REEC: Submission Confirmation for Consequences of Mangrove Forest Change in South Sulawesi

em.reec.0.420dea.3dd833d1@editorialmanager.com on behalf of Editorial Office <em@editorialmanager.com>

Thu 3/26/2015 7:28 PM

Inbox

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

Dear Mr Malik,

Your submission entitled "Consequences of Mangrove Forest Change in South Sulawesi" has been received by journal Regional Environmental Change

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author. The URL is http://reec.edmgr.com/.

Your manuscript will be given a reference number once an Editor has been assigned.

Thank you for submitting your work to this journal.

Kind regards,

Editorial Office
Regional Environmental Change

Now that your article will undergo the editorial and peer review process, it is the right time to think about publishing your article as open access. With open access your article will become freely available to anyone worldwide and you will easily comply with open access mandates. Springer's open access offering for this journal is called Open Choice (find more information on www.springer.com/openchoice). Once your article is accepted, you will be offered the option to publish through open access. So you might want to talk to your institution and funder now to see how payment could be organized; for an overview of available open access funding please go to www.springer.com/oafunding.
Although for now you don't have to do anything, we would like to let you know about your upcoming options.

RE: REEC - Manuscript Sent Back

Abdul Malik

Sun 4/12/2015 8:27 PM

Sent Items

To: Sridhar, Bhavani <Bhavani.Sridhar@springer.com>;

Dear Bhavani Sridhar
Springer Journals Editorial Office
Regional Environmental Change

I just inform to you that I have shortened and resubmitted of the manuscript in accordance to the guidelines of journal.

Abdul Malik
Dept. of Geosciences & Natural Resource Management
University of Copenhagen
Øster Voldgade 10, 1350 København K

From: Sridhar, Bhavani [Bhavani.Sridhar@springer.com]
Sent: Wednesday, April 08, 2015 1:55 PM
To: Abdul Malik
Subject: REEC - Manuscript Sent Back

Dear Dr. Malik,

Many thanks for letting me know.

We look forward to receiving your manuscript at the earliest convenience.

Best regards,
Bhavani

Bhavani Sridhar
Springer
Journals Editorial Office (JEO)
JEO Assistant
---
tel +91 44 42197752
fax + 91 44 42197763
Bhavani.Sridhar@springer.com
www.springer.com

-----Original Message-----
From: Abdul Malik [mailto:malik@ign.ku.dk]
Sent: Tuesday, April 07, 2015 6:56 PM
To: Sridhar, Bhavani
Subject: RE: REEC - Manuscript Sent Back

Dear Bhavani Sridhar
Springer Journals Editorial Office
Regional Environmental Change

We thank you for the notification. We are working on a shortened version of the manuscript to be resubmitted once in accordance with the guidelines.

Best regards,

Abdul Malik
Dept. of Geosciences & Natural Resource Management University of Copenhagen Øster Voldgade 10, 1350 København K

_____

From: em.reec.114.424ea0.f840a1d1@editorialmanager.com [em.reec.114.424ea0.f840a1d1@editorialmanager.com] on behalf of Bhavani Sridhar [em@editorialmanager.com]
Sent: Tuesday, April 07, 2015 8:34 AM
To: Abdul Malik
Subject: REEC - Manuscript Sent Back

Dear Mr Abdul Malik,

I have noticed that you have submitted a manuscript titled 'Consequences of Mangrove Forest Change in South Sulawesi' through the Regional Environmental Change's Editorial Manager site. The status of this manuscript is recorded as "Sent Back to Author", which means that you have not taken all the required steps necessary to comply with the requisites of the submission process and the journal.

If you still wish to submit this manuscript to the Regional Environmental Change, please log in to your author menu and take the required action. In case you have already submitted the paper (to Regional Environmental Change from another login, or to another journal), please let me know so that I can remove the submission.
You can also obtain the login credentials for the journal, by using "Send Username/Password" available in the home page.

If we do not hear back from you or receive your completed submission within the next 14 days, then we will assume that you do not intend to pursue this, and the paper will be removed from the system.

Please do not hesitate to contact me should you require any assistance in completing the submission process.

With kind regards,
Bhavani Sridhar
Springer Journals Editorial Office
Regional Environmental Change

RE: REEC: Manuscript entitled Consequences of Mangrove Forest Change in South Sulawesi returned to author

Abdul Malik

Sun 4/12/2015 8:47 PM

Sent Items

To: Editorial Office <reec@pik-potsdam.de>;

Dear
Wolfgang Cramer
Editor-in-Chief
Regional Environmental Change

We just inform to you that We have shortened and resubmitted of the manuscript in accordance with your journal can accommodate.

Best regards,

Abdul Malik
Dept. of Geosciences & Natural Resource Management
University of Copenhagen
Øster Voldgade 10, 1350 København K

From: em.reec.0.422719.04523d75@editorialmanager.com [em.reec.0.422719.04523d75@editorialmanager.com] on behalf of Editorial Office [em@editorialmanager.com]
Sent: Tuesday, March 31, 2015 7:55 AM
To: Abdul Malik
Subject: REEC: Manuscript entitled Consequences of Mangrove Forest Change in South Sulawesi returned to author

Dear Mr Malik,

we shall be pleased to consider your paper for external review, but I would like to invite you for a revision before we do so. The reason for this is that the current text is much longer than our journal can accomodate. Not counting the references, it is about 6800 words, and you have 13 display items which are counted with 300 words each. The resulting number therefore makes 10700, while in practice it should not exceed 8000.

I believe you can quite easily modify your paper by moving some less important material into an electronic supplement, for which there are no length restrictions (within reason...).

So please edit your submission and make the necessary changes by logging into the Editorial Manager at:
http://reec.edmgr.com/
and clicking on "Submissions Waiting for Author's Approval".

You must then click on "Edit Submission", make the necessary changes, upload your revised manuscript, remove your old manuscript, and approve your submission.

If you have any questions, please do not hesitate to contact me.

Kind regards,

Wolfgang Cramer
Editor-in-Chief
Regional Environmental Change

RE: REEC: Manuscript entitled Consequences of Mangrove Forest Change in South Sulawesi returned to author

Abdul Malik

Thu 4/16/2015 3:37 AM

Sent Items

To: Editorial Office <reec@pik-potsdam.de>;

Dear Wolfgang Cramer
Editor-in-Chief
Regional Environmental Change

We just inform to you that we have omitted some of less important words and displays of the manuscript to meet the journal's requirements. The present length of paper consist of 6174 words and 6 displays (3 tables and 3 figures, 1800 words, which are counted with 300 words each). So, not counting the references, all of counted to be 7974 words.
You could find the information about length of this paper on the first page of the manuscript as well.

Sincerely yours,

Abdul Malik

Dept. of Geosciences & Natural Resource Management
University of Copenhagen
Øster Voldgade 10, 1350 København K

From: em.reec.0.427f1f.c6068071@editorialmanager.com [em.reec.0.427f1f.c6068071@editorialmanager.com] on behalf of Editorial Office [em@editorialmanager.com]
Sent: Wednesday, April 15, 2015 11:28 PM
To: Abdul Malik
Subject: REEC: Manuscript entitled Consequences of Mangrove Forest Change in South Sulawesi returned to author

Dear Mr Malik,

The manuscript cannot start the review process until the following corrections are made to meet the journal's requirements (see Instructions for authors, as well):

I have looked long and hard, but I cannot find the information about the present length of the paper, which should be estimated following our instructions and given on the first page of the manuscript.

Please edit your submission and make the necessary changes by logging into the Editorial Manager at:
http://reec.edmgr.com/
and clicking on "Submissions Waiting for Author's Approval".

You must then click on "Edit Submission", make the necessary changes, upload your revised manuscript, remove your old manuscript, and approve your submission.

If you have any questions, please do not hesitate to contact me.

Kind regards,

Wolfgang Cramer
Editor-in-Chief
Regional Environmental Change

REEC: A manuscript number has been assigned to Consequences of Mangrove Forest Change in South Sulawesi

em.reec.0.428d09.629c6cea@editorialmanager.com on behalf of
Editorial Office <em@editorialmanager.com>

Sat 4/18/2015 10:51 AM

Inbox

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

Dear Mr Malik,

Your submission entitled "Consequences of Mangrove Forest Change in South Sulawesi" has been assigned the following manuscript number: REEC-D-15-00193.

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author.
The URL is http://reec.edmgr.com/.

Thank you for submitting your work to this journal.

Kind regards,

Editorial Office
Regional Environmental Change

REEC-D-15-00193

Sridhar, Bhavani, Springer <Bhavani.Sridhar@springer.com>

Sat 12/19/2015 8:48 AM

Inbox

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

Cc:Rasmus Fensholt <rf@ign.ku.dk>; Ole Mertz <om@ign.ku.dk>;

Dear Dr. Malik,

Kindly note that we have already received the review reports from the reviewers and additional reviewers have been invited to review your manuscript.

Please be assured that the editor will render a decision as soon as the reviews are in and you will be duly notified regarding the same.

Thank you very much.

Best regards,
Bhavani

Bhavani Sridhar
Springer
Journals Editorial Office (JEO)
JEO Assistant
---
tel +91 44 42197752
fax + 91 44 42197763
Bhavani.Sridhar@springer.com
www.springer.com

From: Abdul Malik [mailto:malik@ign.ku.dk]
Sent: Friday, December 18, 2015 11:12 PM
To: Sridhar, Bhavani, Springer
Cc: Rasmus Fensholt; Ole Mertz
Subject: RE: REEC-D-15-00193

Dear Bhavani Sridhar
Springer Journals Editorial Office
Regional Environmental Change

We would just like to enquire again about the manuscript entitled "Consequences of Mangrove Forest Change in South Sulawesi" with number: REEC-D-15-00193 which has submitted on April this year due to the current status "Required Reviews Completed" but until today we have not received any notifications related to the review outcome from the journal.

Sincerely yours,

Abdul Malik

Dept. of Geosciences & Natural Resource Management
University of Copenhagen
Øster Voldgade 10, 1350 København K

From: Sridhar, Bhavani, Springer [Bhavani.Sridhar@springer.com]
Sent: Thursday, September 03, 2015 9:47 AM
To: Abdul Malik
Cc: Rasmus Fensholt; Ole Mertz
Subject: REEC-D-15-00193

Dear Dr. Malik,

I would like to let you know that your manuscript is currently being evaluated by our subject experts. Please be assured that the editor will render a decision on your manuscript as soon as the reviews are in and you will be duly notified regarding the same.

Thank you very much.

Best regards,
Bhavani

Bhavani Sridhar
Springer
Journals Editorial Office (JEO)
JEO Assistant
---
tel +91 44 42197752
fax + 91 44 42197763
Bhavani.Sridhar@springer.com
www.springer.com

From: Abdul Malik [mailto:malik@ign.ku.dk]
Sent: Wednesday, September 02, 2015 5:43 PM
To: Sridhar, Bhavani, Springer
Cc: Rasmus Fensholt; Ole Mertz
Subject: Status of the manuscript number REEC-D-15-00193

Dear Bhavani Sridhar
Springer Journals Editorial Office
Regional Environmental Change

We would just like to enquire about the status of the manuscript entitled "Consequences of Mangrove Forest Change in South Sulawesi" with number: REEC-D-15-00193 which has submitted on April this year. When do you expect to be able to make a decision on the manuscript?

Sincerely yours,

Abdul Malik
Dept. of Geosciences & Natural Resource Management
University of Copenhagen
Øster Voldgade 10, 1350 København K

REEC: Your manuscript entitled Consequences of Mangrove Forest Change in South Sulawesi

em.reec.0.48bb8e.4637c4fa@editorialmanager.com on behalf of
Editorial Office <em@editorialmanager.com>

Sun 1/24/2016 6:56 PM

Inbox

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

CC: virginia_burkett@usgs.gov

Ref.: Ms. No. REEC-D-15-00193
Consequences of Mangrove Forest Change in South Sulawesi
Regional Environmental Change

Dear Dr. Malik,

two reviewers have now commented on your paper. You will see that they, and the subject editor Dr Virginia Burkett, are advising that you undertake a major revision of your manuscript. If you are prepared to undertake the work required, I would be pleased to reconsider it for publication.

For your guidance, reviewers' comments are appended below. Please note that the instructions for authors are written also for you, and they need to be followed in every aspect, which is currently not the case.

If you decide to revise the work, please submit a list of changes or a rebuttal against each point which is being raised when you submit the revised manuscript.

In order to allow for quick processing, I ask you to submit the revised version by 23-02-2016.

To submit a revision, go to http://reec.edmgr.com/ and log in as an Author. You will see a menu item call Submission Needing Revision. You will find your submission record there.

Yours sincerely,

Wolfgang Cramer
Editor-in-Chief
Regional Environmental Change

Reviewers' comments:

Reviewer #1: The article 'Consequences Of Mangrove Forest Change in South Sulawesi ' makes a very interesting and worthwhile contribution to the literature. From what I've personally observed the rate of loss of mangrove and other coastal habitats in Sulawesi is massive. Slow incremental loss from a such a diverse range of stressors. These habitats together with seagrasses and reefs are vital to millions of people living in very close coupling with the sea in Sulawesi. I feel the MS does a good job at demonstrating some of these points. I work in the region and am acutely aware of the lack of good science coming out of the area despite the huge problems the marine environment faces. Although I feel the article should be published I do feel it needs some minor changes:

I feel that paper is a little 'light' on ecological information discussing the role of mangroves in the region. I myself have published a number of articles on this topic from SE Sulawesi (Unsworth et al MEPS, Unsworth et al Aquatic Biology). The literature in the article is a little light on ecology and key papers, I think the authors should spend a little time looking deeper into the academic literature rather than using consulting reports/reviews.

The paper title is a little misleading as I don't really feel the paper shows the consequences of mangrove loss but does provide some evidence of the perceptions and knowledge of people towards mangrove loss. Please could the authors revise

this.

In places the article is heavy on typos and is a little difficult to read. I think the paper could do with being reviewed in fine detail before being resubmitted.

An interesting point about mangrove loss that I've noticed in the region is that when you lose the mangrove you lose the associated seagrass due to increases in turbidity. Might be nice to potentially speculate about the indirect consequences of mangrove loss and the fisheries impacts (e.g. Unsworth et al 2014 Env Res Lett).

Interesting work, it's nice to find others working in the region.

Kind regards,

Richard Unsworth, Swansea University

Reviewer #2: The paper 'Consequences of Mangrove Forest Change in South Sulawesi' presents an interesting and well written overview of mangrove deforestation in a case study site in Sulawesi.

My comments are as follows:

1. Title: an important part of the paper is on the rate of mangrove deforestation, hence the title does not well reflect the contents of the paper
2. Section "This is in line with FAO (2007), which reported that globally, 3.6 million hectares of mangrove forests were deforested from 1980 to 2005, but the annual deforestation decreased from 185,000 ha/year in the 1980s to 105,000 ha/year after 2000."This is used to confirm that the deforestation in the study area also decreased. However this is nto correct, a global trend cannot be used to confirm a local process.
3. My main comment, however, is that the paper lacks a balanced assessment of how coastal erosion and other environmental problems have affected local communities (the processes themselves are mentioned but their EFFECTS are not analysed) - and how these processes for instance affect at present AND how they may affect future local livelihoods including aquaculture production.
4. In this sense, the paper ends on a positive (but not balanced) note: there have been important economic benefits from the increase in aquaculture. This is all good and well, but its the same story over and again in Indonesia and that is that only the very short term effects are considered by local people, businesses and the government. Yes in the short term there is an increase in income, but of course if coastal erosion continues with 20 to 100 m per year then at some point in the future (when?) aquaculture will no longer be possible. The same for the increasing scarcity of fry: yes it is declining but what are the consequences for aquacuture (and for other fishermen - are they also faced with lower catches??!!). And how about storm damage and sea level rise due to climate change ? And what is the economic impact of salt water intrusion on banana plantations?
5. Hence, for a scientific paper a more balanced view is required. How do these effects add up ? Is it representative to only mention increases in production in the Conclusion and not to even mention in this section the negative environmental effects and their respective economic consequences? (as you will guess I don t think so). And what then are the policy recommendations from the to be produced balanced analysis?

However, I would like to stress that the paper itself is very informative and well written and that once this flaw is addressed this will be a very interesting and important addition to the literature.

Regional Environmental Change

Mangrove Forest Decline: Consequences for Livelihoods and Environment in South Sulawesi

--Manuscript Draft--

Manuscript Number:	REEC-D-15-00193R1
Full Title:	Mangrove Forest Decline: Consequences for Livelihoods and Environment in South Sulawesi
Article Type:	Original Study(max length 12pgs,figs./tabs.keep separate,e-supplements opt)
Keywords:	Mangrove forest; forest degradation; Indonesia; livelihoods; remote sensing.
Corresponding Author:	Abdul Malik Kobenhavns Universitet Copenhagen, DENMARK
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Kobenhavns Universitet
Corresponding Author's Secondary Institution:	
First Author:	Abdul Malik
First Author Secondary Information:	
Order of Authors:	Abdul Malik
	Rasmus Fensholt
	Ole Mertz
Order of Authors Secondary Information:	
Funding Information:	the Directorate of Higher Education, Ministry of Education and Culture, Republic of Indonesia in collaboration with Department of Geosciences and Natural Resource Management, University of Copenhagen — Mr Abdul Malik
Abstract:	Mangrove forests in the tropics and sub tropics grow in saline sediments in coastal and estuarine environments. Preservation of mangrove forests is important for many reasons, including the prevention of coastal abrasion, salt water intrusion, and the spawning, nursery and feeding grounds of diverse marine biota, but also for local livelihood strategies. However, conversion of mangrove areas to aquaculture or other development has often led to rapid and severe loss of mangrove forests and the ecosystem services they provide. Thus, the mangrove forests of the Takalar district, South Sulawesi, studied here have also experienced degradation and declining spatial extent during recent decades. Based on post-classification comparison change detection from satellite imagery and a survey of households, we provide an estimate of the mangrove change in the Takalar district over the past 33 years and its consequences. Mangrove forest areas were continually reduced during the full period of analysis from 1979 to 2011 by 3,344 hectares with the biggest annual negative change of dense mangrove forest cover (8.37%) occurring during the period 2006-2011. The changes were caused mainly by the conversion to aquaculture and consequences have been increasing forest degradation, coastal abrasion, salt water intrusion, a decline in fish captures, a reduction in shrimp and milkfish fry, and outbreaks of shrimp disease. However, expansions of aquaculture and seaweed development have provided new opportunities for alternative employment and the export of shrimp and seaweed have provided foreign exchange.
Additional Information:	
Question	**Response**

Does your submission belong to a Special Issue currently in preparation for this journal?	No
If yes, please ensure that your submission occurs according to the approved plans of the respective guest editors. If this is the case, please give the title of the Special Issue and the name of the editors you have been in contact with here.	
Author Comments:	Dear Editor Thanks for opportunity revise our manuscript and potentially acceptable for publication. Based on the comments by the reviewers provided in your letter, we uploaded the file of the revised manuscript, figure and table and responses and comments of reviewers document. We hope that the revised manuscript is accepted for publication. Sincerely Yours, Abdul Malik Section Geography Department of Geosciences and Nature Resource Management University of Copenhagen E-mail: malik@ign.ku.dk

~~CONSEQUENCES OF~~ MANGROVE FOREST ~~CHANGE~~ DECLINE: CONSEQUENCES FOR LIVELIHOODS AND ENVIRONMENT IN SOUTH SULAWESI

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

[1] Department of Geography, State University of Makassar (UNM), Indonesia. Jl. Malengkeri Raya, Kampus Parangtambung. E-mail: abdulmalik@unm.ac.id.

[2] Section of Geography, Department of Geosciences and Natural Resource~~s~~ Management, University of Copenhagen~~Section of Geography~~, ØsterVoldgade 10, 1350 ~~København~~ Copenhagen K, Denmark. Email: malik@ign.ku.dk; rf@ign.ku.dk and om@ign.ku.dk.

