fish price (IDR/USD/kg)} / \text{total loss of} \quad (7)$$

188 mangrove area during the period 2003 - 2011 (612 ha) from Malik et al. [15]

- 188 • Carbon sequestration value (CSV)

$$\text{CSV} = \text{carbon sequestration rate (100 - 200 tonC/ha)} \times \text{total area of mangrove} \quad (8)$$

(1,719 ha) x price of carbon market (USD 5.5/tonCO₂)

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

193 3.2.2. Commercial Aquaculture

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

$$\text{Total area of aquaculture (ha)} = \text{number of farmers (23 farmers)} \times \text{area of aquaculture} \quad (9)$$

per farmer (3 ha)

$$\text{Investment cost} = \text{cost construction (IDR/USD/ha)} + \text{farming equipment} \quad (10)$$

(IDR/USD/unit) x total area of aquaculture (ha)

$$\text{Production cost} = \text{fixed cost (e.g. equipment depreciation) (IDR/USD/unit)} + \text{variable} \quad (11)$$

cost (fry, feed, fertilizer, fuel, etc) (IDR/USD/unit) x total area of aquaculture (ha)

$$\text{Benefit of AV} = \text{production (kg/ha/yr)} \times \text{price (IDR/USD/kg)} \times \text{total area of} \quad (12)$$

aquaculture (ha)

$$\text{Net Benefit/yr of AV} = \text{benefit of AV (IDR/USD/yr)} - (\text{investment cost} + \text{production} \quad (13)$$

cost) (IDR/USD/yr)

$$\text{Net benefit/ha/yr of AV} = \text{net benefit of AV (IDR/USD/yr)} / \text{total area of aquaculture} \quad (14)$$

(ha)

195 3.2.3. Cost-Benefit Analysis (CBA)

196 CBA is conducted to compare economic value of mangrove with commercial aquaculture, to
197 ~~address-assess~~ whether converting mangrove forest into commercial aquaculture is economically
198 feasible. CBA is used to determining the NPV of internal costs and benefits of commercial
199 aquaculture. ~~Based on Malik et al. [15],~~ the project life ~~span~~ of aquaculture was found to be five
200 years on average in ~~this-the study~~ area [15]. Several studies (e.g. [38,4,36,39]) have observed that
201 shrimp production decreases successively after the fifth year due to the lower survival rate of

202 shrimp. Hence, the production of shrimp over a 10-year project period also decreases by 5 – 20%
 203 and investment and production costs increase to sustain shrimp production [39]. However,
 204 aquaculture involves external costs including environmental cost (water pollution cost) related to
 205 the high salinity content of the water released from the ponds, agrochemical runoff and forest
 206 rehabilitation cost for land degradation [36]. Thus, CBA is required to including also the NPV of
 207 external cost. The value of environmental cost was adopted from Lan [40], who reported that the
 208 production of 360,000 tons of shrimps generates an environmental cost of ~~USD~~280 million USD
 209 (1 kg shrimp produced = USD 1.28), whereas the forest rehabilitation cost was estimated from
 210 seed provision, planting and maintenance costs [39]. The forest rehabilitation cost was estimated
 211 from year 6 to year 10.

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

$$220 \quad NPV = \sum_{i=1}^n \frac{Bit-Cit}{(1+r)^t} \text{ (Ordinary CBA)}$$

$$221 \quad NPV = \sum_{i=1}^n \frac{(Bit+EBit)-(Cit-ECit)}{(1+r)^t} \text{ (Extended CBA)} \quad (15)$$

221 Where:

222 NPV = Net Present Value

223 B = annual gross benefit; EB = annual extended benefit

224 C = annual gross cost; EC = annual extended cost

225 r = discount rate

226 i = each benefit or cost

227 t = period of time

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

$$\text{Environmental cost} = \text{shrimp production (kg/ha/yr)} \times \text{USD 1.28} \times \text{total area of shrimp ponds (ha)} \quad (16)$$

$$\text{Forest rehabilitation cost} = \text{seed provision cost (USD/ha)} + \text{planting cost (USD/ha)} + \text{maintenance cost (USD/ha)} \times \text{total area of aquaculture (ha)} \quad (17)$$

229 4. Results and Discussion

230 4.1. DUV of mangroves

231 In past decades, people who lived around mangroves in this area were highly dependent on
 232 mangroves for various fishery and forestry products for domestic and commercial purposes. In

233 fisheries, mangrove forest has benefits for the capture of fish, crab and shrimp as well as
 234 aquaculture, whereas in forestry, benefits related to the collection of firewood, charcoal production
 235 and Nypa palm leaf crafting are generated.