* Corresponding author

Abstract

Mangrove forests in the tropics and sub tropics grow in saline sediments in coastal and estuarine environments. Preservation of mangrove forests is important for many reasons, including the prevention of coastal abrasion, salt water intrusion, and ~~also~~ the spawning, nursery and feeding grounds of diverse marine biota, but also for local livelihood strategies. However, ~~for~~ conversion of~~many~~ mangrove areas to aquaculture or other development~~of the world, unsustainable utilization and the profit orientation of communities have~~ has often led to rapid and severe loss of mangrove ~~loss with serious consequences~~forests and the ecosystem services they provide. ~~The~~ Thus, the mangrove forests of the Takalar district, South Sulawesi, ~~are~~ studied here ~~as a case area that has~~have also experienced ~~suffered from~~ degradation and declining spatial extent during recent decades. ~~On the basis of~~Based on ~~a~~ post-classification comparison ~~of~~ change detection from satellite imagery and a survey of households, we provide an estimate of the mangrove change in the Takalar district over the past 33 years and its consequences. Mangrove forest areas were continually reduced during the full period of analysis from 1979 to 2011 by 3,344 hectares ~~and~~ with the biggest annual negative change of dense

mangrove forest cover (8.37%) occurring during the period 2006–2011. The changes were caused mainly by the conversion into to shrimp aquaculture ponds and consequences manifest themselves ashave been increasing forest degradation, coastal abrasion, salt water intrusion, a decline in volumes fishing captures, and a reduction in shrimp and milkfish fry, and outbreaks of shrimp disease. However, expansionss of aquacultureshrimp ponds and seaweed development have provided new opportunities for alternative employment in the study area and the production and export value of shrimp and seaweed and hasve provided foreign exchange.

Keywords: Mangrove forest; forest degradation; Indonesia; livelihoods; remote sensing.

1. Introduction

Mangrove forests are found in tropical and subtropical climates, along the coast and river estuaries affected by tides. Mangrove forests are essential for protecting coastal areas from wave impact (Dahuri, 2003) and their functions can be characterized in physical, biological and economic terms. Physical functions include prevention protection of the coastline, and prevention of salt intrusion and sediment trapping, whereas biological functions include the ability to stabilize or balance the ecosystem by being the source of nutrients and acting as the nursery, feeding and spawning grounds for fish, crabs and shrimps. Mangrove forests have economic relevance in terms of agriculture, tourism, fisheries and timber resources. Moreover, mangrove and they can produce provide basic materials for household and industrial purposes, such as firewood, charcoal and paper, which are all of high commercial value for local communities (Giesen et al. 2007; Ghufran, 2012).

Almost half of the total mangrove forest cover in the world has disappeared over the past decade (Curran, 2002) due to an increase in commercial logging, fuel wood collection, charcoal production, mining, conversion to agriculture (mainly rice paddies and coconut), ~~and~~ housing and aquaculture ~~ponds~~ (Giesen et al. 2007). However, the conversion of mangrove areas to shrimp ponds has been the most important development (Primavera, 2000; Alongi, 2002). According to available data from FAO (2007), 3.6 million hectares of mangrove forest have disappeared over the past 25 years, with Asia being the region with the largest loss (more than 1.9 million hectares since 1980). In the Philippines, around 139,500 hectares of mangrove were lost to aquaculture ponds between 1951 and 1988 (Primavera, 2000). In Thailand about 56 percent of the total mangrove area, or 20,500 km^2, was converted to shrimp aquaculture and other forms of coastal development in the period from 1961 to 1996 (Charuppat and Charuppat, 1997), and in Vietnam, over the last 50 years mangrove forests have been reduced by at least 220,000 hectares (Hong and Dao, 2004).

The degradation and decline of mangrove areas have had environmental and socio-economic consequences for coastal communities. Mangrove is one of the most carbon rich forests in the tropics, which, with their deep organic soils, could contribute to climate change mitigation through programmes such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation) (Murdiyarso et al. 2009). Yet, ~~D~~deforestation of mangrove has ~~thus~~ been estimated to lead to massive carbon stock emissions ~~of about 255 MgC/ha~~is (~~on average of~~ 0.~~19~~08-0.48 PgC ~~(190 million metric tons)~~ per year ~~to the atmosphere)~~ (~~Murdiyarso~~ Donato et al. ~~2012~~2015~~1~~). Moreover, the conversion of mangrove to aquaculture has caused a decrease in biomass and the habitat of benthos and plankton and has reduced the seed source of marine shrimp, mud crabs

and species that lay eggs at sea (Hong and Dao, 2004). The aquaculture (e.g. shrimp farming) itself also causes environmental problems due to uncontrolled use of chemical fertilizers and pesticides and has in many places been unsustainable due to water pollution and disease outbreaks (Hong and Dao, 2004). However, the expansion of aquaculture has also had positive consequences for food security and the provision of labour. In 2008, fisheries and aquaculture supplied 142 million tons of fish~~,~~ of which 115 million tons was used for human food in the form of frozen fish, prepared or preserved fish and cured fish (FAO, 2011). Since 1980, fisheries and aquaculture have contributed to increasing employment by an average of 3.6 percent per year (FAO, 2011). Fisheries and aquaculture also contributed to improving household livelihoods (Valderrama et al. 2010) and increasing national income due to the growth in the quantity and value of shrimp exports that provide foreign exchange (Bailey, 1988).

Indonesia has the largest mangrove areas in the world but they were reduced from 4.25 million hectares in 1980 to 3.16 million hectares in 2003, see Table 1 (FAO, 2007; ~~Forestry Ministry of Indonesia, 2005~~Noor et al. 2006) with an annual deforestation rate of 1.24% between 1980 and 2005 (Murdiyarso et al. 2015). ~~One reason is that local communities inhabiting~~There are multiple pressures on mangrove areas ~~use the mangrove for~~including the collection of firewood, housing material, charcoal production, and material for handi~~-~~craft~~ings as well as ~~,~~conversion to ~~shrimp ponds,~~ aquaculture, agriculture and settlement (Noor et al., 2006). However, the main factor behind the deforestation and degradation of mangrove in Borneo, Sumatra, Java and Sulawesi is conversion to shrimp farming (Sidik, 2008; Onrizal, 2010; Suryono, 2006; Nurkin, 1994), as is also the case in other Asian countries (Barbier and Cox, 2002). Only i~~I~~n Papua~~,~~ is mangrove degradation ~~is~~ mainly due to commercial logging

by forest concession companies and wood chip industries (Sraun, 2004). ~~Data from the General Directorate of Fisheries (1991) and the Forestry Ministry of Indonesia (2005)~~Noor et al. (2006) show that ~~shrimp farming~~aquaculture expansion led to deforestation of about 481,000 hectares of mangrove between 1991 and 2003 (Table 1), whereas in Papua, commercial logging has degraded 14,531 hectares of mangrove per year, causing an annual decrease in fish production ~~volume (~~of 76.3 tons~~/year),~~ but increasing employment by 46% during the 12 year period and foreign exchange from timber by USD 2.3 million/year (Sraun, 2004). Furthermore, Onrizal (2010) reported a loss of mangroves of about 61,715 hectares during the period 1977 to 2006, which caused a decrease in fish species in North Sumatra. Sidik (2008) stated that 63% of the mangrove in Mahakam Delta, East Kalimantan had disappeared by 2001 and the peak degradation was found to occur during the period 1996 to 2000. ~~Mangrove loss has caused seawater intrusion, sedimentation and increased vulnerability of local communities' livelihoods and has led to conflicts over land ownership between various resource users as well as water pollution.~~ In Segara Anakan, Central Java, the largest mangrove area in Java, mangroves have decreased from 35,000 hectares in 1930 to 12,000 hectares in 1996, causing a decrease in species diversity and changes in the distribution pattern of mangroves (Suryono, 2006). In South Sulawesi, mangroves covered an area of approximately 110,000 hectares in the early 1950s (Giesen et al. 1991), whereas by 2003, about 75% of the mangrove had been lost, leaving only 27,000 hectares (Table 1), of which most areas were affected by the expansion of ~~shrimp ponds~~aquaculture (Noor et al. 2006). Tangko and Pantjara (2007) reported that areas with shrimp ponds in South Sulawesi had increased dramatically during the period from 1990 to 2005 (by 25,295 hectares), mainly at the expense of mangrove forests. Exact

and updated information on the density and spatial distribution pattern of the mangrove areas and the consequences of past decades of deforestation are so far poorly documented. The data provided by FAO (2007), which related to changes up to the year 2005, are still being used as a reference for the current status, which complicates decision making on the management and conservation of mangrove forests.

<Table 1. Insert>

Timely and accurate inventory and monitoring ~~schemes~~ of mangrove forest areas are necessary for decision making~~,~~ and ~~remote sensing is one of the technologies for mapping and rapid monitoring that can provide updated high accuracy data quickly and inexpensively. Information on mangrove forest areas and changes can be derived from recent and historical~~ high resolution satellite imagery can provide such information quickly, inexpensively and with high accuracy. In some countries, remote sensing for inventory, change detection and management of mangrove forest has been conducted using images from Landsat and SPOT and very high spatial resolution multispectral and SIR-C radar data (Wang et al. 2003). However, analyses at the household level are also needed to identify utilization of mangrove by households that live around mangrove forests to obtain data and information concerning the consequences of mangrove change.

In order to address the lack of knowledge on change in mangrove areas in Sulawesi as outlined above, the objective of this paper is to analyze the environmental and socioeconomic consequences of mangrove forest area change over the past 33 years. The Takalar district in South Sulawesi is used as a case study for highlighting

changes that are occurring in many parts of Indonesia and elsewhere in Southeast Asia. Mangrove forest change between 1979 and 2012 is assessed by using satellite image data from Landsat MSS and TM and SPOT 4 for a post-classification comparison change detection analysis, and interviews with local communities provide information about the consequences of the observed changes.

2. Study Area

Takalar District is located in the southern part of South Sulawesi Province (between latitude 5°12' - 5°38' and longitude 119°10'- 119°39', see figure 1). The district covers 566.51 km^2, divided into nine sub-districts (Galesong, South Galesong, North Galesong, Mangarabombang, Mappakasunggu, Pattallassang, South ~~Polongbangkeng~~Polombangkeng, North ~~Polongbangkeng~~ Polombangkeng and Sanrobone). Mappakasunggu consists of a mainland part and some small islands (Tanakeke, Lantangpeo, Bauluang, Satangnga and Dayang ~~Dayang~~dayangan) (BPS-Kab. Takalar, 2012).

The district has a coastline of about ± 74 km (Ukkas, 2001) and several rivers (Cikoang in Mangarabombang, Pappa in Pattallassang, Biringkassi in Sanrobone, Sabala in South Galesong, Saro and Galesong in Galesong and Beba in North Galesong). The population is 272,316, and the population density is 481 people per km^2 (BPS-Kab. Takalar~~Statistics of Takalar District~~, 2012).

<Figure 1.Insert>

3. Material and Methods

3.1. Digital Image Processing

In this study, we used images from two different sources: Landsat and SPOT 4. The images were from 3 January 1979 (Landsat MSS), from 21 May 1996 and 24 February 2006 (Landsat TM) and from 7 August 2011 (SPOT 4). We also used a 1:50,000 digital topographical maps from 2006. The images and digital topographical maps were geo-referenced to WGS 84/UTM zone 50S.

The steps in image processing included both pre-processing and image analysis. Geometric corrections of the four images were done using the digital topography map, and False Colour Composite (FCC) maps were created to facilitate the interpretation process. The Normalized Difference Vegetation Index (NDVI) was calculated as an indicator of vegetation density in mangrove forests (Seto and Fragkias, 2007; Emch and Peterson, 2006). Image classification was conducted using a supervised maximum likelihood classification (Sremongkontip et al. 2000; Manassrisuksi et al. 2001) including a separation between mangrove forest (five different density classes), ~~shrimp~~ aquaculture ~~ponds~~, water and other surfaces. An accuracy assessment of the 2011 image classification was done using the confusion matrix method (Lillesand et al. 2008; Wang et al. 2003) on the basis of ground truth data collected during the fieldwork experiment conducted in August 2012. In the absence of historical ground truth information the accuracy of the historical images was established using independent (of the training areas) test areas in the satellite imagery. Hence, the test pixels for these images only partly ~~fulfill~~fulfil the conditions of valid ground truth (Foody, 2002). ~~however,~~but this approach is often used as a work-around to assess the accuracy of older Landsat images for areas where no independent validation information is available (Congalton, 1991). Finally, the GIS overlay technique was used to conduct a post-classification comparison

change detection analysis to detect the changes in the four images classified (Manassrisuksi et al. 2001).

3.2. Household Survey

The household survey was undertaken in ~~10~~ ten areas (including seven sub-districts) covering the islands of Lantangpeo, Tanakeke, Bauluang and Satangnga (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). The selection of these areas was based on the criteria that mangrove forests should be present and that there should be some element of pressure on the forest for conversion to shrimp ponds, commercial logging, charcoal production, fuel wood collection and Nypa palm crafting. Questionnaires were administered to 100 respondents, who were selected by a Purposive Sampling method (Patton, 1990). Thus, the respondents all had a direct relation to and dependence on mangrove forests, such as fishermen, seaweed and shrimp farmers, firewood collectors, charcoal producers and Nypa palm crafters. Heads of household were interviewed by the first author~~s~~ and trained enumerators, and the information obtained included basic household information such as age, number of dependents, education, livelihood and income source. Moreover, information was collected on the respondents' understanding of mangrove functions, benefits, and details of their use of mangrove forests.

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3.3. Accuracy assessment

The results showed that the levels of overall accuracy on Landsat MSS 1979, Landsat TM 1996 and 2006, and SPOT 4 2011 were 92.52%, 95.82%, 97.26% and

96.28%. Overall accuracy (including all land use/cover classes) was assessed from pixel samples collected (3021, 2703, 2664 and 2741, respectively, covering all classes). For the mangrove class, the user's ~~accuracy~~ and producer's accuracies~~y~~ were found to be 85.90%, 85.68% (n=329); 85.71%, 86.19% (n=156); 84.03% 85.21% (n=121); and 87.83%, 83.47% (n=101), respectively. An accuracy of ≥ 85% is considered acceptable when image classification is used for post-classification comparison change detection (Anderson et al. 1976) to determine mangrove changes overtime (Giri et al. 2007).

4. Results

4.1. Mangrove Forest Change

The satellite image based post-classification comparison change detection analysis showed that over the 33 years studied, the total areas of mangrove forest in Takalar District decreased by 66.05% or 3,344 hectares (Table 2 and Figure 2). The largest annual negative change (2.97%) in mangrove forests was found to occur during the period 1979-1996, followed by the period 1996-2006 (2.82%); a slower decrease rate was found during the period 2006-2011 (0.89%).

When analyzing changes on the basis of different classes of mangrove forest density (distinguishing between three classes: high/highest, moderate and low/lowest density of mangrove forest, Table 3 and Figure 2) it becomes clear that the general decline in mangrove forests is not equally distributed amongst different density classes. The most pronounced decrease (in total ha) was found for the high/highest density classes of mangrove, with a loss of approximately 1.812 hectares. The biggest annual change of high/highest density mangrove occurred during the period 2006-2011 (8.37%). For moderate, as well as for the low/lowest density mangrove classes, a

decrease from 1979-2006 ~~can be observed to~~ changes into an increase for the last period of analysis (2006-2011). This increase is, however, not big enough to counter balance the rapid decrease in dense mangrove forest during this period.

<Table 2. Insert>

<Table 3. Insert>

4.2. Distribution of Mangrove

In 1979, mangrove forest was found in the sub-districts of Mappakasunggu, Mangarabombang, Pattallassang, Sanrobone and South Galesong. The largest area was found in Mappakasunggu, particularly on Tanakeke Island. Smaller mangrove areas were found in Lantangpeo, Bauluang and Satangnga Islands, and along the coast and river of Cikoang in Mangarabombang sub-district, the rivers of Pappa in Pattallassang sub-district, Biringkassi in Sanrobone sub-district and Sabala in South Galesong sub-district. In 1996, the mangrove forests located on Tanakeke and Lantangpeo Islands had degraded and declined, whereas seaside mangrove forest was retained. On the Islands of Bauluang and Satangnga, mangrove forest was unchanged. Mangrove forests located along the coasts of Mangarabombang, Sanrobone and South Galesong sub-districts also degraded until they were only present around the rivers of Cikoang, Pappa, Biringkassi and Sabala. In the river area of Pappa, the mangrove area ~~was observed to have~~ increased. In 2006, mangrove forests located on Tanakeke Island declined even further, as was the case along the coasts of Mangarabombang, Sanrobone and South Galesong and the rivers of Cikoang, Pappa, Biringkassi and Sabala. On Lantangpeo Island, mangrove cover increased moderately due to reforestation~~. A~~ and in 2011, mangrove

forest cover declined further in Tanakeke, Lantangpeo, Bauluang and Satangnga Islands and around the rivers of Pappa and Biringkassi, but at a slower rate compared to the earlier periods. Particularly for the coast and river of Cikoang in Mangarabombang, areas of increased mangrove cover were found due to replanting (Figure 3).

<Figure 2. Insert>

<Figure 3. Insert>

4.3. Mangrove Conversion to ~~Shrimp~~ Aquaculture ~~Ponds~~

The total area of mangrove forests being converted into ~~shrimp~~ aquaculture ~~ponds~~ between 1979 and 2011 was 77.45% (2,593 hectares) (Table 2). The largest annual change rate of converting mangrove to ~~shrimp ponds~~aquaculture (4.98%) occurred during the period 1979 to 1996, followed by an annual decrease of 3.42% during the period 2006 to 2011 and a 0.06% increase during the period 1996 to 2006. The largest areas of intensified aquaculture~~shrimp pond cultivation~~ are found on Tanakake Island, Mappakasunggu sub district and in Banyuanyara village, Sanrobone sub district (Figure 2).

4.4. Utilization of Mangrove Forest by Households

Mangrove~~s~~ forest in Takalar district is ~~one of the essential~~an important natural resource ~~that supports of~~contributing to household livelihoods. Over the last decades, households in this area have been highly dependent~~d~~ on mangrove~~s~~ products include~~ings~~ forest~~ry~~ products (e.g. firewood, charcoal, and Nypa palm leaves crafting~~.~~) and fisheries products (e.g. fish, crabs, shrimps, and aquaculture such as ~~(~~shrimp ponds and seaweed farming~~)~~). ~~However, capture of fish (fishermen)~~Fishing is the main

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livelihood of household heads~~. Fish capture~~ and takes place between February and September when sea conditions are good.~~ , whereas~~ October to January, when there are large waves and strong wind, are used to rest, repair boats and fishing gear or engage in alternative work. The income per month from fishing is generally very low ~~(~~earning less than ~~Indonesia Rupiah (IDR) 500,000 (~~USD 53~~))~~. Thus, some of the household heads ~~part of them has to~~ engage themselves in a variety of activities such as commercial logging and seaweed farming ~~for~~ to obtain alternative income ~~source~~.

~~In C~~commercial selective logging~~, selectively logging~~ of specific species and sizes of mangrove trees ~~has been conducted~~is common. *Rhizophora* sp. wood with a stem height ~~stem~~ of about four meters and a diameter of 4 to 8 cm ~~was~~ is favoured because it is stronger and provides better quality firewood and charcoal than other species. Monthly production is on average five bundles, and with a price per bundle of ~~IDR 80,000 (~~USD 8.4~~2~~), the average monthly income is ~~IDR 400,000 (~~USD 42~~.10~~). Charcoal products are also mostly from *Rhizophora* sp. The production process lasts about 10 days (six days for burning and four days for cooling) and each burning session can produce 500 kg of charcoal, which is packaged in 25 kg bags that are sold for ~~IDR 50,000 (~~USD 5.~~26~~3~~)~~ per bag~~,~~ providing an average monthly income of ~~IDR 3,000,000 (~~USD 31~~5.786~~). Nypa palm leaves are used to build roofs and walls, as well as to make hats, floor mats and baskets. Hat production was the most common among survey~~ed~~ respondents and was mostly conducted by women, whereas men collected the leaves with~~,~~ up to 100 bundles per operation (1-2 times per month). ~~The~~ One ~~crafter~~ woman could produce almost 20 hats and use six bundles per day. Hats were sold to a trader for ~~IDR 3,000 to 5,000~~USD 0.3 to USD 0.5 per hat, depending on the size, and ~~a~~ the monthly income could reach ~~IDR 3,000,000 (~~USD 31~~5.786~~).

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Aquaculture (e.g. shrimp farming) is widely practiced in the mangrove areas of Indonesia and areas of intensive shrimp farming cover Java, Sumatera, Kalimantan and South Sulawesi (including the Takalar district studied here) (Bengen and Dutton, 2004). The average extent of ponds is three hectares and applied mainly a the traditional system of aquaculture which is dominated by polyculture with shrimp and milkfish (*Chanos chanos*) or milkfish and seaweed *(Gracilaria sp.*),. However, followed bybut monoculture of shrimp or milkfish is also common. To meet the needs of sShrimp and milkfish fry is , shrimp farmers bought from a hatchery. Two annual harvests per stocking season yield a shrimp production from monoculture of 200-300 kg/ha and a milkfish production of 1700-2500 kg/ha. The production from polyculture (shrimp and milkfish) was between 600-800 kg/ha (of which 70% is from milkfish), whereas milkfish and seaweed produced between 6000-7000 kg/ha of which about 65% is from seaweed. The total income per production cycle is between IDR 10 to 24 million (USD 1,053 to and 2,526). In addition, statistical data from Takalar district (BPS-Kab. Takalar, 2007-2012) showed that during the period 2006 to 2011, the annual average income of shrimp farmers increased from IDR 32 million (USD 3,368) to IDR 48 million (USD 5,053) with an annual average increase of 11%.

Many households are also engaged in sSeaweed farming (is another marine-based activity where has conducted in the coastal area (about 100 m from the coastline)) and many of households has engaged bothcither as single activity and or as an alternative income source. The sSpecies cultivating cultivated is mainly from *Eucheuma Cottonii* and using the 'long line floating method', where seaweed seedlings are collected from the sea. The number of lines depends on the extent of the farming area, but on average, the survey respondents had 300 lines (one line length is 20 meters long

and lines are placed ~~at a distance of~~ one meter ~~from each other~~apart), providing a potential income per crop cycle of up to ~~IDR 7.2 million (~~USD 758~~)~~. In addition, statistical data from Takalar district (BPS-Kab. Takalar, 2007-2012) show that during the period 2006 to 2011, the annual average income of seaweed farmers increased from ~~IDR 38.4 million (~~USD 4,042~~)~~ to ~~IDR 86.4 million (~~USD 9,095~~)~~, with an annual average increase of 18%.

5. Discussion

5.1. Mangrove Forest Change

Mangrove forest areas in Takalar, South Sulawesi have over the past 33 years declined by more than half of their previous extent. The traditional activities of communities, who live in mangrove areas, play a fairly small role in this decline as they mainly use mangrove resources for domestic purposes such as firewood, house materials and fish traps. However, in the early 1970s, commercial logging of mangrove ~~wood~~ began to supply the Gowa paper factory in South Sulawesi (Nurkin, 1979), but currently this has stopped due to the limited remaining ~~area of~~ mangrove forests. Nonetheless, commercial logging of firewood and charcoal for food stalls in Makassar, the capital of South Sulawesi province and elsewhere, remains and has caused continued degradation and declining stocks of mangroves. Moreover, there is a high demand for the wood of several mangrove tree species, especially *Rhizophora* sp. ~~locally called *Bakau*~~, which is preferred for firewood and charcoal production because it is hard, dense, ~~heavy~~ and has a high calorific value (Aksornkoae, 1993; Nurkin, 1994). In addition, firewood from *Rhizophora* sp. generally produces a superior flavour of food and burns slowly (Nurkin, 1994). Nypa palm leaves have also been used for centuries

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and the products are closely linked to the traditions of ~~ethnics~~ local people in South Sulawesi. Nypa palm leaves ~~have~~ are been used as material for roofing and wall webbing as well as hats, floor mats and baskets, the latter being most common now due to the introduction of modern housing.

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The most important driver of mangrove decline, however, has been the introduction of tiger shrimp in the early 1980s. With an increasing international demand, this has become the main fisheries commodity in South Sulawesi, as is also the case in other areas of Indonesia and Southeast Asia (Purnomo, 1992; Béland et al. 2006). Indonesia, Thailand, China, India, Vietnam, Bangladesh and India have become the major exporting countries (GlobeFish, 2001) and the international demand can be met either by catching tiger shrimp at sea or through aquaculture. However, because Indonesia ~~issued in since1980 the Presidential Decree Number 39 prohibiting~~has prohibited trawling operations in the marine territory since 1980 in order to preserve marine biological resources, the only way that tiger shrimp production can be increased is through expansion and intensification of aquaculture (Purnomo, 1992). In Takalar district, the total area of mangrove forests being converted into shrimp ponds (77.45%) occurred during the period 1979 – 2011 and a large scale expansion of ~~shrimp~~ aquaculture ~~ponds~~ during this period also took place in Tanakeke Island~~s~~ and Banyuanyara village. Over the period 1979-2011, the loss of mangrove forests in Takalar district constitutes 8.37% of the losses in South Sulawesi and 0.30% of total Indonesian losses, whereas the loss through conversion to aquaculture~~shrimp ponds~~ has contributed about 5.36% for South Sulawesi and about 0.40% for Indonesia.

The increase in aquaculture~~shrimp ponds~~ is mainly due to local fishermen changing their livelihoods to become shrimp farmers, as shrimp farming generates

high~~er~~ revenue and is an export commodity that has not experienced steep declines in prices (BPS-Propinsi ~~Statistic of South~~ Sulawesi Selatan, 2007-2012). In addition, government support in the form of credit and subsidies to farmers to expand shrimp ponds has also been an important driver (Nurkin, 1994). In 2011, the central government provided about ~~IDR 12.9 billion (~~USD 1.3 million~~)~~ and the local government about ~~IDR 3.8 billion (~~USD 400 thousand~~)~~ ~~in~~ to support ~~to~~ shrimp farmers (Department of Marine and Fisheries of South Sulawesi, 2011).

Although the acceleration of mangrove forest destruction due to shrimp pond expansion increased during 1980s and 1990s, the rate of deforestation has decreased since the early 2000s~~. This is in line with FAO (2007), which reported that globally, 3.6 million hectares of mangrove forests were deforested from 1980 to 2005, but the annual deforestation decreased from 185,000 ha/year in the 1980s to 105,000 ha/year after 2000. A main reason for the decreasing rates of mangrove deforestation, in Takalar and at the global scale, was~~because of~~due to an outbreak of White Spot Disease (WSD) in the 2000s, which is a contagious shrimp disease ~~of shrimp~~ caused by the White Spot Syndrome Virus (Crockford, 2001; Alifuddin et al. 2003). WSD outbreaks are often characterized by high shrimp mortality and rapid infection of the population (Crockford, 2001; Alifuddin et al. 2003).

Over the past five years, the annual expansion of shrimp ponds has returned to previous high rates, but the expansion is less focused on monoculture of tiger shrimp, as farmers have been traumatized by several harvest failures and heavy losses due to WSD outbreaks. Households in the Takalar district were found to focus more on polyculture of shrimp and milkfish or milkfish and seaweed. This transition from monoculture towards a more resilient polyculture has also been observed in Philippines, Thailand and

Taiwan (Fast, 1992). Monocultures of shrimp have also changed to farming white leg shrimp (*Penaeus vannamei*), which can be stocked in high densities and is relatively more resistant to disease (Tangko and Pantjara, 2007).

5.2. Consequences of Mangrove Change

~~Deforestation of mangrove forests due to varied activities and mainly from the expansion of shrimp farming~~aquaculture over the last decades has had serious environmental and socioeconomic consequences. The most important consequence the mangrove forest change is the decrease of quantity and quality. During past 3 decades, the total mangrove loss in the Takalar district reached 3,344 hectares and 1,315 hectares for the classes of low and lowest density mangrove respectively. This corresponds to the general situation in many Southeast Asian countries characterized by deforestation and degradation of mangroves due to firewood collection, charcoal production and shrimp ponds expansion. In 1990s and 2000s approximately 1,220 thousand hectares of mangrove forest in Southeast Asia have been converted to shrimp farming (ranging at the national level between 190 (Brunei Darussalam) and 438 (Indonesia) thousand hectares) (Giesen et al. 2007). Beside the density, the loss of mangroves in this area have decreased number of species, diversity, frequency, and coverage of mangrove forest. Today, forests mostly consist seedling and sapling (Malik et al, 2015b).

Salt water intrusion into cropland is another problem that has made banana ~~it~~ cultivation difficult ~~for banana to grow~~ (Halim, 2012) ~~since this plant has~~due to ~~its~~a low tolerance to salt (Palacios et al. 2000). ~~A high accumulation of salt in the soil causing water and nutrients can not move into plant roots therefore disturb new seeds grow (Wentz, 2001). In this area, banana production is one of various income sources of communities from agriculture land (BPS Kab. Takalar, 2007 – 2012). Therefore, the~~

~~salt intrusion can spending on goods and services and in indirect can effected to income~~ East Kalimantan, where dry season salt intrusion ~~has stretch done hundred~~ contaminated the drinking water (Sidik, 2008), and in the Mekong Delta in Vietnam, where the freshwater supply for 300,000 hectares of agricultural land was disrupted by salt water (Clayton and Brennan, 1999).

The tropical marine ecosystems (e.g. mangroves and seagrass beds) are interconnected and optimal ~~have influence each other to~~ provi~~de~~sioning of marine resources and fishing grounds ~~and~~are dependent on the well-functioning of all components of the ecosystem ~~have interconnections to sea~~ (Unsworth et al, 2008, 2014). Seagrass beds ~~is~~are an important habitat for juveniles and adult fish (Unsworth et al, 2008), and ~~have~~carry a significant proportion ~~to~~of fish catch (Unsworth et al. 2014). The degradation and deforestation of mangroves is likely to ha~~s~~ve indirect consequences to reduce fish, crab and shrimp catches due to a decline in seagrass beds caused by a subsequent increase~~s~~ in water turbidity (from increased land surface runoff) ~~and turbidity when~~ and wave action ~~in the seagrass beds~~ (Kirkman and Kirkman, 2002). ~~Fish, crab and shrimp catches by fishermen have been reduced since the mangrove degraded.~~ Consequently, m~~M~~ost fishing has to be conducted further away as there are fewer fish in coastal areas, and this in turn leads to higher capital investment in equipment and operational costs. Over the past years, crab species of high economic value ~~as export commodity~~ (e.g. giant mud crab (*Scylla serrata*) and blue swimmer crab (*Portunus pelagicus*)) were~~as~~ reported to be increasingly difficult to find in some mangrove areas of South Sulawesi and consequently many households have stopped ~~capturing~~ catching crabs (Taslim, 2006). KKP-Indonesia (~~The~~ Ministry of Marine and Fisheries of Indonesia) (2012) reported that the volume of fish capture in South

Sulawesi decreased from 354,399 to 158,138 tons (55.4%) from 2003 to 2011. A similar decline in fish capture also occurred in North Sumatra and was ~~attributed~~ by communities attributed to degrading mangrove forests (Onrizal et al. 2009). In contrast, in the Mahakam Delta, there is no evidence that the productivity of fisheries has decreased due to the loss of mangrove (Sidik, 2008).

Finally, the availability of shrimp and milkfish fry has declined, as has the stock of a number of fish species that depend on mangrove forests in South Sulawesi. Unsworth et al. (2008, 2009) found seagrass meadows and mangroves ~~are~~to be important habitats for juveniles fish of some reef fish species ~~and are support to Indo-Pacific fish assemblages~~ by increasing the availability of shelter and food services. Hamilton and Snedaker (1984) reported that 80 percent of the commercial marine biota in Florida, USA is dependent on mangrove forests. Moreover, almost 100% of shrimp and 49% of demersal fish caught in the Strait of Malacca depend on mangrove areas (Macintosh, 1982). ~~In this place and elsewhere in Indonesia~~Moreover, the availability of natural shrimp or milkfish fry declines as mangroves disappear. ~~in nature become one of the most faced problem in aquaculture development. (stated the shrimp fry (*Penaeus monodon*) caught in nature only around 4% - 6% while the rest are others shrimp fry with low economic value and other organisms which being caught in the net.~~ Shrimp farmers reported that it is very difficult to find enough fry of shrimp or milkfish in nature to meet their needs for farming and ~~; therefore,~~ they ~~must buy from and be~~are therefore dependent on hatcheries. While the ~~The existence of~~ hatcheries produce ~~are supported farmers to get~~ shrimp and milkfish fry ~~with~~of high quality and have~~. In addition it~~ become a ~~major~~ source income and employment in many coastal regions ~~as reported by~~ (Rönnbäck, 2002), they also lead to increase pressure on wild ~~. Nonetheless,~~

~~the development of hatcheries, however, has consequenced to marine biodiversity and~~ the sea ~~and died~~ (Rönnbäck, 2001 and 2002, Primavera, 2006).

Furthermore, ~~in shrimp farming,~~ farmers have used shrimp feed that does not meet the requirements of environmentally friendly aquaculture and this has led to outbreaks of shrimp diseases. ~~They~~ Farmers have tried to increase production volumes using high stocking densities of fry and excessive feed, chemical fertilizers and pesticides. However, this can reduce the water quality and cause the growth of micro-organisms, leading to shrimp disease and directly ~~contaminating~~ contaminate soils, rivers and coastal habitats (Garno, 2004; Lan, 2013). ~~In this area the largest pond nutrients was coming from the Urea fertilizer (one hectare reach a ton) (Chandra, 2014). The use of Urea in large measure turned out to cause problems of its own. B~~One example relates to eutrophication ~~is~~from the excessive use of Urea ~~which, besides not being economical, it also it~~ (nitrogen rich chemical fertilizer). Misuse of Urea caus~~ing~~es phytoplankton blooming that subsequently reduces decomposition processes and threaten~~sed~~ the survival rate of shrimp and fish ~~and decomposition process~~ due to depletion of dissolved oxygen (Makmur et al. 2011)~~.~~. ~~The food was not eaten, feces and urine waste can cause eutrophication and depletion of oxygen (Rönnbäck, 2001).~~ In addition, excessive ~~the~~ use of chemicals ~~in an excessive measure and undesirable~~ may cause toxicity to non-target populations~~,~~ (cultured species, the human consumer, and wild biota), development of antibiotic resistance~~,~~ and accumulation of residues (Primavera, 1998, Rönnbäck, 2001).

In addition to the environmental ~~consequences~~impact, mangrove forest losses have also had socioeconomic consequences, both positive and negative. A Cost-Benefit Analysis (CBA) over a 10-year period ~~was applied to~~showed that the ecological

functions of mangrove that includes ~~providing~~ nursery grounds, protectionng from prevention ofng seawater intrusion, and carbon sequestration ~~in this area over a 10-~~ Value (NPV) than aquaculture production that even had a ~~and~~ negative NPV ~~of extended to cover~~ environmental costs such as (water pollution, ~~) and~~ forest included (Malik et al, 2015a). ~~In a hectare, the loss of mangroves would be eliminated has consequence to~~caused an average loss of fish catch in South Sulawesi of 1,211 tons Indonesia, ~~(Ministry of Marine and Fisheries of Indonesia),~~ 2012).

This l~~L~~ow income~~s~~ from fish capture and the period of rest due to unfavourable weather conditions for several months in this area have forced many fishermen to seek alternative livelihoods such as engaging in commercial logging and/or becoming shrimp or seaweed farmers. ~~The last mentioned option has provided new employment opportunities as labourers, both on family farms and on other people's farms.~~ Statistical data from Takalar district (BPS-Kab. Takalar. 2007-2012) show that during the period 2007 to 2011, the use of labourers in shrimp farming and seaweed farming increased by 1,585 people (from 4,515 people to 6,100 people corresponding to an annual average growth of 8.7%) and 5,541 people (from 3,352 people to 8,893 people corresponding to an annual average growth of 31%), respectively. The majority of shrimp and seaweed labourers only have an elementary school education~~. T~~ and they have limited knowledge of the environment and aquaculture techniques. Knowledge about running an aquaculture business is obtained by copying other businesses~~;~~ as labourers often work ~~at~~ in a business only until they have enough experience to open their own business (MAP Indonesia, 2011). The new livelihood as shrimp and seaweed farmers has increased the average income per month compared to that of fishermen, but with the shrimp diseases and a fragile coastal environment caused by aquaculture, the new

livelihoods could be a risky strategy compared to the lower, but more stable income from mangrove resources.

Change back to the traditional system is not likely to occur as t~~T~~he expansion of shrimp ponds and the widespread culture of seaweed provide important export commodities ~~and hence changes in production have consequences~~ for the economy of South Sulawesi. Between 2006 and 2011, the production of shrimp increased by about 7,510 tons (annual average growth of 11.24%) despite slight decreases in 2009 and 2011 due to WSD, and seaweed production increased by 1,073,084 tons (an annual average growth of 30%). Despite production increases, the volume of shrimp exports decreased by about 1,267 tons, but the value increased by USD 9,085,000 (from USD 33,322,000 to USD 42,407,000) as market prices increased. The volume of seaweed export increased by about 46,895 tons between 2009 and 2011 with an increase in export value of USD 22,934,000 (from USD 56,953,000 to USD 79,887,000) (~~Statistics of South~~BPS-Propinsi Sulawesi Selatan, 2007-2012). This makes South Sulawesi the third largest shrimp producer in Indonesia after Lampung and South Sumatra, and the largest seaweed producer in the country (~~Statistic of South~~BPS-Propinsi Sulawesi Selatan, 2007-2012; ~~Ministry of Marine and Fisheries of Indonesia~~KKP- Indonesia, 2012). Consequently, the South Sulawesi authorities are not likely to discourage further expansion of aquaculture as it remains crucial for the provincial economy.

This paper addresses changes in mangrove forests and their consequences using Takalar district, South Sulawesi as a case study. The information on the current status of mangrove change cover and consequences contributes to the understanding of mangrove changes globally and in particular in Indonesia, which has the largest mangrove areas in

the world. ~~It also provides support for decision making on the management and~~ mangroves for firewood, charcoal production, commercial logging and Nypa palm crafting, and have especially converted them into ~~shrimp farms~~aquaculture ponds~~,~~ dependency on and unsustainable utilization of mangrove forests ~~and the profit~~ mangrove loss with environmental and socioeconomic consequences. In addition, the role of governments in inflating shrimp production targets to meet the need for export and foreign exchange by providing of credit to farmers to expand shrimp ponds and intensify farming has also contributed to mangrove change and its impacts. On the basis of an interpretation of multi-temporal satellite imageries and a survey of households, we provide~~d~~ an estimate of mangrove change over the past 33 years and the consequences it. More than half of the total mangrove forest area has degraded and declined mainly due to conversion into ~~shrimp~~ aquaculture ~~ponds~~. The largest annual change was found during the period from 1979 to 1996 and took place primarily in Tanakeke ~~island~~ Island Banyuanyara village. However, since year 2000 the rate of expansion has decreased due to an outbreak of White Spot Disease, which has caused ~~several~~ harvest failures and severe economic losses. The degradation and decline of mangroves have caused coastal erosion, salt water intrusion and also causing a decline in the annual production of fisheries. Declining stocks of shrimps and milkfish fry force shrimp farmers to buy these from hatcheries, and ~~furthermore~~ water pollution and outbreaks of shrimp disease ~~also~~ threaten shrimp production. Nonetheless, the expansion of shrimp and seaweed farming has created new alternative employment possibilities and the shift in fishermen's livelihood to shrimp and seaweed farming has brought a significant increase in income, although the sustainability of this income is uncertain.