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

251 The highest benefit of DUV was obtained from fish production, earning ~~IDR 498,850,000~~
 252 ~~(USD52,5113 kUSD)~~(USD x 1,000) per year, followed by charcoal production for ~~IDR~~
 253 ~~83,685,600~~ (USD9 kUSD8,809) per year (numbers rounded to the nearest thousand in text as
 254 compared to table values throughout the paper for improved readability). Thus, the total benefit of
 255 the DUV of mangrove ecosystem is ~~IDR 777,621,600~~ (USD81,8552 kUSD) per year (Table 1).

256
 257 **Table 1. The Direct Use Value (DUV) of mangrove sin 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
Forestry 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

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

265 Even though fish capture is the dominant source of revenue for the local population and the
266 highest generator of net benefit per year (~~IDR 498,850,000 = USD52,5113 kUSD~~), the highest net
267 benefit value per household per year (~~IDR 27,895,200 = USD2,9363 kUSD~~) is derived from
268 charcoal production. Over the last decades, clearing mangrove to expand shrimp ponds has been
269 wide spread in this area, causing mangrove areas to decrease and degrade rapidly, which in turn
270 has led to a decrease in fish production and fishermen's income [15].

271 4.2. IUV of mangroves

272 Besides providing a variety of products, mangrove forest supports ecological services by
273 protecting the coastline from exposure to waves, preventing seawater intrusion and providing
274 nursery grounds and carbon sequestration [43]. Mazda et al. [44] stated that the stand of *Kandelia*
275 *candel* (six years old) can reduce waves with an offshore height of 1 m to 0.05 m when they reach
276 the shore. Hajramurni [45] and Halim [46] revealed that abrasion and seawater intrusion occurred
277 in several places in the region where mangrove is absent. Abrasion was found along the coast in
278 six sub districts of Takalar district (Mappakasunggu, Mangarabombang, Sanrobone, South
279 Galesong, Galesong and North Galesong), reaching 20 - 100 metres per year over the past five
280 years. Moreover, seawater intrusion into inland areas has made growth conditions difficult for
281 local crops such as banana. Furthermore, Pirzanet et al. [47] and Gunarto [48] found that 17
282 commercial fish species inhabit and use mangroves as nursery grounds in Lamuru Estuary, Bone
283 district, South Sulawesi while 27 commercial fish species do so in the Tongke-tongke mangrove
284 forest area and Sinjai district. In Selangor, Malaysia, Sasekumar et al. [49] noted that many species
285 of fish (119) and prawn (9) inhabit and use mangrove as nursery and feeding grounds. In addition,
286 Ong [33] reported that mangrove could store 100 – 200 ton C/ha above ground, whereas below
287 ground carbon can reach 700 ton C/1 m soil thickness/ha (with an estimated carbon sink rate of
288 1.5 ton C/ha/yr).

289 In this case study area, the net benefit values of these mangrove services have been estimated
290 using the replacement cost and benefit transfer methods. Annual values of prevention of coastline
291 erosion and seawater intrusion provided by mangroves were estimated ~~to be to be in the range of~~
292 ~~IDR 11,328,512,000 (USD1,192,475kUSD)~~ to ~~61,512,500,000 (USD6,475 kUSD,000)~~ or ~~IDR~~
293 ~~6,590,176/ha (USD694 USD/ha)~~ to ~~35,783,886/ha (USD3,767 USD/ha)~~ and ~~IDR 4,523,080,000~~
294 ~~(USD476 kUSD,114)~~ or ~~IDR 2,631,227/ha (USD277 USD/ha)~~, respectively. ~~The value of~~
295 ~~coastline protection services is dominated by the TEV of mangrove. This finding is similar in~~
296 ~~Thailand as reported by Barbier et al. [8].~~ Provision of nursery ground service was estimated to

amount to IDR 13,326,364,198 (USD 1,403,277k USD) 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 k USD, 450 to USD 1,891,089k USD) 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 mk USD, 016,814 to USD 10,245 mk USD, 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 7,182k USD/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 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: 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 (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

328 are furthermore a rich source of steroids, triterpenes, saponins, flavonoids, alkaloids and tannins
 329 [53].

330 By transferring benefit values of medicine material of mangroves in East Luwu district
 331 Indonesia [37], the estimation of the annual benefit value of medicinal material in this area was
 332 ~~IDR 2,563,888,500(USD269270 kUSD,883)~~ (mangrove extent of 1,719 ha) or ~~IDR 1,491,500~~
 333 ~~(USD157 USD)~~ per hectare (Table 3). However, over the past decades mangroves in the study
 334 area have degraded, leading to depletion of their composition and diversity [28]. Nonetheless, the
 335 economic value of medicinal material in this area is quite high and many species commonly used
 336 for medicine are available, such as *Avicennia sp.*, *Bruguiera sp.*, *Ceriops sp.*, *Excoecaria sp.*,
 337 *Sonneratia sp.*, and especially *Rhizophora sp.* [28].

338

339

Table 3. The Option Value (OV) of mangrove 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

340 4.4. TEV and NPV of Mangroves

341 On the basis of the sum values of the DUV, IUV and OV, the annual benefit of the TEV of
 342 mangroves ~~is varies estimated to in the range of varies between be~~ ~~IDR 41,501,241,298—~~
 343 ~~100,666,954,298 (USD 4,370 68,582kUSD —and 10,596,5527 kUSD)~~ or ~~IDR 38,165,377—~~
 344 ~~72,584,058 (USD4,018kUSD/ha —and 8 7,641kUSD)/ha per hectare~~(Table 4). In addition, the
 345 NPVs per hectare for all three values (~~the~~ DUV, IUV and OV) of mangroves benefits (~~over a 10-~~
 346 ~~year time period with a discount rate of 10%)~~ were ~~IDR 2,572,943 (USD 271 USD (DUV)), IDR~~
 347 ~~126,260,406— 322,024,022 (USD in the range between 13 kUSD ,291and —34 kUSD (IUV),~~
 348 ~~3,897)and IDR 8,483,225(USD893 USD (OV), respectively)~~(Table 5).

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

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

361

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

NPV	DUV	IUV	OV
NPV (IDRUSD)	<u>4,422,889,286</u>	<u>217,041,638,583</u>	<u>22,846,488 – 14,582,664,5971,</u>
NPV (IDR/ha)	<u>465,567</u>	<u>553,559,294,612</u>	<u>258,269,399</u>
NPV (USD/ha)	<u>2,572,943</u>	<u>126,260,406 – 322,024,022</u>	<u>8,483,225</u>
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 57,216k USD)~~ (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 43,2,800k USD)~~ (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].