~~In addition, the production volume of shrimp and seaweed, and the export creating a~~

Acknowledgements

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References

Aksornkoae, S. (1993) *Ecology and management of mangroves*. IUCN Wetlands Programme. IUCN, Bangkok, Thailand, 176 pp.

Alifuddin M., Dana D., Eidman M., Malole M.B., Pasaribu F.H. (2003) Penyakit White SPOT pada Udang Windu (Penaeus Monodon FAB.): Penularan Melalui Perendaman dengan Virus White Spot 20, 100 dan 200 μg/ml dengan Waktu Ekspos 120 Menit. *Jurnal Akuakultur Indonesia, 2 (1): 31-35.*

Alongi D.M. (2002) Present State and Future of the World's Mangrove Forests. *Environmental Conservation 29 (3): 331-349*

Anderson J.R., Hardy E.E., Roach J.T., and Witmer R.E. (1976) A Land Use and Land Cover Classification System for Use with Remote Sensor Data. *Geological Survey Professional Paper 964* (Conversion to Digital 2001)

Bailey C. (1988) The social consequences of tropical shrimp mariculture development. *Ocean and Shoreline Management. Vol. 11 (1), 31-44.*

Barbier and Cox (2002) Economic and Demographic Factors Affecting Mangrove Loss in the Coastal Provinces of Thailand, 1979–1996. *Ambio: A Journal of the Human Environment 31(4):351-357.*

Béland, M., Goïta, K., Bonn, F., Pham, T. T. H. (2006) Assessment of land-cover changes related to shrimp aquaculture using remote sensing data: a case study in the GiaoThuy District, Vietnam. *International Journal of Remote Sensing*, 27: 8, 1491-1510.

BPS-Kab.Takalar, (2007 – 2012). Kabupaten Takalar dalam angka 2007-2012. Badan Pusat Statistik (BPS) Kabupaten Takalar, Indonesia. Available data on *www.takalarkab.go.id*. Accessed 10 March 2013

BPS-Kab.Takalar, (2012). Kabupaten Takalar dalam angka 2012. Badan Pusat Statistik (BPS) Kabupaten Takalar, Indonesia. Available data on *www.takalarkab.go.id*. Accessed 10 March 2013.

BPS-Propinsi Sulawesi Selatan, (2007 – 2012). Sulawesi Selatan dalam angka 2007-2012. Badan Pusat Statistik (BPS) Propinsi Sulawesi Selatan, Indonesia. Available data on *www.sulsel.bps.go.id*. Accessed 10 March 2013.

Clayton and Brennan (1999) A review of economic issues for sustainable shrimp farming in the Mekong Delta, Vietnam. *Paper presented at the 43th Annual Conference of the Australian Agriculture and Resource Economic Society*, Christ church, New Zaeland, January 20-22nd.

Congalton, R.G. (1991) A review of assessing the accuracy of classifications of remotely sensed data, *Remote Sensing of Environment, 37(1), 35–46*

Crockford, M. (2001) White Spot Disease. *Australia and New Zealand Standard Diagnostic Procedures, 1-16.*

Curran, S. (2002) Migration, Social Capital and the Environment: Considering Migrant Selectivity and Network in Relation to Coastal Ecosystems. *Popul. Dev. 28, 89-125*.

Dahuri R. (2003) *Keanekaragaman Hayati Laut. Aset Pembangunan Berkelanjutan Indonesia*. Gramedia Pustaka Utama, Jakarta.

Department of Marine and Fisheries of South Sulawesi (2011) Udang Sumber Pendapatan Terbesar Kedua Sulsel. http://www.antarasulsel.com/print/27200 /udang-sumber-pendapatan-terbesar-kedua-sulsel. Accessed 2 April 2014

Donato D.C, Kauffman J.B, Murdiyarso D, Kurnianto S, Stidham M, and Kannien M (2011) Mangroves among the most carbon-rich forests in the tropics. *Nature Geoscience 4, 293–297.*

Emch M. and Peterson M. (2006) Mangrove Forest Cover Change in the Bangladesh Sundarbans from 1990-2000: A Remote Sensing Approach. *Geocarto International, 21:1, 5-12.*

FAO (2007) *The World's Mangroves 1980 – 2005*. Food and Agriculture Organization. Rome, Italy.

FAO (2011) *The State of Fisheries and Aquaculture.* Food and Agriculture Organization. Rome, Italy.

Fast A.W. (1992) Penaeid extensive growout systems. *In:* Fast A.W. and Lester L. J. (Eds.) Marine Shrimp Culture: Principle and Practices. Elseiver Science Publisher, 355-368.

Foody, G. M. (2002) Status of land cover classification accuracy assessment. *Remote Sensing of Environment 80, 185–201.*

~~Forestry Ministry of Indonesia (2005) Luas Mangrove per Propinsi di Indonesia. *In* Noor Y.R., Khazali M., Suryadiputra I N.N. Panduan Pengenalan Mangrove di Indonesia. PHKA/WI IP, Bogor. P. 25.~~

Garno, Y.S. (2004) Pengembangan budidaya udang dan potensi pencemarannya pada perairan pesisir. *Jurnal Teknik Lingkungan P3TL-BPPT.5. (3): 187-192*

~~General Directorate of Fisheries (1991) Luasan Tambak per Propinsi di Indonesia. *In* Noor Y.R., Khazali M., Suryadiputra I N.N. Panduan Pengenalan Mangrove di Indonesia. PHKA/WI IP, Bogor. P. 25.~~

Giesen, W., M. Baltzer & R. Baruadi (1991) *Integrating Conservation with Land-use Development in Wetlands of South Sulawesi.* Publication of PHPA/AWB, Bogor, 240 pages.

Giesen W., Wulffraat S., Zieren M., and Scholten L. (2007) *Mangrove Guidebook for Southeast Asia*. FAO and Wetlands International.

Giri C., Pengra B., Zhu Z., Singh A., Tieszen L.L. (2007) Monitoring Mangrove Forest Dynamics of the Sundarbans in Bangladesh and India using Multi-temporal Satellite data from 1973 to 2000. *Estuarine, Coastal and Shelf Science 73, 91-100*

GlobeFish (2001) *Food Market: Shrimp Production*. http://www.globefish.org. Accessed 5 May 2013

Hajramurni A. (2010) Abrasion Speed in Takalar hit 100 meters a year, *The Jakarta Post. Tuesday, April 27 2010, 7:16 PM. http://www.thejakartapost.com/news/ 2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html. Accessed 13 March 2013*

Halim A. 2012. Kerusakan Mangrove Memiskinkan Warga. *http://sains.kompas.com read 2012/11/23/03510427/. Kerusakan.Mangrove. Memiskinkan.Warga. Jumat, 23 November 2012. Accessed 13 March 2013*

Hamilton LS, Snedaker SC (eds) (1984). *Handbook for mangrove area management.* Honolulu, Hawaii: Environment and Policy Institute, East-West Center.

Hong P.N. and Dao Q.T.Q. (2004) Environmental Impacts of Shrimp Culture in the Mangrove Areas of Vietnam. *Annual Report of FY 2003*,The Core University

Program between Japan Society for the Promotion of Science (JSPS) and National Centre for Natural Science and Technology (NCST) P.195-P.203

Kirkman H and Kirkman JA (2002) The management of seagrasses in Southeast Asia. *Bulletin of Marine Science. 71 (3): 1379–90.*

KKP-Indonesia, (2012). Statistical data of marine and fisheries. http://statistik.kkp.go.id/. (Accessed 1 March 2013).

Lan N.T.P. (2013) Social and ecological challenges of market-oriented shrimp farming in Vietnam. *SpringerPlus (2):675.*

Lillesand T.M., Kiefer R.W., and Chipman J. (2008) *Remote Sensing and Image Interpretation*, 6th edition. New York: John Wiley and Sons.

Macintosh, DJ. (1982) Fisheries and aquaculture significance of mangrove swamps, with special reference to the Indo-West Pacific region. *In*: Muir & Roberts (Eds.). Recent Advances in Aquaculture. pp. 4–85. England: Croom Helm

Manassrisuksi K., Weir M. and Hussin Y.A. (2001) Assessment of Mangrove Rehabilitation Programmer Using Remote Sensing and GIS: A Case Study of Amphur Khlung, Chantaburi Province, Eastern Thailand. *Paper presented at the 22nd Asian Conference on Remote Sensing 5 – 9 November 2001, Singapore.*

MAP Indonesia (2011) *Kajian Risilian (Situational and contextual field assessment and analysis-Restoring Coastal Livelihood Project).* Mangrove Action Project (MAP) Indonesia, Sulawesi Selatan.

~~Ministry of Marine and Fisheries of Indonesia (2012) *Statistical Data of Marine and Fisheries.* http://statistik.kkp.go.id/. Accessed 1 March 2013~~

Malik A, Fensholt R, Mertz O (2015a) Economic valuation of mangroves for comparison with commercial aquaculture in South Sulawesi, Indonesia. *Forests 6(9):3028–304*

Malik A, Fensholt R, Mertz O (2015b) Mangrove exploitation effects on biodiversity and ecosystem services. *Biodiversity and Conservation 24:3543-3557*

Matsuda Y. (2010) Integrated Coastal Zone Management with Sustainable Aquaculture. Available on : *Food and Fertilizer Technology Center for the Asian and Pacific Region (http://www.agnet.org/). Accessed 25 February 2013*

Murdiyarso D., Donato D., Kauffman J.B., Kurnianto S., Stidham M., and Kanninen M. (2009) Carbon storage in mangrove and peat land ecosystems: A preliminary account from plots in Indonesia. *Working paper 48.Center for International Forestry Research (CIFOR).* Bogor. Indonesia.

Murdiyarso D., Purbopuspito J., Kauffman J. B., Warren M., Sasmito S., Donato D., Manuri S., Krisnawati H., Taberima S., and Kurnianto S. (2015). The potential of Indonesian mangrove forests for global climate change mitigation. *Nature Climate Change. 5, DOI: 10.1038/NCLIMATE2734.*

Noor Y.R., Khazali M., Suryadiputra I N.N. (2006) *Panduan Pengenalan Mangrove di Indonesia*. PHKA/WI-IP, Bogor. 219 pages.

~~Murdiyarso, D., Kauffman, J.B., Warren, M., Pramova, E. and Hergouale'h, K. (2012) Tropical wetlands for climate change adaptation and mitigation: Science and policy imperatives with special reference to Indonesia. *Working Paper 91. Center for International Forestry Research (CIFOR).* Bogor. Indonesia.~~

~~Noor Y.R., Khazali M., Suryadiputra I N.N. (2006) *Panduan Pengenalan Mangrove di Indonesia*. PHKA/WI-IP, Bogor. 219 pages~~

Onrizal, A. Purwoko, and M. Mansor (2009) Impact of mangrove forests degradation on fisherman income and fish catch diversity in eastern coastal of North Sumatra, Indonesia. *International Conference on Natural and Environmental Sciences 2009 (ICONES'09) in Banda Aceh on May 6-8, 2009.*

Onrizal (2010) Perubahan tutupan hutan mangrove di pantai timur Sumatera Utara periode 1977 – 2006. *Jurnal Biologi Indonesia 6 (2): 163-172.*

Palacios M.P, Haman D. Z, Del-Nero E, Pardo A, Pavon N. (2000) Banana production irrigated with treated effluent in the Canary Islands. *American Society of Agricultural Engineers 43(2): 309-314.*

Patton, M. (1990) *Qualitative Evaluation and Research Methods.* Pp. 169-186. Baverly Hills, CA: Sage.

~~Presidential Decree of Republic Indonesia Number 39 Year 1980 on the prohibition of trawling operations in marine territorial of Indonesia to preserve marine biological resources. *www.bphn.go.id/data/documents/ 80kp039.doc. Accessed 3 April 2013*~~

Primavera J.H. (1998). Tropical shrimp farming and its sustainability. *In:* S. de Silva (Ed.), Tropical Mariculture. Academic Press, London, pp. 257-289.

Primavera J.H. (2000) Development and conservation of Philippine mangroves: institutional issues. *Ecological Economics 35: 91-106.*

Primavera J.H. (2006) Overcoming the impacts of aquaculture on the coastal zone. *Ocean & Coastal Management 49: 531 – 545.*

Rönnbäck, P. (2001) Shrimp aquaculture - State of the art. Swedish EIA Centre, *Report 1*. Swedish University of Agricultural Sciences (SLU), Uppsala. (ISBN 91-576-6113-8)

Rönnbäck P. (2002) Environmentally sustainable shrimp aquaculture. Prepared for the Swedish Society for Nature Conservation.

Sathirathai S. and Barbier E.B. (2001) Valuing Mangrove Conservation in Southern Thailand. *Contemporary Economic Policy. Vol 19 (2), 109-122.*

Seto K.C. and Fragkias M. (2007) Mangrove Conversion and Aquaculture Development in Vietnam: A Remote Sensing-Based Approach for Evaluating the Ramsar Convention on Wetlands. *Global Environmental Change 17, 486-500.*

Sidik A.S. (2008) The changes of mangrove ecosystem in Mahakam Delta Indonesia: A complex social-environmental pattern of linkages in resources utilization. *Paper presented at The South China Sea Conference, Malaysia, 25-29 November 2008.*

Sraun Y. (2004) Dampak kerusakan hutan Mangrove pada kondisi social ekonomi penduduk di Distrik Bintuni Kabupaten Teluk Bintuni. *Master Thesis.* Gadjah Mada University, Yogyakarta, Indonesia.

Sremongkontip S., Hussin Y.A. and Groenindijk L. (2000) Detecting Changes in the Mangrove Forests of Southern Thailand Using Remotely Sensed Data and GIS. *International Archives of Photogrammetry and Remote Sensing. Vol. XXXIII, Part B7.* Amsterdam.

Suryono C.A. (2006) Struktur populasi vegetasi mangrove di laguna Segara Anakan Cilacap, Jawa Tengah. *Jurnal Ilmu Kelautan Universitas Diponegoro.Vol. 11(2): 112-118*

Tangko A.M. dan Pantjara B. (2007) Dinamika Pertambakan Perikanan di Sulawesi Selatan Kurun Waktu 1990-2005. *Media Akuakultur. Vol. 2 (2), 118-123.*

Taslim R.S.A (2006) Hutan Bakau Pesisir Sulsel Perlu Direhabilitasi. http://opini-kelautan.blogspot.com/2006/08/hutan-bakau-pesisir-sulsel-perlu.html. Accessed 23 March 2015.

Ukkas, M., (2001) Pemetaan Potensi/Zonasi Wilayah Pesisir dan Pulau-pulau Kecil Kabupaten Takalar. *Laporan Penelitian Universitas Hasanuddin*, Makassar.

Unsworth RKF, de Leon PS, Garrard SL, Jompa J, Smith DJ and Bell JJ (2008) High connectivity of Indo-Pacific seagrass fish assemblages with mangrove and coral reef habitats. *Marine Ecology Program Series, 353: 213–24.*

Unsworth RKF, Garrard SL, de Leon PS, Cullen LC, Smith DJ, Sloman KA and Bell JJ. (2009) Structuring of Indo-Pacific fish assemblages along the mangrove-seagrass continuum. *Aquatic Biology 5, 85-95.*

Unsworth RKF, Hinder SL, Bodger OG, and Cullen-Unsworth LC (2014) Food supply depends on seagrass meadows in the coral triangle. *Environmental Research Letters 9 (9) , 094005. 10.1088/1748-9326/9/9/094005.*

Valderrama, D., Hishamuda, N., Zhou, S. (2010) Estimating Employment in World Aquaculture. *FAO Aquaculture Newsletter 45, 24-25*.

Wang Y., Bonynge G., Nugranad J., Traber M., Ngusaru A., Tobey J., Hale L., Bowen R., and Makota V. (2003) Remote Sensing of Mangrove Change along the Tanzania Coast. *Marine Geodesy, 26: 1-2, 35-48.*

To the Reviewer,

We would like to sincerely thank and appreciate for the highly constructive critics to this manuscript. We have implemented all these suggestions in the revised version.

Here is the detail of the revisions in the manuscript and our responses to the reviewers' comments:

REVIEWER #1

The article 'Consequences of Mangrove Forest Change in South Sulawesi ' makes a very interesting and worthwhile contribution to the literature. From what I've personally observed the rate of loss of mangrove and other coastal habitats in Sulawesi is massive. Slow incremental loss from a such a diverse range of stressors. These habitats together with seagrasses and reefs are vital to millions of people living in very close coupling with the sea in Sulawesi. I feel the MS does a good job at demonstrating some of these points. I work in the region and am acutely aware of the lack of good science coming out of the area despite the huge problems the marine environment faces. Although I feel the article should be published I do feel it needs some minor changes:

- I feel that paper is a little 'light' on ecological information discussing the role of mangroves in the region. I myself have published a number of articles on this topic from SE Sulawesi (Unsworth et al MEPS, Unsworth et al Aquatic Biology). The literature in the article is a little light on ecology and key papers, I think the authors should spend a little time looking deeper into the academic literature rather than using consulting reports/reviews.

Response:

Thanks for the suggestions, we have expanded the discussion to elaborate more on the ecological effects.

- The paper title is a little misleading as I don't really feel the paper shows the consequences of mangrove loss but does provide some evidence of the perceptions and knowledge of people towards mangrove loss. Please could the authors revise this.

Response:

Thanks for the suggestions. It is correct that we base the paper both on local perceptions of losses, on actual change in livelihood conditions and on the literature. We have tried to clarify this in the manuscript. We have modified the title, but think that a large part of the discussion and data from households deals with the consequences. Hence, we have kept this word in the title.

- In places the article is heavy on typos and is a little difficult to read. I think the paper could do with being reviewed in fine detail before being resubmitted.

Response:

Thanks for the suggestions. We have revised these accordingly throughout the revised version (including the use of the term aquaculture instead of shrimp farming throughout the revised version of the manuscript).

- An interesting point about mangrove loss that I've noticed in the region is that when you lose the mangrove you lose the associated seagrass due to increases in turbidity. Might be nice to potentially speculate about the indirect consequences of mangrove loss and the fisheries impacts (e.g. Unsworth et al 2014 Env Res Lett).

Response:

Thanks for the suggestions, we have included some considerations about this in the revised version of the discussion.

REVIEWER #2

The paper 'Consequences of Mangrove Forest Change in South Sulawesi' presents an interesting and well written overview of mangrove deforestation in a case study site in Sulawesi.

My comments are as follows:

- Title: an important part of the paper is on the rate of mangrove deforestation, hence the title does not well reflect the contents of the paper

Response:

The title has been modified – see also comment to reviewer #1 – to indicate that we show mangrove decline.

- Section "This is in line with FAO (2007), which reported that globally, 3.6 million hectares of mangrove forests were deforested from 1980 to 2005, but the annual deforestation decreased from 185,000 ha/year in the 1980s to 105,000 ha/year after 2000."This is used to confirm that the deforestation in the study area also decreased. However this is nto correct, a global trend cannot be used to confirm a local process.

Response:

Correct, we have decided to remove this part (highlighted in red) of the text.