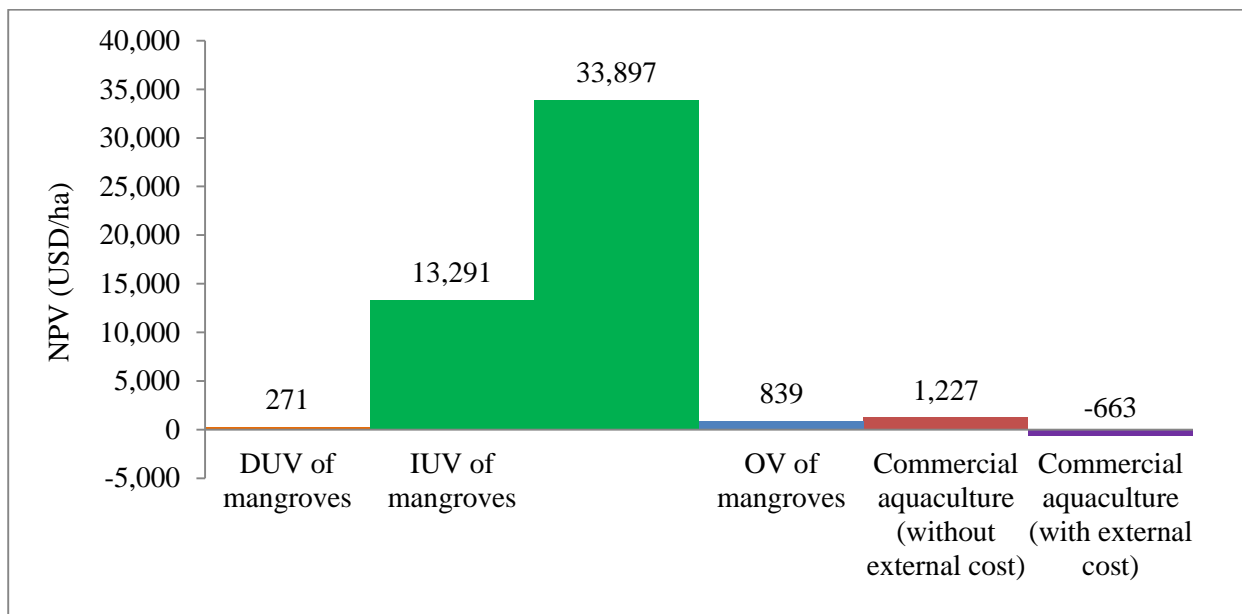
In summary, degraded and decreased areas of mangroves, water pollution caused by waste ponds and the loss of nursery, feeding and spawning grounds of marine organisms have become visible evidence of the environmental impacts of aquaculture development. If local environmental conditions are recoverable, 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	IDRUSD	57,216543,549,500
2	Production cost	IDRUSD/yr	42,800406,600,000
3	Production		
	Shrimp	Kg/ha/yr	422
	Milkfish	Kg/ha/yr	6,700
	Seaweed (<i>Gracilaria sp.</i>)	Kg/ha/yr	2,862
4	Market price		
	Shrimp	IDRUSD/Kg	5.7955,000
	Milkfish	IDRUSD/Kg	1.5815,000
	Seaweed (<i>Gracilaria sp.</i>)	IDRUSD/Kg	0.424,000
5	Benefit of AV	IDRUSD/yr	327,7963,114,060,000
	Net benefit of AV	IDRUSD/yr	227,7802,163,910,500
	Net benefit/ha/yr of AV	IDRUSD/ha/yr	3,30131,361,022
6	NPV without external cost:		
	NPV	IDRUSD	84,659804,260,088
	NPV	IDRUSD/ha	1,22711,655,943
7	NPV with external cost:		
	NPV	IDRUSD	-45,752-434,647,387
	NPV	IDRUSD/ha	-663-6,299,237

Exchange rate: USD 1 = IDR 9,500

411
412



413

414 **Figure 2.** Comparison of the Net Present Value (NPV) of mangroves versus commercial
415 aquaculture in the Takalar district, South Sulawesi.

416 5. Conclusions

417 This study has demonstrated that the annual TEV of mangrove benefits is IDR 41,501,241,298—
418 100,666,954,298 (USD 4,368,582—10,596,552) or IDR 38,165,377—72,584,058 (USD 4,018—
419 7,641) per hectare. The calculation included the DUV of mangroves (the benefit value of fisheries
420 and forestry products), the IUV of mangroves (the benefit value of protecting the coastline,
421 preventing seawater intrusion, acting as a nursery ground and carbon sequestration), and the OV
422 of mangroves (benefit value of medicine). The highest contribution of the TEV of mangroves was
423 derived from the IUV of mangroves (94%). The net benefit value of commercial aquaculture
424 amounts to IDR 2,163,910,500 (USD 227,780) or IDR 31,361,022 (USD 3,301) per hectare. In
425 addition, the NPVs per hectare for the DUV, IUV and OV and aquaculture were IDR 2,572,943
426 (USD 271), IDR 126,260,406—322,024,022 (USD 13,291—33,897), IDR 8,483,225 (USD 893)
427 and IDR 11,655,943 (USD 1,227), respectively. This study has demonstrated that the economic
428 benefit value of mangrove is economically beneficial rather than exceeds the economic benefit
429 value of commercial aquaculture in the Takalar district, South Sulawesi. The highest contribution
430 of the TEV (Total Economic Value) of mangroves was found to be derived from the IUV (Indirect
431 Use Value) of mangroves (the benefit value of protecting the coastline, preventing seawater
432 intrusion, acting as a nursery ground and carbon sequestration). ~~Although~~ The conversion of
433 mangroves into commercial aquaculture has was found to have a higher beneficial value than the
434 DUV (Direct Use Value; the benefit value of fisheries and forestry products) and OV (Option
435 Value; benefit value of medicine) of mangroves and at a first glance seems to be financially viable.
436 However, but when the IUV of mangroves is included in the comparison, the ~~benefit~~ value of

437 mangroves is considerably higher. In addition, when the analysis of NPV ([Net Present Value](#)) was
438 extended to include [also](#) the costs of environmental and forest rehabilitation, the revenue of
439 aquaculture became negative ~~or~~ [and thereby](#) no longer economically beneficial.

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

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455 **Author Contributions**

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

459 **Conflict of Interest**

460 The authors declare no conflict of interest.

461 **References**

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

- 472 6. Brander, L. M.; Wagtendonk, A. J.; Hussain, S. S.; McVittie, A.; Verburg, P. H.; Groot, R. S.
473 d.; Ploeg, S. v. d., Ecosystem service values for mangroves in Southeast Asia: A meta-analysis
474 and value transfer application. *Ecosystem Services* **2012**,*1* (1), 62-69.
- 475 7. Rönnbäck, P., The ecological basis for economic value of seafood production supported by
476 mangrove ecosystems. *Ecological Economics* **1999**, *29*, 235-252.
- 477 8. Barbier, E. B.; Koch, E. W.; Silliman, B. R.; Hacker, S. D.; Wolanski, E.; Primavera, J.;
478 Granek, E. F.; Polasky, S.; Aswani, S.; Cramer, L. A.; Stoms, D. M.; Kennedy, C. J.; Bael,
479 D.; Kappel, C. V.; Perillo, G. M. E.; Reed, D. J., Coastal Ecosystem-Based Management with
480 Nonlinear Ecological Functions and Values *Science* **2008**,*319*, 321-323.
- 481 9. Vo, Q. T.; Kuenzer, C.; Vo, Q. M.; Moder, F.; Oppelt, N., Review of valuation methods for
482 mangrove ecosystem services. *Ecological Indicators* **2012**,*23*, 431-446.
- 483 10. Curran, S., Migration, Social Capital, and the Environment: Considering Migrant Selectivity
484 and Networks in Relation to Coastal Ecosystems *Population and Development Review*
485 **2002**,*28*, 89-125.
- 486 11. Giri, C.; Ochieng, E.; Tieszen, L. L.; Zhu, Z.; Singh, A.; Loveland, T.; Masek, J.; Duke, N.,
487 Status and distribution of mangrove forests of the world using earth observation satellite data.
488 *Global Ecology and Biogeography* **2011**,*20* (1), 154-159.
- 489 12. FAO *The World's Mangroves 1980 – 2005*; Food and Agriculture Organization (FAO):
490 Rome, Italy, 2007.
- 491 13. Onrizal, Perubahan Tutupan Hutan Mangrove di Pantai Timur Sumatera Utara Periode 1977
492 – 2006. *Jurnal Biologi Indonesia* **2010**,*6* (2), 163-172.
- 493 14. Nurkin, B., Degradation of Mangrove Forests in South Sulawesi, Indonesia. *Hydrobiologia*
494 **1994**,*285*, 271-276.
- 495 15. Malik, A.; Fensholt, R.; Mertz, O., Consequences of Mangrove Forest Change in South
496 Sulawesi. REEC, under review.
- 497 16. Forest-Ministry-Indonesia, *Luas Mangrove per Propinsi di Indonesia In Noor Y.R., Khazali*
498 *M., Suryadiputra I.N.N. Panduan Pengenalan Mangrove di Indonesia*. PHKA/WI-IP: Bogor,
499 Indonesia. , 2006; p 219.
- 500 17. WGMFDA. *Kelautan dan Perikanan dalam Angka 2013*; Working Group of Marine and
501 Fisheries Data Arrangement (WGMFDA). Centre of Data, Statistics and Information,
502 Ministry of Marine and Fisheries of Indonesia: Jakarta, Indonesia, 2013.
- 503 18. GlobeFish. Food Market: Shrimp Production <http://www.globefish.org>. (accessed May 5,
504 2013).
- 505 19. Barbier, E. B., Habitat-Fishery Linkages and Mangrove Loss in Thailand. *Contemporary*
506 *Economic Policy* **2003**,*21* (1), 59-77.
- 507 20. Hogarth, P., *The Biology of Mangroves and Seagrass* 2ed.; Oxford University Press: New
508 York, 2007.
- 509 21. Chee, Y. E., An Ecological Perspective on the Valuation of Ecosystem Services. *Biological*
510 *Conservation* **2004**,*120*, 549-565.
- 511 22. Beaumont, N. J.; Austen, M. C.; Mangi, S. C.; Townsend, M., Economic valuation for the
512 conservation of marine biodiversity. *Marine pollution bulletin* **2008**,*56* (3), 386-96.
- 513 23. Samonte-Tan, G. P. B.; White, A. T.; Tercero, M. A.; Diviva, J.; Tabara, E.; Caballes, C.,
514 Economic Valuation of Coastal and Marine Resources: Bohol Marine Triangle, Philippines.
515 *Coastal Management* **2007**,*35* (2-3), 319-338.
- 516 24. Ukkas, M. *Pemetaan Potensi/Zonasi Wilayah Pesisir dan Pulau-pulau Kecil Kabupaten*
517 *Takalar*; Laporan Penelitian. Universitas Hasanuddin: Makassar, Indonesia, 2001.
- 518 25. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2012*. ; Badan Pusat Statistik (BPS)
519 Kabupaten Takalar: Takalar, Indonesia, 2012.
- 520 26. BPS-Kab.Takalar *Kabupaten Takalar Dalam Angka 2004-2012*.; Badan Pusat Statistik (BPS)
521 Kabupaten Takalar: Takalar: Takalar, Indonesia, 2004-2012.