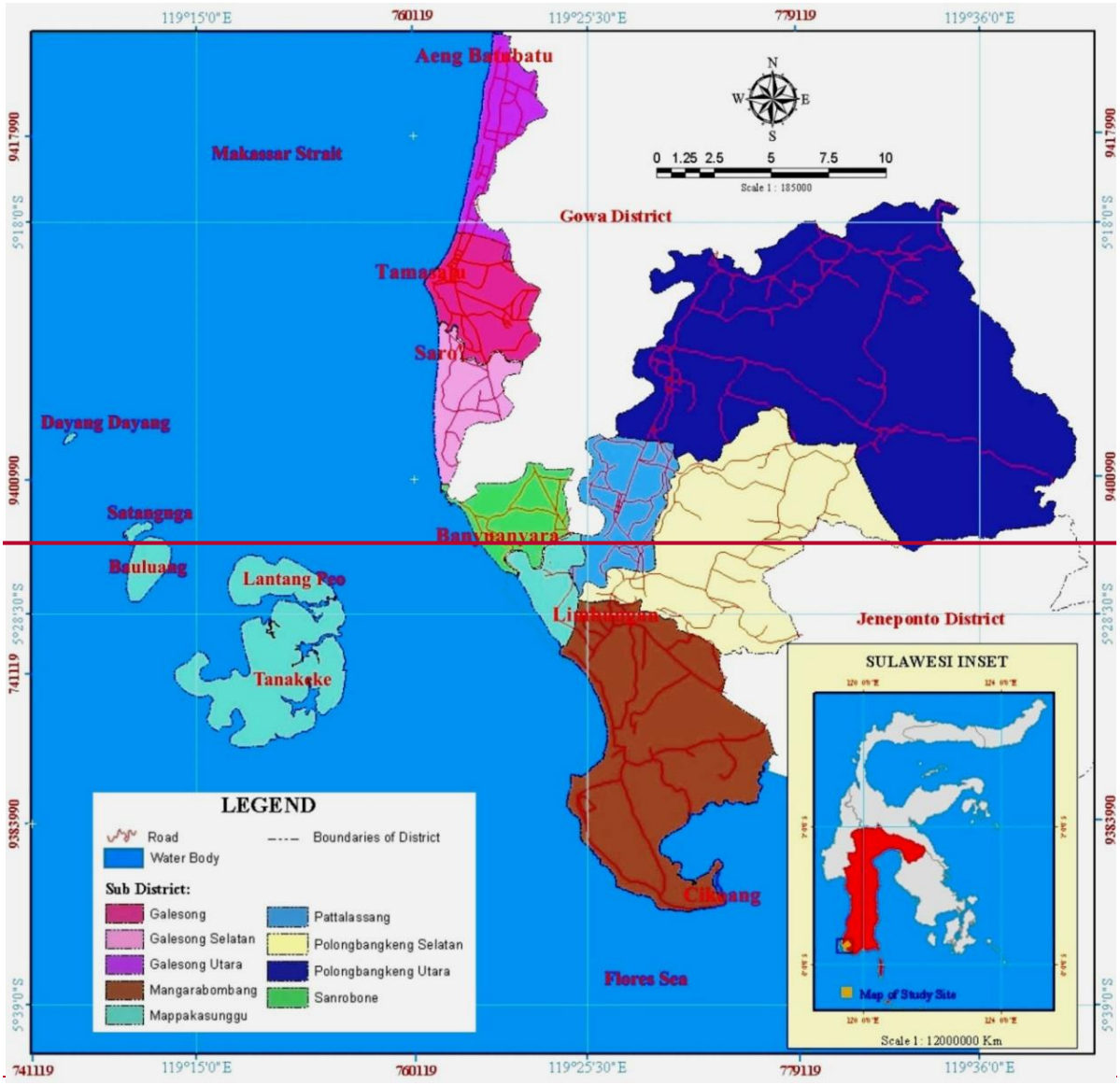
- My main comment, however, is that the paper lacks a balanced assessment of how coastal erosion and other environmental problems have affected local communities (the processes themselves are mentioned but their EFFECTS are not analysed) - and how these processes for instance affect at present AND how they may affect future local livelihoods including aquaculture production.
  In this sense, the paper ends on a positive (but not balanced) note: there have been important economic benefits from the increase in aquaculture. This is all good and well, but its the same story over and again in Indonesia and that is that only the very short term effects are considered by local people, businesses and the government. Yes in the short term there is an increase in income, but of course if coastal erosion continues with 20 to 100 m per year then at some point in the future (when?) aquaculture will no longer be possible. The same for the increasing scarcity of fry: yes it is declining but what are the consequences for aquacuture (and for other fishermen - are they also faced with lower catches??!!). And how about storm damage and sea level rise due to climate change ? And what is the economic impact of salt water intrusion on banana plantations?
  Hence, for a scientific paper a more balanced view is required. How do these effects add up ? Is it representative to only mention increases in production in the Conclusion and not to even mention in this section the negative environmental effects and their respective economic consequences? (as you will guess I don t think so). And what then are the policy recommendations from the to be produced balanced analysis?

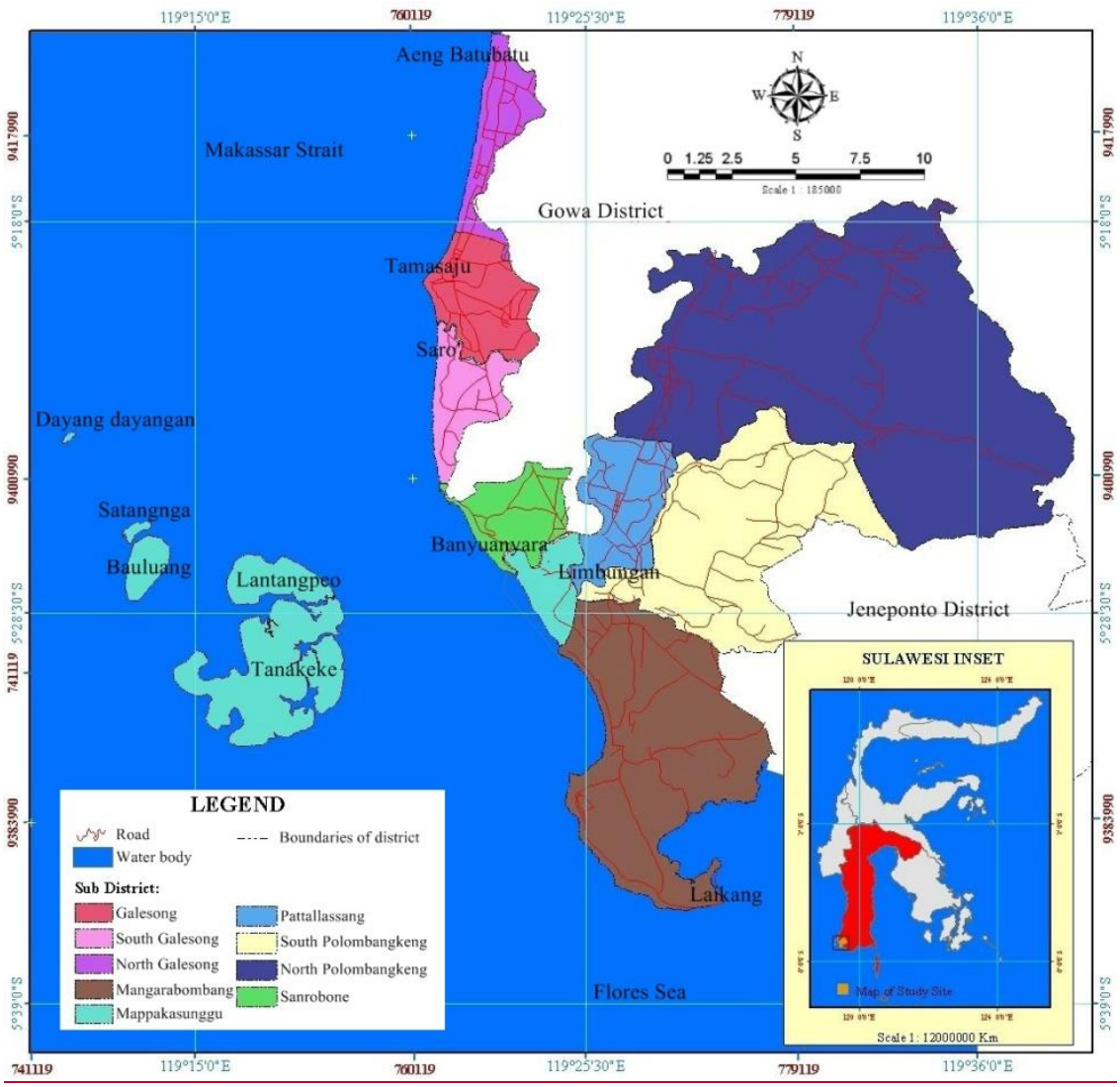
Response:

Thanks for the suggestions. We acknowledge this point and we have expanded the discussion to make a more balanced assessment, including more aspects of environmental impacts and also mentioning caveats to the income increases and exports success – that this may not last with the current system of production. Some of these aspects are covered in more detail in two papers published before this one (Malik A, Fensholt R, Mertz O (2015) Economic valuation of mangroves for comparison with commercial aquaculture in South Sulawesi, Indonesia. *Forests 6(9):3028–304* and Malik A, Fensholt R, Mertz O (2015) Mangrove exploitation effects on biodiversity and ecosystem services. *Biodiversity and Conservation 24:3543-3557*).

Figure

Figure 1. Case Study Area; Takalar District, South Sulawesi Province, Indonesia

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Makassar Strait
Gowa District
Tamasaju
Saro'
Dayang dayangan
Satangnga
Bauluang
Lantangpeo
Tanakeke
Banyuanyara
Limbungan
Jeneponto District
Laikang
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9417990
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9383990
741119
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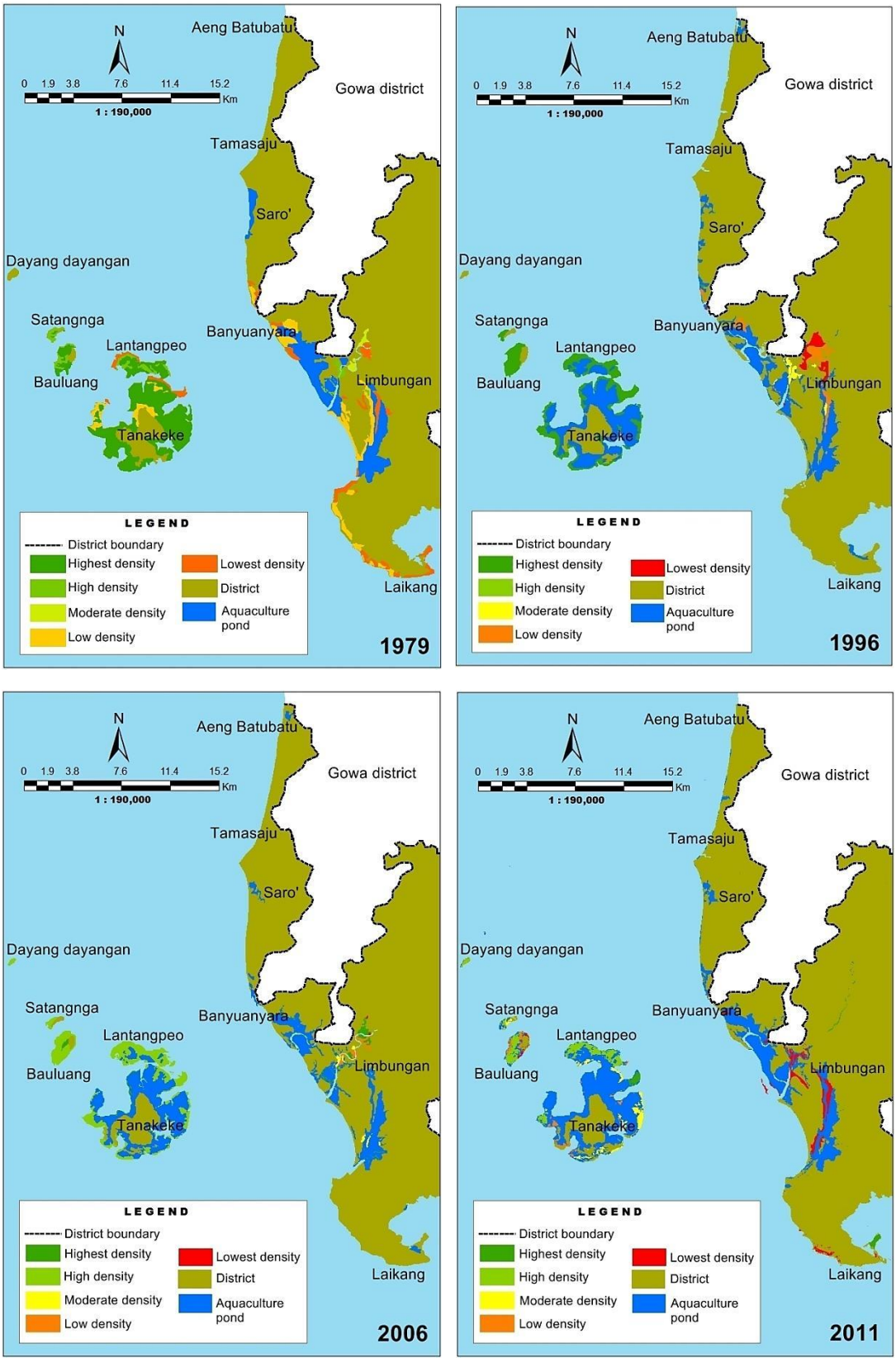
5°28'30"S
5°39'0"S
LEGEND
Road
Boundaries of district
Water body
Sub District:
Galesong
South Galesong
North Galesong
Mangarabombang
Mappakasunggu
Pattallassang
South Polombangkeng
North Polombangkeng
Sanrobone
SULAWESI INSET
Map of Study Site
Scale 1 : 12000000 Km

Figure 2. Mangrove forest change in the Takalar District, South Sulawesi Province 1979-2011.

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Gowa district
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Bauluang
Tanakeke
Banyuanyara
Limbungan
Cikoang
LEGEND
District Boundary
Highest dense
Hight dense
Moderate dense
Low dense
Lowest dense
District
Shrimp pond
1979


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Km
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Aeng Batubatu
Gowa district
Tamasaju
Saro'
Dayang Dayang
Satangnga
Lantangpeo
Bauluang
Tanakeke
Banyuanyara
Limbungan
Cikoang
LEGEND
District Boundary
Highest dense
Hight dense
Moderate dense
Low dense
Lowest dense
District
Shrimp pond
1996


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Gowa district
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Satangnga
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Limbungan
Cikoang
LEGEND
District Boundary
Highest dense
Hight dense
Moderate dense
Low dense
Lowest dense
District
Shrimp pond
2006


N
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Gowa district
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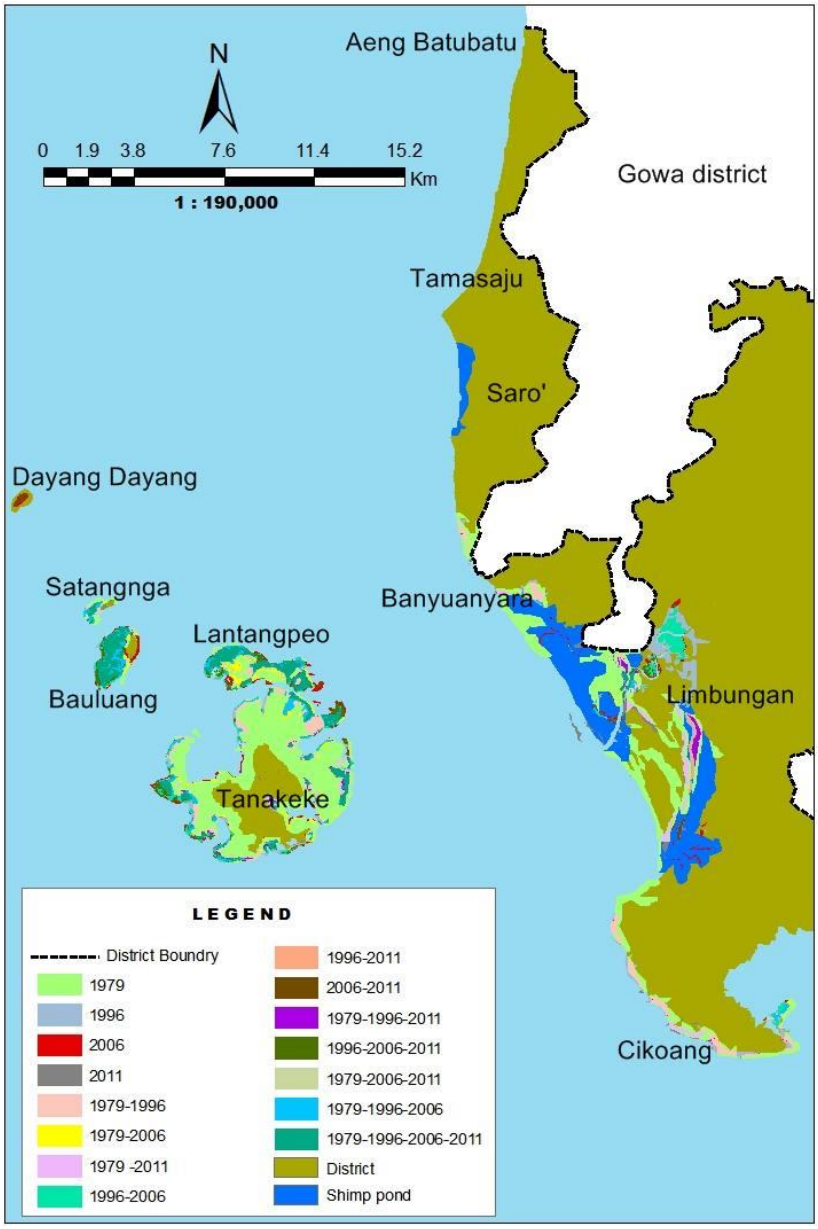
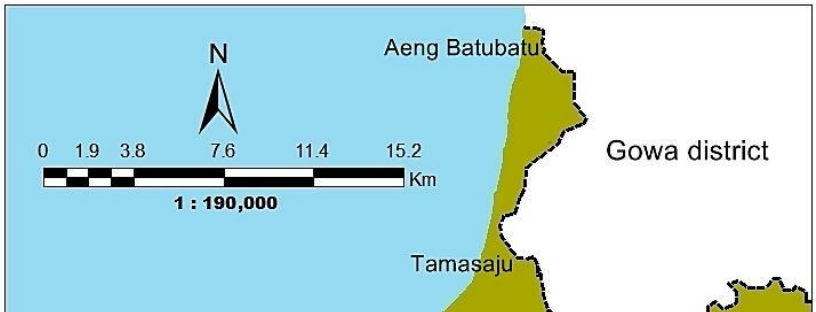
Cikoang
LEGEND
District Boundary
Highest dense
Hight dense
Moderate dense
Low dense
Lowest dense
District
Shrimp pond
2011

Figure 3. Overlay of mangrove forest cover. Legend colours represent different combinations of mangrove forest cover history for the 4 images analyzed (1979, 1996, 2006 and 2011).





Table

Table 1. Mangrove Change and ~~Shrimp Farming~~Areas Converted to Aquaculture ~~Converted per~~by Province in Indonesia

Province	Mangrove Change (ha)			~~Shrimp~~ Area Converted to ~~Farming~~Aquaculture ~~Converted~~ (ha)		
	1982	2003	Change	1991	2003	Change
Nanggroe Aceh Darussalam	54,335	18,000	-36,335	39,476	73,000	+33,524
North Sumatera	60,000	25,000	-35,000	1,826	34,000	+32,174
West Sumatera	0	17,000	+17,000	0	0	0
Riau	276,000	235,000	-41,000	192	3	-189
Jambi	65,000	5,000	-60,000	40	2,000	+1,960
South Sumatera	195,000	128,000	-67,000	325	58,000	+57,675
Bangka Belitung	0	63,000	+63,000	0	1,000	+1,000
Bengkulu	0	2,000	-2,000	94	0	-94
Lampung	17,000	0	-17,000	2,939	34,000	+31,061
West Java and Jakarta	28,608	2,000	-26,608	50,330	4,000	-46,330
Banten	0	3,000	+3,000	0	15,000	+15,000
Middle Java & Yogyakarta	13,577	9,000	-4,577	30,497	53,000	+22,503
East Java	7,750	26,000	+18,250	47,913	91,000	+43,087
Bali	1,950	3,000	+1,050	626	0	-626
West Nusa Tenggara	3,678	13,000	+9,322	4,996	13,000	+8,004
East Nusa Tenggara	1,830	19,000	+17,170	550	1,000	+450
West Kalimantan	40,000	137,000	+97,000	32	5,000	+4,968
Midde Kalimantan	10,000	38,000	+28,000	0	2,000	+2,000
South Kalimantan	66,650	99,000	+32,350	1,405	19,000	+17,595
East Kalimantan	266,800	367,000	+100,200	6,107	208,000	+201,893
Middle Sulawesi	0	44,000	+44,000	861	8,000	+7,139
Southeast Sulawesi	29,000	64,000	+35,000	6,636	16,000	+9,364
North Sulawesi	4,833	12,000	+7,167	590	0	-590
Gorontalo	0	15,000	+15,000	0	3,000	+3,000
South Sulawesi	66,000	27,000	-39,000	73,088	109,000	+35,912
Maluku	100,000	128,000	+28,000	65	1,000	+935
North Maluku	0	42,000	+42,000	0	0	0
Papua	2,943,000	1,622,000	-1,321,000	95	0	-95
T o t a l	4,251,011	3,163,000	-1,088,011	268,683	750,003	+481,320

Table 2. Mangrove Forest Change and Conversion to ~~Shrimp~~ Aquaculture. ~~Ponds~~

Year	Mangrove Change				Conversion to ~~Shrimp~~ Aquaculture ~~Ponds~~			
	Area (ha)	Change in Area from Previous Period (ha)	Annual Change (ha)	(%)	Area (ha)	Change in Area from Previous Period (ha)	Annual Change (ha)	(%)
1979	5,063	-	-	-	1,989.29	-	-	-
1996	2,507	- 2,556	-150.35	-2.97	3,672.39	+1,683.1	+99.01	+4.98
2006	1.799	- 708	-70.8	-2.82	3,913.27	+ 240.88	+ 24.09	+0.66
2011	1,719	- 80	- 16	-0.89	4,582.35	+669.08	+133.82	+3.42
Total		-3,344				+2,593.06		

Table 3. Mangrove Forest Density Change

No.	Criteria of Density	Year	Extent	Period Change (ha)	Total (ha)	Annual Change (ha)	Annual Change (%)
1	High and Highest	1979	2738.97	-		-	-
		1996	1608.88	-1130.09		66.48	-2.43
		2006	1594.64	-14.24		1.42	-0.09
		2011	927	-667.64	-1811.97	133.53	-8.37
2	Moderate	1979	452.57	-		-	-
		1996	281.9	-170.67		10.04	-2.22
		2006	59.91	-221.99		22.20	-7.87
		2011	235	+175.09	-217.57	35.02	58.45
3	Low and Lowest	1979	1871.45	-		-	-
		1996	598.63	-1272.82		74.87	-4.00
		2006	144.45	-454.18		45.42	-7.58
		2011	556	+411.55	-1315.45	82.31	56.98

FW: REEC: Submission Confirmation for REEC-D-15-00193R1

Abdul Malik

Tue 2/23/2016 5:15 PM

Sent Items

To:Rasmus Fensholt <rf@ign.ku.dk>; Ole Mertz <om@ign.ku.dk>;

Dear Rasmus and Ole

I have resubmitted the revision version of manuscript to REEC. I forwarded to you an email confirmation from REEC.

Regards,

Malik

From: em.reec.0.4963d7.3432e01c@editorialmanager.com [em.reec.0.4963d7.3432e01c@editorialmanager.com] on behalf of Editorial Office [em@editorialmanager.com]
Sent: Tuesday, February 23, 2016 4:57 PM
To: Abdul Malik
Subject: REEC: Submission Confirmation for REEC-D-15-00193R1

Ref.: Ms. No. REEC-D-15-00193R1
Mangrove Forest Decline: Consequences for Livelihoods and Environment in South Sulawesi

Dear Dr. Malik,

Regional Environmental Change has received your revised submission.

You may check the status of your manuscript by logging onto Editorial Manager at http://reec.edmgr.com/.

Kind regards,

Editorial Office
Regional Environmental Change

FW: REEC-D-15-00193R1: Manuscript entitled Mangrove Forest Decline: Consequences for Livelihoods and Environment in South Sulawesi returned to author

Abdul Malik

Mon 3/7/2016 9:54 AM

Sent Items

To: Rasmus Fensholt <rf@ign.ku.dk>;

2 attachments (790 KB)

Manuscript_revision_AM_07mar2016.docx; REEC Author Instructions Sept 2015.pdf;

Dear Rasmus

I just forwarded email from Editor of REEC (see below) and let you know that I have edited the manuscript (just deleted some words not substantial in the manus) and references list (edited the format and added Doi article that exist) to meet the journal requirements.
I am sorry I was not detail look the journal requirements earlier.
Now, no counting the references list, the text of manus consisted 6175 words and 3 figures and 3 tables equivalent to 1800 words (figure and table 300 words each), so the total 7975 words (length of journal requirement = 8000 words).
I also change the font to 10 point of Times Roman and align text to left.

Please find the final look of the manus and REEC author instruction for you look.

Best regards,

Malik

From: em.reec.0.49a13c.2c94a9aa@editorialmanager.com [em.reec.0.49a13c.2c94a9aa@editorialmanager.com] on behalf of Editorial Office [em@editorialmanager.com]
Sent: Saturday, March 05, 2016 2:54 PM
To: Abdul Malik
Subject: REEC-D-15-00193R1: Manuscript entitled Mangrove Forest Decline: Consequences for Livelihoods and Environment in South Sulawesi returned to author

The submission id is: REEC-D-15-00193R1

Dear Dr. Malik,

The manuscript cannot start the review process until the following corrections are made to meet the journal's requirements (see Instructions for authors, as well):

Missing information about length, incorrectly formatted references - maybe other faults, too, please DO FOLLOW THE INSTRUCTIONS.

Please edit your submission and make the necessary changes by logging into the Editorial Manager at:
http://reec.edmgr.com/

and clicking on "Submissions Waiting for Author's Approval".

You must then click on "Edit Submission", make the necessary changes, upload your revised manuscript, remove your old

manuscript, and approve your submission.

If you have any questions, please do not hesitate to contact me.

Kind regards,

Wolfgang Cramer
Editor-in-Chief
Regional Environmental Change

FW: Author Approve Changes or submits updated ms by author

Abdul Malik

Sat 3/19/2016 9:23 AM

Sent Items

To:Rasmus Fensholt <rf@ign.ku.dk>; Ole Mertz <om@ign.ku.dk>;

1 attachments (2 MB)

REEC-D-15-00193_R1_4.pdf;

Dear Rasmus and Ole

I just forwarded this email to let you know that I have re-submitted the manuscript to REEC journal
(Attached the final look of manuscript).

I also hopefully the revised version of manuscript now can be accepted.

Best wishes
Malik

From: em.reec.0.49eedc.c92a93f1@editorialmanager.com [em.reec.0.49eedc.c92a93f1@editorialmanager.com] on behalf of Editorial Office [em@editorialmanager.com]
Sent: Saturday, March 19, 2016 9:06 AM
To: Abdul Malik
Subject: Author Approve Changes or submits updated ms by author

Dear Dr. Malik,

Re: Mangrove forest decline: Consequences for livelihoods and environment in South Sulawesi

The submission id is: REEC-D-15-00193R1

Thank you for approving the changes that the Editor made to your submission or updating your submission according to the requested changes.

You will be able to check on the progress of your paper by logging on to Editorial Manager as an author. The URL is http://reec.edmgr.com/.

Thank you for submitting your work to this journal.

Kind regards,

Editorial Office
Regional Environmental Change

Current Status of the manuscript REEC-D-15-00193R1

Abdul Malik

Mon 4/18/2016 2:52 PM

Sent Items

To: Regional Environmental Change Editorial Office <reec@pik-potsdam.de>;

Cc: Rasmus Fensholt <rf@ign.ku.dk>; Ole Mertz <om@ign.ku.dk>;

Dear
Dear Wolfgang Cramer
(Editor-in-chief, Regional Environmental Change)

I just want to know the current status of the manuscript with the title "Mangrove forest decline: Consequences for livelihoods and environment in South Sulawesi" with number: REEC-D-15-00193R1 after revision based on comments and suggestions of reviewers.
Sorry, might be you have tried to contact me for this during the period where my university email was deactivated.

Best regards,

Abdul Malik
Dept. of Geosciences & Natural Resource Management
University of Copenhagen
Øster Voldgade 10, 1350 København K

From: Regional Environmental Change Editorial Office [reec@pik-potsdam.de]
Sent: Tuesday, March 08, 2016 2:53 PM
To: Abdul Malik
Subject: Re: further to your first revision of the paper

Thank you, take the time you need (and please report ALL the changes made between the initial version and the then resubmitted version in ONE table, do not bother about the "intermediate" changes)

Cheers,

Wolfgang C

Abdul Malik wrote on 08 Mar 2016, 14:13:

> Dear Wolfgang Cramer
> (Editor-in-chief, Regional Environmental Change)
>
> Despite a lot of work will now have to be redone (partly at least) due to this problem, but we can understand it.
> We will go through the manuscript more by the comments and suggestions of Dr. Burkett revision and resubmit in the near future.
>
> best regards,
>
> Malik
>
> ---
>
> **From:** Regional Environmental Change Editorial Office [reec@pik-potsdam.de]
> **Sent:** Monday, March 07, 2016 10:20 PM
> **To:** Abdul Malik
> **Cc:** Virginia Burkett

Subject: further to your first revision of the paper

Dear Dr Malik,

I apologize but a technical glitch has occurred in the handling of your paper. You will recall that, in January, you received a request for a major revision, and you have worked on the manuscript. I then sent it back to you to allow you to correct some minor formatting aspects of it.

I have now learned that our handling editor, Dr Virginia Burkett, actually has very kindly made a very profound revision of your manuscript (investing a lot of time in order to help you), however this document was unfortunately not passed on to you.

So with apologies, I am sending it here now. I am sorry if this renders part of your previous work on the revision unnecessary, this is really due to a problem on our side. But I am, at the same time, convinced that your paper will improve significantly if you do the extra work of carefully considering, and using, the edits suggested by Dr Burkett.

Best wishes,

Wolfgang Cramer

Prof. Dr. Wolfgang Cramer
Editor-in-chief, Regional Environmental Change
Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale (IMBE)
Aix Marseille Université, CNRS, IRD, Avignon Université, Technopôle Arbois-Méditerranée
Bât. Villemin – BP 80, F-13545 Aix-en-Provence cedex 04, France
Tel. +33-4-42-90-84-86

Prof. Dr. Wolfgang Cramer
Editor-in-chief, Regional Environmental Change
Institut Méditerranéen de Biodiversité et d'Ecologie marine et continentale (IMBE)
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Tel. +33-4-42-90-84-86

FW: REEC: Your manuscript entitled Mangrove forest decline: Consequences for livelihoods and environment in South Sulawesi

Abdul Malik

Mon 5/2/2016 8:36 AM

Sent Items

To:Rasmus Fensholt <rf@ign.ku.dk>; Ole Mertz <om@ign.ku.dk>;

Dear both

This email below from REEC that mentioned some minor points of the Editor Dr Virginia Burkett to the manuscript that should be revised before publication - I would like to revise these and send it back to you both.

Best regards,
Malik

From: em.reec.0.4ae066.89223bd8@editorialmanager.com [em.reec.0.4ae066.89223bd8@editorialmanager.com] on behalf of Editorial Office [em@editorialmanager.com]
Sent: Sunday, May 01, 2016 8:39 AM
To: Abdul Malik
Subject: REEC: Your manuscript entitled Mangrove forest decline: Consequences for livelihoods and environment in South Sulawesi

CC: virginia_burkett@usgs.gov

Ref.: Ms. No. REEC-D-15-00193R1
Mangrove forest decline: Consequences for livelihoods and environment in South Sulawesi
Regional Environmental Change

Dear Dr. Malik,

our editor, Dr Virginia Burkett, only has minor points for you to consider in what might be the final revision of your paper before publication. Please pay attention to these, and also to the instructions for authors which you have partly not accounted for (there is no indication of length, and several references are incomplete).

For your guidance, reviewers' comments are appended below.

If you decide to revise the work, please submit a list of changes or a rebuttal against each point which is being raised when you submit the revised manuscript.

Your revision is due by 31-05-2016.

To submit a revision, go to http://reec.edmgr.com/ and log in as an Author. You will see a menu item call Submission Needing Revision. You will find your submission record there.

Yours sincerely,

Wolfgang Cramer
Editor-in-Chief
Regional Environmental Change

Reviewers' comments:

The revised paper is much improved. The authors did an excellent job at explaining their responses to reviewer comments. The edits to the title and new figure with the household survey data are important. The paper still needs a few text edits of a grammatical nature and clarification is needed in a few places as follows:

Page 2, Line 21 – for subject/verb agreement, change "produces" to "produce"
Page 2, Line 36 – insert a comma before the words "according to available data"
Page 2, Line 42 – a decrease from 500,000 hectares of forest to 256,185 is roughly a 50% decrease not a 100% decrease.
Page 5, Line 17 – the precise number may have been 27,316 in 2012 but it is no doubt different today. Please insert in the sentence the date that the population was reported to be 27,316 in the source document (BPS-Kab.)
Page 5, Line 27 – insert period at end of sentence
Page 6 footnote – italicize both genus and species, capitalize only the genus as follows: Nypa fruticans
Page 7, Line 42 – the authors have not addressed the problem with this sentence, which still states that mangrove losses were in the highest density mangrove class and the loss was "approximately 1.812 hectares during 2006-2011". The decimal place or the total number must be wrong. How can this class have decreased the most when only 1.8 hectares was actually lost?
Page 8, line 24 – river should be capitalized in "Papa river"
Page 8, line 38 – please insert the word "with" between the words "associated replanting"
Page 9, Line 50 - The Abstract states that mangrove forests were reduced by 66.05% (3,344 hectares) during 1979-2011, but this line states that 77.54% of the total mangrove forests were converted to shrimp farms. On page 11, lines 31-33, you state that 77.54% of the total mangrove forest losses were associated with conversion to aquaculture ponds. Please correct Line 50 on page 9 to state that "77.54% of the loss of mangrove forests were associated with aquaculture development."
Page 9, line 38 – this line is still not clear. Don't you mean five bundles per month per harvester (not harvest)? The next sentence implies that you are talking about individual people (harvesters).
Page 9, line 52 – were hats sold to more than one "trader"? If there was only one trader, please ignore this comment.
Page 10, line 25 – this part does not make sense: "income source where has conducted in the coastal area".
Page 11, line 17 – suggest changing "this has become" to "cultured shrimp have become"
Page 13, Line 5 – suggest deleting "The" at the beginning of the sentence.
Page 13, Line 56 – suggest deleting the word "respondents" in this phrase, "shrimp farmer respondents reported, since it is assumed that the observation was from your household surveys.
Page 14, Line 13 – need to insert the word "shrimp" after the word "juvenile"

Page 14-line 31 – sentence gives a precise statistic 12,648 hectare of mangrove infected by the disease as if it were a current statistic. Provide date of the observation of the 12,648 hectare of mangrove infected in the sentence (it looks like it was around 2007, which is the date of the source document).

—

Mangrove forest decline: Consequences for livelihoods and environment in South Sulawesi

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

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[2] Section of Geography, Department of Geosciences and Natural Resource Management, University of Copenhagen, ØsterVoldgade 10, 1350 Copenhagen K, Denmark. E-mail: om@ign.ku.dk and rf@ign.ku.dk.

* Corresponding author: E-mail: malik@ign.ku.dk; Tel.: +45-353-241-63; Fax: +45-353-225-01

Abstract

Mangrove forests in the tropics and sub tropics grow in saline sediments in coastal and estuarine environments. Preservation of mangrove forests is important for many reasons, including the prevention of coastal erosion and seawater intrusion; the provision of spawning, nursery and feeding grounds of diverse marine biota; and for direct use (such as firewood, charcoal, and construction material) – all of which benefit the sustainability of local communities. However, for many mangrove areas of the world, unsustainable resource utilization and the profit orientation of communities have often led to rapid and severe mangrove loss with serious consequences. The mangrove forests of the Takalar District, South Sulawesi are studied here as a case area that has suffered from degradation and declining spatial extent during recent decades. On the basis of a post-classification comparison of change detection from satellite imagery and a survey of households, we provide an estimate of the mangrove change in the Takalar District during 1979 - 2011 and the consequences of those changes. Mangrove forest areas were reduced by 66.05% (3,344 hectares) during the 33-year period of analysis and the biggest annual negative change of dense mangrove forest cover (8.37%) occurred during the period 2006 - 2011. The changes were caused mainly by the mangrove clearing and conversion to aquaculture and consequences have been increasing forest degradation, coastal abrasion, seawater intrusion, a decline in fish capture, a reduction in juvenile shrimp and milkfish, and outbreaks of shrimp disease. On the other hand, the clearing and impoundment of mangrove forests for shrimp and seaweed culture have provided a source of foreign exchange and new opportunities for employment in the study area.

Keywords: Mangrove forest; forest degradation; livelihoods; remote sensing.

1. Introduction

Mangrove forests are found in tropical and subtropical climates, along the coast and river estuaries affected by tides. Mangrove forests are essential for protecting coastal areas from wave impact (Dahuri 2003) and their functions can be characterized in physical, biological and economic terms. Physical functions include prevention of coastal erosion and seawater intrusion and the retention of sediments and nutrients, whereas biological functions include the ability to stabilize or balance the ecosystem by being the source of nutrients and acting as the nursery, feeding and spawning grounds for fish, crabs and shrimps. Mangrove forests have economic relevance for agriculture, tourism, fisheries and timber resources and produce~~s~~ basic materials for household and industrial purposes, such as firewood, charcoal and paper, of high commercial value for local communities (Giesen et al. 2007; Ghufran 2012).

Almost half of the total mangrove forest cover in the world has disappeared since 1980 (MA 2005) due to an increase in commercial logging, fuel wood collection, charcoal production, mining, conversion to agriculture (mainly rice paddies and coconut), housing and aquaculture ponds (Giesen et al. 2007). However, the conversion of mangrove areas to shrimp ponds has been the most important development (Murdiyarso et al. 2015). The loss rate of mangrove forests is reported to be 1 - 2% per year (Duke et al. 2007) and, according to available data from FAO (2007), 3.6 million hectares of mangrove forest disappeared during 1980 - 2005, with Asia being the region with the largest loss (more than 1.9 million hectares since 1980). In the Philippines, the total mangrove cover was around 256,185 hectares in 2000, which is ~~almost~~ roughly a ~~100~~50% decrease from an estimate of 500,000 hectares in 1918 (Long and Giri 2011). In Southern Thailand about 50 % of the total mangrove area has been converted to shrimp aquaculture and other forms of coastal development during 1975-2005 with less than 10% left on the east coast (Thampanya et al. 2006). In the Mui Cau Mau, Vietnam, mangrove forests have decreased drastically from 71,345 hectares to 33,083 hectares during the period 1953 - 1992, but in 2011 an increase to 46,712 hectares was reported due to replanting as part of integrated mangrove-aquaculture system (Van et al. 2015).