- 522 27. BPS-Sulsel, *Sulawesi Selatan Dalam Angka 2012*. Badan Pusat Statistik Sulawesi Selatan
523 (BPS-Sulsel): Sulawesi Selatan, Indonesia, 2012.
- 524 28. Malik, A.; Fensholt, R.; Mertz, O., Mangrove Exploitation Effects on Biodiversity and
525 Ecosystem Services. BIOC, under review.
- 526 29. Patton, M., *Qualitative Evaluation and Research Methods*. Sage: Beverly Hills, CA, 1990
527 p532.
- 528 30. Pearce, D.; Moran, D., *The Economic Value of Biodiversity*. Earthscan: UK, 1994.
- 529 31. UNEP, *Guidelines for conducting economic valuation of coastal ecosystem goods and*
530 *services*. UNEP/GEF/SCS Technical Publication 2007.
- 531 32. KKP-Indonesia, *Statistical Data of Marine and Fisheries* Kementerian Kelautan dan
532 Perikanan (KKP) Indonesia <http://statistik.kkp.go.id/> (Accessed 1 March 2013): Jakarta,
533 Indonesia, 2012.
- 534 33. Ong, J. E., Mangroves – a carbon source or sink. *Chemosphere* **1993**,*27*, 1097-1107.
- 535 34. Diaz, D.; Hamilton, K.; Johnson, E., *Forest Carbon Market 2011: From Canopy to Currency*.
536 Forest Trend Ecosystem Marketplace: Washington DC 2011; p 93.
- 537 35. Mayudin, A., Kondisi Ekonomi Pasca Konversi Hutan Mangrove menjadi Lahan Tambak di
538 Kabupaten Pangkajene Kepulauan Propinsi Sulawesi Selatan. *Eksos* **2012**,*8* (2), 90-104.
- 539 36. Sathirathai, S.; Barbier, E. B., Valuing Mangrove Conservation in Southern Thailand.
540 *Contemporary Economic Policy* **2001**,*19* (2), 109-122.
- 541 37. Sribianti, I., Valuasi Ekonomi Hutan Mangrove: Studi Kasus Valuasi Ekonomi Kawasan
542 Hutan Mangrove Malili Kabupaten Luwu Timur *Jurnal Sains & Teknologi* **2008**,*8* (3), 186-
543 192.
- 544 38. Hong, P. N., Impact of Shrimp Culture Extension on Environmental and Biodiversity
545 resources in Marsh of Coastal Zone. *Journal of Fisheries* . **1995**,*3*, 6-9 and 25.
- 546 39. Harahab, N., *Penilaian Ekonomi Ekosistem Hutan Mangrove dan Aplikasinya dalam*
547 *Perencanaan Wilayah Pesisir*. Graha Ilmu Publisher: Yogyakarta, Indonesia, 2010.
- 548 40. Lan, T. D., Coastal aquaculture and shrimp farming in North Vietnam and environmental cost
549 estimation. *Aquatic Ecosystem Health & Management* **2009**,*12* (3), 235-242.
- 550 41. Gunawardena, M.; Rowan, J. S., Economic Valuation of a Mangrove Ecosystem Threatened
551 by Shrimp Aquaculture in Sri Lanka. *Environmental management* **2005**,*4*, 535-550
- 552 42. Setyawan, A. D.; Winarno, K., Pemanfaatan Langsung Ekosistem Mangrove di Jawa Tengah
553 dan Penggunaan Lahan di Sekitarnya; Kerusakan dan Upaya Restorasinya. *Biodiversitas*
554 **2006**,*7* (3), 282-291.
- 555 43. Ong, J. E.; Gong, W. K., *Structure, Function and Management of Mangrove Ecosystems*
556 International Society for Mangrove Ecosystems (ISME) Okinawa, Japan, and International
557 Tropical Timber Organization (ITTO Yokohama, Japan.: 2013.
- 558 44. Mazda, Y.; Magi, M.; Kogo, M.; Hong, P. N., Mangroves as a coastal protection from waves
559 in the Tong King delta, Vietnam. *Mangroves and Salt Marshes* **1997**,*1* (2), 127-135.
- 560 45. Hajramurni, A. Abrasion speed in Takalar hits 100 meters a year.
561 [http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-](http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html)
562 [year.html](http://www.thejakartapost.com/news/2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html) (accessed March 13, 2013).
- 563 46. Halim, A. Kerusakan Mangrove Memiskinkan Warga.
564 [http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiski-](http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga)
565 [nkan.Warga](http://megapolitan.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga) (accessed March 13, 2013).
- 566 47. Pirzanet, A. M.; Gunarto; Daud, R.; Utoyo; Kabangnga, N. *Pemantapan Budidaya Kepiting*
567 *Bakau untuk Mengantisipasi Dampak Penangkapan di perairan Sungai Lamuru, Kabupaten*
568 *Bone*; Balai Penelitian Perikanan Pantai: Maros, Indonesia, 1999.
- 569 48. Gunarto, Konservasi mangrove sebagai pendukung sumberdaya hayati perikanan pantai
570 *Jurnal Litbang Pertanian* **2004**,*23* (1).