The degradation and decline of mangrove areas have many potential environmental and socio-economic consequences for coastal communities. The conservation of mangrove forests, which are

among the most carbon rich forests in the tropics, could contribute to climate change mitigation through programmes such as REDD+ (Reducing Emissions from Deforestation and Forest Degradation) (Murdiyarso et al. ~~2009~~2010). Yet, deforestation of mangrove has been estimated to lead to massive carbon stock emissions (0.08-0.48 PgC per year) (Donato et al. 2011). Moreover, the conversion of mangrove forests to aquaculture ponds has caused a decrease in nursery habitat of marine shrimp (*Penaeus* sp.), mud crabs (*Skylla* sp.) and other shellfish and fish species that spawn in coastal and offshore waters (~~Hong~~ Phan and Quan~~Dao~~ 2004). The aquaculture (e.g. shrimp farming) itself also causes environmental problems due to uncontrolled use of chemical fertilizers and pesticides and has in many places been unsustainable due to water pollution and disease outbreaks (~~Hong~~ Phan and ~~Dao~~ Quan 2004). However, the expansion of aquaculture has also had positive consequences for food security and the provision of labour. In 2008, the combination of capture fisheries and aquaculture supplied 142 million tons of fish, of which 115 million tons was used for human food (FAO 2011). Fisheries and aquaculture also contributed to improving household livelihoods (Valderrama et al. 2010) and increased national income due to shrimp export providing foreign exchange (Bailey 1988).

Indonesia has the most extensive mangrove forests in the world but they were reduced from 4.25 million hectares in 1980 to 3.16 million hectares in 2003, (Table 1) (FAO 2007; Noor et al. 2006) with an annual deforestation rate of 1.24% between 1980 and 2005 (Murdiyarso et al. 2015).

There are multiple pressures on mangrove areas including the collection of firewood, housing material, charcoal production, and material for handicrafts as well as conversion to aquaculture, agriculture and settlement (Noor et al. 2006). However, the main factor behind the deforestation and degradation of mangrove in Borneo, Sumatra, Java and Sulawesi is conversion to shrimp farming (Sidik 2008; Onrizal 2010; Suryono 2006; Nurkin 1994), as is also the case in other Asian countries (Barbier and Cox 2002).

Noor et al. (2006) show that aquaculture expansion led to deforestation of about 481,000 hectares of mangrove between 1991 and 2003 (Table 1). Furthermore, Onrizal (2010) reported a loss of mangroves of about 61,715 hectares during the period 1977 to 2006, which caused a decrease in fish species in North Sumatra. Sidik (2008) stated that 63% of the mangrove in Mahakam Delta, East Kalimantan had disappeared by 2001 and the peak degradation was found to occur during the period 1996 to 2000. In Segara Anakan, Central Java, the largest mangrove area in Java, mangroves have decreased

from 35,000 hectares in 1930 to 12,000 hectares in 1996, causing a decrease in species diversity and changes in the distribution pattern of mangroves (Suryono 2006). In South Sulawesi, mangroves covered an area of approximately 110,000 hectares in the early 1950s (Giesen et al. 1991), whereas by 2003, about 75% of the mangrove was lost, leaving only 27,000 hectares (Table 1), of which most areas were affected by the expansion of aquaculture (Noor et al. 2006). Tangko and Pantjara (2007) reported that areas with shrimp ponds in South Sulawesi had increased dramatically during the period from 1990 to 2005 (by 25,295 hectares), mainly at the expense of mangrove forests.

Exact and updated information on the density and spatial distribution pattern of mangrove forests and the consequences of decades of deforestation are, so far, poorly documented. The data provided by FAO (2007), which related to changes up to the year 2005, are still being used as a reference for the current status, which complicates decision making on the management and conservation of mangrove forests.

<Table 1 Insert>

Timely and accurate inventory and monitoring of mangrove forests are necessary for decision making. Remote sensing technologies enable quick, inexpensive and accurate land cover mapping, monitoring and change detection. In some countries, remote sensing for inventory, change detection and management of mangrove forest has been conducted using images from Landsat and SPOT and very high spatial resolution multispectral and SIR-C radar data (Wang et al. 2003). Timely, accurate socio-economic data, on the other hand, is needed to assess the consequences of these uses on individual households and communities.

The objective of this paper is to characterize the areal extent and socio-economic consequences of mangrove forest losses in Sulawesi during the 33-year period, 1979 - 2011. The Takalar District in South Sulawesi is used as a case study for highlighting changes that are occurring in many parts of Indonesia and elsewhere in Southeast Asia.

2. Study Area

Takalar District is located in the southern part of South Sulawesi Province (between latitude 5°12' - 5°38' and longitude 119°10'- 119°39', see fig. 1). The district covers 566.51 km^2, divided into nine sub-Districts (Galesong, South Galesong, North Galesong, Mangarabombang, Mappakasunggu, Pattallassang, South Polombangkeng, North Polombangkeng and Sanrobone). Mappakasunggu consists of a mainland part and some small islands (Tanakeke, Lantangpeo, Bauluang, Satangnga and Dayang dayangan) (BPS-Kab. Takalar 2012).

The district has a coastline of about ± 74 km (Ukkas 2001) and several rivers (Cikoang in Mangarabombang, Pappa in Pattallassang, Biringkassi in Sanrobone, Sabala in South Galesong, Saro and Galesong in Galesong and Beba in North Galesong). The population is 272,316, and the population density is 481 people per km^2 (BPS-Kab. Takalar 2012, Agustus).

Mangrove forests in this area primarily consist of 10 species (*Avicennia alba, Bruguiera gymnorrhiza, Ceriops tagal, Excoecaria agallocha, Lumnitzera racemosa, Nypa fruticans, Rhizophora apiculata, Rhizophora mucronata, Rhizophora stylosa* and *Sonneratia alba*). *Rhizophora mucronata* is the most dominant species, followed by *Sonneratia alba* in 2012 (Malik et al. 2015b)

<Fig. 1 Insert>

3. Material and Methods

3.1. Digital Image Processing

In this study, we used images from two different sources: Landsat and SPOT 4. The images were from 3 January 1979 (Landsat MSS), from 21 May 1996 and 24 February 2006 (Landsat TM) and from 7 August 2011 (SPOT 4). We also used a 1:50,000 digital topographical maps from 1999 (Bakosurtanal 1999). The images and digital topographical maps were geo-referenced to WGS 84/UTM zone 50S.

The steps in image processing included both pre-processing and image analysis. Geometric corrections of the four images were done using the digital topography map, and False Colour Composite (FCC) maps were created to facilitate the interpretation process. The Normalized Difference Vegetation Index (NDVI) was calculated as an indicator of vegetation density in mangrove forests (Seto and Fragkias 2007; Emch and Peterson 2006). Image classification was conducted using a supervised maximum likelihood classification (Sremongkontip et al. 2000; Manassrisuksi et al. 2001) including a separation

between mangrove forest (five different density classes), aquaculture, water and other surfaces. An accuracy assessment of the 2011 image classification was done using the confusion matrix method (Lillesand et al. 2008; Wang et al. 2003) on the basis of ground truth data collected in August 2012. In the absence of historical ground truth information the accuracy of the historical images was established using independent (of the training areas) test areas in the satellite imagery. Hence, the test pixels for these images only partly fulfill the conditions of valid ground truth (Foody 2002), but this approach is often used as a work-around to assess the accuracy of older Landsat images for areas where no independent validation information is available (Congalton 1991). Finally, the GIS overlay technique was used to conduct a post-classification comparison change detection analysis to detect the changes in the four images classified (Manassrisuksi et al. 2001).

3.2. Household Survey

A household survey was undertaken in ten areas (including seven sub-Districts) covering the islands of Lantangpeo, Tanakeke, Bauluang and Satangnga (sub-District of Mappakasunggu), and the villages of Laikang (sub-District of Mangarabombang), Limbungan (sub-District of Pattallassang), Banyuanyara (sub-District of Sanrobone), Saro' (sub-District of South Galesong), Tamasaju (sub-District of Galesong) and Aeng Batubatu (sub-District of North Galesong).

The selection of these areas was based on the criteria that mangrove forests should be present and that there should be some element of pressure on the forest for conversion to shrimp ponds, commercial logging, charcoal production, fuel wood collection and nipa palm production[1].

Questionnaires were administered to 100 respondents, who were selected by a Purposive Sampling method (Patton 1990). Thus, the respondents all had a direct relation to and dependence on mangrove forests, such as fishermen, seaweed and shrimp farmers, firewood collectors, charcoal producers and nipa palm crafters. Heads of household were interviewed by the first author and trained enumerators, and the information obtained included basic household information such as age, number of dependents, education, livelihood and income source. Moreover, information was collected on the respondents' understanding of mangrove functions, and benefits, as well as their use of mangrove forests.

3.3. Accuracy assessment

[1] *Nypa ~~Fruticans~~fruticans*, a common component of mangrove forests, is valued primarily for its fruit and sap production, medicinal purposes, and leaves, which are crafted for various purposes.

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The results of the remote sensing analyses showed that the levels of overall accuracy on Landsat MSS 1979, Landsat TM 1996 and 2006, and SPOT 4 2011 were 92.52%, 95.82%, 97.26% and 96.28%. Overall accuracy (including all land use/cover classes) was assessed from pixel samples collected (3021, 2703, 2664 and 2741, respectively, covering all classes). For the mangrove class, the user's and producer's accuracies were found to be 85.90%, 85.68% (n=329); 85.71%, 86.19% (n=156); 84.03% 85.21% (n=121); and 87.83%, 83.47% (n=101), respectively. An accuracy of ≥ 85% is considered acceptable when image classification is used for post-classification comparison change detection (Anderson et al. 1976) to determine mangrove changes overtime (Giri et al. 2007).

4. Results

4.1. Mangrove Forest Change

The satellite image based post-classification comparison change detection analysis showed that over the 33 years studied, the total areas of mangrove forest in Takalar District decreased by 66.05% or 3,344 hectares (Table 2 and Fig. 2). The largest average annual negative change (2.97%) in mangrove forests was found to occur during the period 1979-1996, followed by the period 1996-2006 (2.82%); a slower average annual decrease rate was found during the period 2006-2011 (0.89%).

When analyzing changes on the basis of different classes of mangrove forest density (distinguishing between three classes: high/highest, moderate and low/lowest density of mangrove forest, Table 3 and Fig. 2A) it becomes clear that the general decline in mangrove forests is not equally distributed amongst different density classes. The most pronounced decrease (in total ha) was found for the high/highest density classes of mangrove, with a loss of approximately 1, 812 hectares during the period 1979 - 2011. The greatest annual change of high/highest density mangrove occurred during the period 2006-2011 (8.37%). For moderate, as well as for the low/lowest density mangrove classes, a decrease from 1979-2006 changes into an increase for the most recent period of analysis (2006-2011). This increase is, however, not large enough to counter balance the rapid decrease in dense mangrove forest during this period.

<Table 2 Insert>

<Table 3 Insert>

4.2. Distribution of Mangrove

In 1979, mangrove forest was found in the sub-Districts of Mappakasunggu, Mangarabombang, Pattallassang, Sanrobone and South Galesong. The largest area was found in Mappakasunggu, particularly on Tanakeke Island. Smaller mangrove areas were found in Lantangpeo, Bauluang and Satangnga Islands, and along the coast and river of Cikoang in Mangarabombang sub-District, the rivers of Pappa in Pattallassang sub-District, Biringkassi in Sanrobone sub-District and Sabala in South Galesong sub-District. In 1996, the mangrove forests located on Tanakeke and Lantangpeo Islands had degraded and declined, whereas seaside mangrove forest was retained. On the Islands of Bauluang and Satangnga, mangrove forest area was unchanged. Mangrove forests located along the coasts of Mangarabombang, Sanrobone and South Galesong sub-Districts also degraded until they were only present around the rivers of Cikoang, Pappa, Biringkassi and Sabala. In Pappa ~~river~~ River area, the mangrove area increased. In 2006, mangrove forests located on Tanakeke Island declined even further, as was the case along the coasts of Mangarabombang, Sanrobone and South Galesong and the rivers of Cikoang, Pappa, Biringkassi and Sabala. On Lantangpeo Island, mangrove cover increased moderately due to reforestation and in 2011, mangrove forest cover declined further in Tanakeke, Lantangpeo, Bauluang and Satangnga Islands and around the rivers of Pappa and Biringkassi, but at a slower rate compared to the earlier periods. Along for the coast and Cikoang River in Mangarabombang, areas of increased mangrove cover were associated with replanting (Fig. 2B).

<Fig. 2A-B Insert>

4.3. Mangrove Conversion to Aquaculture

The total area loss of mangrove forests in the Takalar District ~~loss~~ ~~converted~~ associated with ~~into~~ aquaculture development between 1979 and 2011 was 77.54% (2,593 hectares) (Table 2). The largest annual change rate of converting mangrove to aquaculture (4.98%) occurred during the period 1979 to 1996, followed by an annual decrease of 3.42% during the period 2006 to 2011 and a 0.06% increase during the period 1996 to 2006. The most aquaculture pond development is found on Tanakake Island, Mappakasunggu sub-District and in Banyuanyara village, Sanrobone sub-District (Fig. 2).

4.4. Utilization of Mangrove Forest by Households

Mangrove forests provide essential natural resources that support household livelihoods in the Takalar District. Over the recent decades households in this area have been highly dependent upon mangroves for their production of wood and fiber products (e.g. firewood, charcoal, and nipa palm leaves) and capture fisheries and aquaculture products (e.g. fish, crabs, shrimp, and seaweed) (Fig. 3). However, fishing is the main livelihood of household heads (Fig. 3).

<Fig. 3 Insert>

Fish capture takes place between February and September when sea conditions are good. October to January, when there are large waves and strong wind, are used as periods to rest, repair boats and fishing gear or engage in alternative work. The income per month from fishing is generally very low earning less than USD 53. Thus, many of fishermen engage themselves in a variety of income-producing activities such as commercial logging and seaweed farming.

Commercial selective logging of specific species and sizes of mangrove trees is common. *Rhizophora* sp. wood with a stem height of about four meters and a diameter of 4 to 8 cm is favoured because it is stronger and provides better quality firewood and charcoal than other species. Monthly production is on average five bundles per harvester, and with a price per bundle of USD 8.4, the average monthly income is USD 42. Charcoal products are also mostly from *Rhizophora* sp. The production process lasts about 10 days (six days for burning and four days for cooling) and each burning session can produce 500 kg of charcoal, which is packaged in 25 kg bags that are sold for USD 5.3 per bag providing an average monthly income of USD 316. Nipa palm leaves are used to build roofs and walls, as well as to make hats, floor mats and baskets. Hat production was the most common among surveyed respondents and was mostly conducted by women, whereas men collected the leaves with up to 100 bundles per operation (1-2 times per month). Hats were sold to ~~a~~ traders for USD 0.3 to USD 0.5 per hat, depending on the size, and the monthly income could reach USD 316.

Aquaculture (e.g. shrimp farming) is widely practiced in the mangrove areas of Indonesia and areas of intensive shrimp farming cover Java, Sumatra, Kalimantan and South Sulawesi (including the

Takalar District studied here) (Bengen and Dutton 2004). The average extent of a shrimp pond is three hectares and applied mainly as a traditional system of aquaculture that is dominated by polyculture with shrimp and milkfish (*Chanos chanos*) or milkfish and seaweed *(Gracilaria*). However, monoculture of shrimp or milkfish is also common. Two annual harvests per stocking season yield shrimp production from monoculture of 200-300 kg/ha and milkfish production of 1700-2500 kg/ha. The production from polyculture (shrimp and milkfish) was between 600-800 kg/ha (of which 70% is from milkfish), whereas milkfish and seaweed produced between 6000-7000 kg/ha of which about 65% is from seaweed. The total income per production cycle is between USD 1,053 and 2,526. In addition, statistical data from Takalar District (BPS-Kab. Takalar 2007-2012) showed that during the period 2006 to 2011, the annual average income of shrimp farmers increased from USD 3,368 to USD 5,053 with an annual average increase of 11%.

Many households are also engaged in seaweed farming either as single activity or as an alternative ~~income source where has conducted in the coastal area (about 100 m from the coastline)~~. The species cultivated is mainly *Eucheuma Cottonii* using the 'long line floating method' (by using mangrove wood as stakes) where seaweed seedlings are collected from the sea. The number of lines depends on the extent of the farming area, but on average, the survey respondents had 300 lines (one line is 20 meters long and lines are placed one meter apart), providing a potential income per crop cycle of up to USD 758. In addition, statistical data from Takalar District (BPS-Kab. Takalar 2007-2012) show that during the period 2006 to 2011, the annual average income of seaweed farmers increased from USD 4,042 to USD 9,095, with an annual average increase of 18%.

5. Discussion

5.1. Mangrove Forest Change

Mangrove forest areas in Takalar, South Sulawesi have over the past 33 years declined by more than half of their previous extent. The traditional activities of communities, who live in mangrove areas, play a fairly small role in this decline as they mainly use mangrove resources for domestic purposes such as firewood, house materials and fish traps. However, in the early 1970s, commercial logging of mangrove began to supply the Gowa paper factory in South Sulawesi (Nurkin 1979), but currently this has stopped due to the limited remaining mangrove forests. Nonetheless, commercial logging of firewood

and charcoal for food stalls in Makassar, the capital of South Sulawesi province and elsewhere, remains and has caused continued degradation and declining stocks of mangroves. Moreover, there is a high demand for the wood of several mangrove tree species, especially *Rhizophora* sp., which is preferred for firewood and charcoal production because it is hard, dense, and has a high calorific value (Aksornkoae 1993; Nurkin 1994). In addition, firewood from *Rhizophora* sp. generally produces a superior flavour of food and burns slowly (Nurkin 1994). Nipa palm leaves have also been used for centuries as material for roofing and wall webbing as well as hats, floor mats and baskets.

The most important driver of mangrove decline, however, has been the introduction of tiger shrimp and aquaculture in the early 1980s. With an increasing international demand, ~~this has become~~cultured shrimp have become the main fisheries commodity in South Sulawesi, as is also the case in other areas of Indonesia and Southeast Asia (Purnomo 1992; Béland et al. 2006). Indonesia, Thailand, China, ~~India, Vietnam, Bangladesh~~ and India have become the major exporting countries (Rönnbäck ~~GlobeFish~~ 2001) and the international demand can be met either by catching tiger shrimp at sea or through aquaculture. However, because Indonesia has prohibited trawling operations in the marine territory since 1980 to preserve marine biological resources, the only way that tiger shrimp production can be increased is through expansion and intensification of aquaculture (Purnomo 1992). In Takalar District, the total area of mangrove forests being converted into shrimp ponds (77.54%) occurred during the period 1979 - 2011 and a large scale expansion of aquaculture during this period also took place in Tanakeke Island and Banyuanyara village. Over the period 1979 - 2011, the loss of mangrove forests in Takalar District constitutes 8.37% of the losses in South Sulawesi and 0.30% of total Indonesian losses, whereas the loss through conversion to aquaculture has contributed about 5.36% for South Sulawesi and about 0.40% for Indonesia.

The increase in aquaculture is mainly due to local fishermen changing their livelihoods to shrimp farming, which generates high revenue and is an export commodity that has not experienced steep declines in prices (BPS-Prop. Sulawesi Selatan 2007-2012). In addition, government support in the form of credit and subsidies to farmers to expand shrimp ponds has also been an important driver (Nurkin 1994).

Although mangrove forest destruction due to shrimp pond expansion increased during 1980s and 1990s, the rate of deforestation has decreased since the early 2000s due to an outbreak of White Spot

Disease (WSD) in the 2000s, which is caused by a pathogen (white spot syndrome virus) that rapidly infects crustacean populations and results in high shrimp mortality (Crockford ~~2001~~2008; Alifuddin et al. 2003).

Over the past five years, the annual expansion of shrimp ponds has returned to previous high rates, but the expansion is less focused on monoculture of tiger shrimp, as farmers have been traumatized by several harvest failures and heavy losses due to WSD outbreaks. Households in the Takalar District were found to focus more on polyculture of shrimp and milkfish or milkfish and seaweed. This transition from monoculture towards a more resilient polyculture has also been observed in Philippines, Thailand and Taiwan (Fast 1992). Farmers have also changed to farming white leg shrimp (*Penaeus vannamei*), which can be stocked in high densities and is relatively more resistant to disease (Tangko and Pantjara 2007).