- 571 49. Sasekumar, A.; Chong, V. C.; Leh, M. U.; D’Cruz, R., Mangroves as a Habitat for Fish and
572 Prawns. *Hyrobiologia* **1992**,*247*, 195-207.
- 573 50. Salem, M. E.; Mercer, D. E., The Economic Value of Mangrove: A Meta-Analysis.
574 *Sustainability* **2012**,*4*, 359-383.
- 575 51. Jusoff, K.; Taha, D., Managing Sustainable Mangrove Forests in Peninsular Malaysia.
576 *Journal of Sustainable Development* **2008**,*1* (1).
- 577 52. Prakash, M.; Sivakumar, T., A study on antibacterial activity of mangrove plant *Excoecaria*
578 *agallocha* L. *International Journal of Current Microbiology and Applied Sciences* **2013**, *2* (8),
579 260-262.
- 580 53. Bandaranayake, W. M., Traditional and medicinal uses of mangroves. *Mangroves and Salt*
581 *Marshes* **1998**,*2*, 133-148.
- 582 54. Frost, R., Dwindling Indian Sundarban Mangrove: The Way Out. *Science and Culture*
583 **2010**,*76* (7–8), 275-282.
- 584 55. MAP-Indonesia *Kajian Risilian (Situational and contextual field assessment and analysis-*
585 *Restoring Coastal Livelihood Project)*; Mangrove Action Project (MAP) Indonesia: Sulawesi
586 Selatan, Indonesia, 2011.
- 587 56. Sigit, R. R. Ekonomi Lingkungan: Pilih Mangrove atau Tambak.
588 <http://www.mongabay.co.id/2013/10/25/ekonomi-lingkungan-pilih-mangrove-atau-tambak/>
589 (accessed January 5, 2013).

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