5.2. Consequences of Mangrove Change

While the present study has mainly documented change in mangrove areas and household-based perceptions of consequences, several other studies document the impacts of mangrove loss on the physical and ecological functions of the ecosystem. The diversity of species has declined and today mangrove forests mostly consist of seedlings and saplings (Malik et al. 2015b). Coastal erosion has occurred in several places in the sub-Districts of Takalar (Fig. 1) which have retracted 20-100 meters per year between 2003 and 2008 (Hajramurni 2010). Low density of mangrove vegetation due to timber harvesting and collection of firewood for charcoal production (Malik et al. 2015b) has been reported to cause coastal erosion (Mazda et al. 2002). Furthermore, development of aquaculture ponds by clearing mangrove forests has caused coastal erosion due to wave attacks and tidal forces (Mazda et al. 2002). The local communities are seriously concerned that big waves, strong winds and flooding of the road with seawater will leave them isolated in their residential areas. Coastal erosion has also destroyed aquaculture ponds, contributing to an increasing abandonment of aquaculture that was initiated when shrimp diseases caused the production to decline. A similar development has been reported in Thailand (Sathirathai and Barbier 2001).

Salt water intrusion into cropland is another problem that has made banana cultivation difficult (Halim 2012) due to a low tolerance to salt (Palacios et al. 2000). Such consequences are also observed elsewhere, for example, in the Mahakam Delta, East Kalimantan, where dry season saltwater intrusion

reached the city of Samarinda and contaminated the drinking water (Sidik 2008), and in the Mekong Delta in Vietnam, where the freshwater supply for 300,000 hectares of agricultural land was disrupted by salt water (Clayton and Brennan 1999).

~~The t~~Tropical marine ecosystems (e.g. mangroves and seagrass beds) are interconnected and optimal provisioning of marine resources and fishing grounds are dependent on the well-functioning of all components of the ecosystem (Unsworth et al. 2008, 2014). Seagrass beds are an important habitat for juveniles and adult fish (Unsworth et al. 2008), and carry a significant proportion of fish catch (Unsworth et al. 2014). The degradation and deforestation of mangroves is likely to have indirect consequences to reduce fish, crab and shrimp catches due to a decline in seagrass beds caused by a subsequent increase in water turbidity (from increased land surface runoff) and wave action (Kirkman and Kirkman 2002).

Consequently, household survey respondents report that most fishing has to be conducted further away as there are fewer fish in coastal areas, and this in turn leads to higher capital investment in equipment and operational costs. Over the past years, crab species of high economic value (e.g. giant mud crab (*Scylla serrata*) and blue swimmer crab (*Portunus pelagicus*)) were reported to be increasingly difficult to find and consequently many households have stopped catching crabs (Taslim 2006). KKP-Indonesia (Ministry of Marine and Fisheries of Indonesia) (2012) reported that the volume of fish capture in South Sulawesi decreased from 354,399 to 158,138 tons (55.4%) from 2003 to 2011. A similar decline in fish capture also occurred in North Sumatra and was attributed to degrading mangrove forests by local communities (Onrizal et al. 2009). In contrast, in the Mahakam Delta, there is no evidence that the productivity of fisheries has decreased due to the loss of mangrove (Sidik 2008).

Finally, household survey respondents report that the availability of shrimp and milkfish juvenile has declined, as has the stock of a number of fish species that depend on mangrove forests in South Sulawesi (Ilman et al. 2011). Unsworth et al. (2008, 2009) found seagrass meadows and mangroves to be important habitats for juvenile fish of some reef fish species by increasing the availability of shelter and food services. Hamilton and Snedaker (1984) reported that 80 % of the commercial marine biota in Florida, USA is dependent on mangrove forests. Moreover, almost 100% of shrimp and 49% of demersal fish caught in the Strait of Malacca depend on mangrove areas (Macintosh 1982). Moreover, the availability of natural shrimp or milkfish juvenile declines as mangroves disappears. Shrimp farmers ~~respondents~~ reported that it is very difficult to find enough juvenile of shrimp or milkfish in nature to

meet their needs for farming and they are therefore dependent on hatcheries. While the hatcheries produce shrimp and milkfish juvenile of high quality and have become a source income and employment in many coastal regions (Rönnbäck 2002), they also lead to increase pressure on wild brood stock or spawn and cause large amounts of bycatch that is usually discharged in the sea (Rönnbäck 2001, 2002; Primavera 2006).

Furthermore, farmers have used shrimp feed that does not meet the requirements of environmentally friendly aquaculture and this has led to outbreaks of shrimp diseases. Farmers have tried to increase production volumes using high stocking densities of juvenile shrimp and excessive feed, chemical fertilizers and pesticides. However, this can reduce the water quality and cause the growth of micro-organisms, leading to shrimp disease and directly contaminate soils, rivers and coastal habitats (~~Carno~~ Sutrisno ~~2004~~2011; Lan 2013). In addition, excessive use of chemicals may cause toxicity to non-target populations (cultured species, the human consumer, and wild biota), development of antibiotic resistance and accumulation of residues (Primavera 1998; Rönnbäck 2001). KKP-Indonesia (2012) reported increasing supplies from 2007 to 2012 of feed (2,298 to 10,749 kg), inorganic fertilizer (17,899 to 43,844 kg) and pesticides (45,200 to 298,763 kg) for the intensification of shrimp farming in South Sulawesi. In addition, Tangko and Pantjara (2007) stated that the outbreaks of WSD have not been fully overcome; 12.648 hectares of mangrove in South Sulawesi, including 210 ha in Takalar District, are still infected by the disease and the losses amount to more than IDR 9 billion (936,663 USD) in 2005. Such WSD outbreaks have caused production losses in other countries as well. In the Philippines, shrimp production dropped from 88,850 tons in 1995 to 36,859 tons in 1998; in Ecuador, from 129,600 tons in 1998 to 50,110 in 2000; and in Taiwan, from 16,715 tons in 1985 to 2,495 tons in 2001 (Fukano, 2004). The disease also affected Thailand, Indonesia, Vietnam, and Mexico (Fukano 2004).

In addition to the environmental impact, mangrove forest losses have also had socioeconomic consequences, both positive and negative. A Cost-Benefit Analysis (CBA) over a 10-year period showed that the ecological functions of mangrove that include nursery grounds, protection from abrasion, prevention of seawater intrusion, and carbon sequestration gave far higher Net Present Value (NPV) than aquaculture production that even had a negative NPV when environmental costs such as water pollution, forest rehabilitation and social cost were included (Malik et al. 2015a). Furthermore, during 2003-2011

the loss of mangroves caused an average loss of fish catch in South Sulawesi of 1,211 tons per year (KKP-Indonesia 2012).

This low income from fish capture and the period of rest due to unfavourable weather conditions for several months in this area have forced many fishermen to seek alternative livelihoods such as engaging in commercial logging and/or becoming shrimp or seaweed farmers. Statistical data from Takalar District gathered by the BPS-Kab. Takalar 2007-2012, the use of labourers in shrimp farming and seaweed farming increased by 1,585 people (from 4,515 people to 6,100 people corresponding to an annual average growth of 8.7%) and 5,541 people (from 3,352 people to 8,893 people corresponding to an annual average growth of 31%), respectively. The majority of shrimp and seaweed labourers only have an elementary school education and they have limited knowledge of the environment and aquaculture techniques. Knowledge about running an aquaculture business is obtained by copying other businesses as labourers often work in a business only until they have enough experience to open their own business (Restoring Coastal Livelihoods ~~Sonjaya~~ 2011). The new livelihood strategies (shrimp and seaweed farmers) have increased the average income per month compared to that of fishermen (based on the household survey), but with the shrimp diseases and a fragile coastal environment caused by aquaculture, the new livelihoods could be a risky strategy compared to the lower, but more stable income from mangrove resources.

Change back to the traditional system is not likely to occur as the expansion of shrimp ponds and the widespread culture of seaweed provide important export commodities for the economy of South Sulawesi. Between 2006 and 2011, the production of shrimp increased by about 7,510 tons (annual average growth of 11.24%) despite slight decreases in 2009 and 2011 due to WSD, and seaweed production increased by 1,073,084 tons (an annual average growth of 30%). Despite production increases, the volume of shrimp exports decreased by about 1,267 tons, but the value increased by USD 9,085,000 (from USD 33,322,000 to USD 42,407,000) as market prices increased. The volume of seaweed export increased by about 46,895 tons between 2009 and 2011 with an increase in export value of USD 22,934,000 (from USD 56,953,000 to USD 79,887,000) (BPS-Prop. Sulawesi Selatan 2007-2012). This makes South Sulawesi the third largest shrimp producer in Indonesia after Lampung and South Sumatra, and the largest seaweed producer in the country (BPS-Prop. Sulawesi Selatan 2007-2012; KKP-Indonesia

2012). Consequently, the South Sulawesi authorities are not likely to discourage further expansion of aquaculture as it remains crucial for the provincial economy.

6. Conclusions

This case study describes mangrove forest losses and related environmental and socioeconomic consequences in the Takalar District, South Sulawesi. Coastal communities in this region utilized mangrove forests as source of firewood, charcoal production, commercial logging and nipa palm (which is used as a roofing material and the crafting of hats and other handmade items). Mangrove forests have also been cleared and impounded for aquaculture, principally shrimp and seaweed farming. High dependency on and unsustainable utilization of mangrove forests, coupled with the profit orientation of communities, has led to rapid mangrove losses. Government shrimp production targets and credit extended by governments to farmers to expand shrimp ponds and intensify farming have also played role in mangrove change and associated impacts.

An analysis satellite images the Takalar District reveal that two thirds (3,344 ha) of the mangrove biome in the region was deforested or severely degraded during 1979-2011, mainly due to conversion to shrimp ponds. The largest annual change was found to occur during the period from 1979 to 1996 and took place primarily in Tanakeke Island and Banyuanyara Village. The rate of expansion of shrimp ponds, however, has decreased since 2000 due to WSD, which has caused several shrimp pond harvest failures and economic losses. Captive fisheries production (fish, crab and shrimp) has declined concomitant with mangrove degradation and loss. Mangrove losses have been associated with coastal erosion and saltwater intrusion and also caused a decline in the annual production of fisheries in some regions. Declining stocks of shrimps and milkfish juvenile force shrimp farmers to buy these from hatcheries, and water pollution and outbreaks of shrimp disease threaten shrimp production.

Household surveys conducted in the study area indicate that the expansion of shrimp and seaweed farming has created new alternative employment possibilities and the shift in fishermen's livelihood to shrimp and seaweed farming has brought a significant increase in income, although the sustainability of this income is uncertain.

This study should contribute to the understanding of mangrove changes globally and, in particular, in Indonesia, which has the largest area of mangrove forest in the world. More information is

needed to assess the long-term ecological and socio-economic consequences of mangrove forest conversion to aquaculture.

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References

Aksornkoae S (1993) Ecology and management of mangroves. IUCN, Bangkok, Thailand

Alifuddin M, Dana D, Eidman M, Malole MB, and Pasaribu FH (2003) White Spot Disease in Black Tiger Shrimp (Penaeus Monodon Fab.): Infection of White Spot Virus at 20, 100 and 200 uG/Ml by Dipping Method within 120 Minutes Exposure TimePenyakit white SPOT pada udang windu (Penaeus monodon FAB.): Penularan melalui perendaman dengan virus white spot 20, 100 dan 200 µg/ml dengan waktu ekspos 120 menit. Jurnal Akuakultur Indonesia 2 (1): 31-35.

Anderson JR, Hardy EE, Roach JT, and Witmer RE (1976) A land use and land cover classification system for use with remote sensor data. U.S. Geol. Survey Prof. Paper 964, 28 p(Vol. 964) US Government Printing Office.

Bailey C (1988) The social consequences of tropical shrimp mariculture development. Ocean Shoreline Manage 11 (1): 31-44. doi:10.1016/0951-8312(88)90004-5

Bakosurtanal (1999) Peta rupa bumi Indonesia. http://www.bakosurtanal.go.id/peta-rupabumi/. Accessed 13 March 2013

Barbier and Cox (2002) Economic and demographic factors affecting mangrove loss in the coastal provinces of Thailand, 1979–1996. Ambio: 31(4): 351-357

Béland M, Goïta K, Bonn F, Pham TTH (2006) Assessment of land-cover changes related to shrimp aquaculture using remote sensing data: a case study in the GiaoThuy District, Vietnam. Int J Remote Sens 27: (8), 1491-1510

BPS-Kab.Takalar (2007 – 2012) Kabupaten Takalar dalam angka 2007-2012. Badan Pusat Statistik (BPS) Kabupaten Takalar, Takalar. Available in: http://takalarkab.bps.go.id/frontend/

BPS-Kab.Takalar (2012, Agustus) Kabupaten Takalar dalam angka 2012. Badan Pusat Statistik (BPS) Kabupaten Takalar, Takalar. Available in: http://takalarkab.bps.go.id/frontend/

Formatted: English (United States)

Formatted: English (United States)

BPS-Prop. Sulawesi Selatan (2007 – 2012) Sulawesi Selatan dalam angka 2007-2012. Badan Pusat Statistik (BPS) Propinsi Sulawesi Selatan, Sulawesi Selatan. Available in: http://sulsel.bps.go.id/

Clayton H and Brennan DC (1999, January) A review of economic issues for sustainable shrimp farming in the Mekong Delta, Vietnam. In 1999 Conference ~~paper presented at the~~ (43th), January 20-22, 1999, Christchurch, New Zaeland (No. 123794) ~~Annual Conference of the~~ Australian Agriculturale and Resource Economics Society
~~, Christ church, New Zaeland, 20-22 January 1999~~

Congalton RG (1991) A review of assessing the accuracy of classifications of remotely sensed data, Remote Sens Environ 37: 35–46

Crockford M (~~2001~~2008) White Spot Disease. Australia and New Zealand Standard Diagnostic Procedures, 1-~~16~~13. ~~Department of Fisheries c/o Department of Agriculture and Food, South Perth~~

Dahuri R (2003) Keanekaragaman ~~Hayati~~ hayati ~~Lautlaut~~ ~~:~~ ~~Aset~~ aset ~~Pembangunan~~ pembangunan ~~Berkelanjutan~~ berkelanjutan Indonesia. Gramedia Pustaka Utama, Jakarta

Donato DC, Kauffman JB, Murdiyarso D, Kurnianto S, Stidham M, and Kannien M (2011) Mangroves among the most carbon-rich forests in the tropics. Nat Geosci 4, 293–297. doi: 10.1038/ngeo1123
Duke NC, Meynecke JO, Dittmann S, Ellison AM, Anger K, Berger U, Cannicci S, Diele K, Ewel KC, Field CD, Koedam N, Lee SY, Marchand C, Nordhaus I, Dahdouh-Guebas F (2007) A world without mangroves? Science, 317 (5834), 41-42

Emch M and Peterson M (2006) Mangrove forest cover change in the Bangladesh Sundarbans from 1990-2000: A remote sensing approach. Geocarto Int 21, 5-12

FAO (2007) The world's mangroves 1980 – 2005. Food and Agriculture Organization of the United Nations, ~~.~~ Rome

FAO (2011) The state of fisheries and aquaculture. Food and Agriculture Organization of the United Nations, ~~.~~ Rome

Fast A~~W~~ (1992) Penaeid extensive growout systems. ~~In: Fast AW and Lester LJ (Eds) Marine shrimp culture: principle and practices. Elsevier, pp 355-368. doi: 10.1016/B978-0-444-88606-4.50002-3~~Developments in aquaculture and fisheries science, 23, 355-368

Foody GM (2002) Status of land cover classification accuracy assessment. Remote Sens Environ 80, 185–201. doi: 10.1016/S0034-4257(01)00295-4

Fukano N (2004) A trend analysis of world shrimp aquaculture. J Int Fish 6, 1-2: ~~43-54~~

~~Garno YS (2004) Pengembangan budidaya udang dan potensi pencemarannya pada perairan pesisir. Teknik Lingkungan P3TL BPPT 5(3): 187-192~~Ghufran ~~M~~HKK (2012) Ekosistem mangrove: potensi, fungsi, dan pengelolaan. Rineka Cipta, Jakarta

Giesen W, Baltzer M and Baruadi R (1991) Integrating conservation with land-use development in wetlands of South Sulawesi. ~~PHPA/AWB, Bogor~~
Integrating conservation with land-use development in wetlands of south Sulawesi.

Giesen W, Wulffraat S, Zieren M, and Scholten L (2007) Mangrove guidebook for Southeast Asia. ~~Food and Agriculture Organization, Bangkok~~FAO Regional Office for Asia and the Pacific

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Giri C, Pengra B, Zhu Z, Singh A, Tieszen LL (2007) Monitoring mangrove forest dynamics of the Sundarbans in Bangladesh and India using multi-temporal satellite data from 1973 to 2000. Estua Coast Shelf S 73, 91-100. doi:10.1016/j.ecss.2006.12.019

~~GlobeFish (2001) Food market: Shrimp production. http://www.globefish.org. Accessed 5 May 2013~~

Hajramurni A (2010) Abrasion speed in Takalar hit 100 meters a year, The Jakarta Post. Tuesday, April 27 2010, 7:16 PM, http://www.thejakartapost.com/news/%202010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html. ~~http://www.thejakartapost.com/news/ 2010/04/27/abrasion-speed-takalar-hits-100-meters-a-year.html.~~ Accessed 13 March 2013

Halim A (2012) Kerusakan mangrove memiskinkan warga. http://sains.kompas.com/read/2012/11/23/03510427/.Kerusakan.Mangrove.Memiskinkan.Warga. ~~, Jumat, 23 November 2012.~~ Accessed 13 March 2013

Hamilton LS ~~and~~ & Snedaker SC (eds) (1984) Handbook for mangrove area management. ~~East West Environment and Policy Institute, Honolulu~~UNEP and East West Centre, Hawai

~~Hong PN and Dao QTQ(2004) Environmental impacts of shrimp culture in the mangrove areas of Vietnam. Annual Report of FY 2003, The Core University Program between Japan Society for the Promotion of Science and National Centre for Natural Science and Technology, pp.195-203~~

Ilman M, ~~Iwan TCW~~Wibisono ITC, and Suryadiputra INN (2011) State of the art information on mangrove ecosystem in Indonesia. Wetland International-Indonesia Programme. Bogor.

Kirkman H and Kirkman JA (2002) The management of seagrasses in Southeast Asia. B Mar Sci 71 (3): 1379–1390

KKP-Indonesia (2012) ~~Statistical data of marine and fisheries~~Sistem informasi diseminasi data statistik kelautan dan perikanan kementerian kelautan dan perikanan. Available in: http://statistik.kkp.go.id/new_sidatik/index.php/guest/buku_statistik. ~~http://statistik.kkp.go.id/.~~ Accessed 1 March 2013

Lan NTP (2013) Social and ecological challenges of market-oriented shrimp farming in Vietnam. SpringerPlus (2): 675. doi: 10.1186/2193-1801-2-675

Lillesand TM, Kiefer RW, and Chipman JW (2008) Digital image Interpretation and analysis. Remote sensing and image interpretation, 6, 545-581th ~~edn~~. Wiley, New York

Long JB and Giri C (2011) Mapping the Philippines' mangrove forests using Landsat imagery. Sensor 11 (3): 2972-2981. doi: 10.3390/s110302972

Macintosh D~~J~~ (1982) Fisheries and aquaculture significance of mangrove swamps, with special reference to the Indo-West Pacific region. ~~In: Muir JF and Roberts RJ (Eds)~~ Recent Advances in Aquaculture, 4-85~~. Croom Helm, London, pp. 3-85~~.

Manassrisuksi K, M Weir ~~M~~ and YA Hussin ~~YA~~ (2001) Assessment of mangrove rehabilitation programme~~r~~ using remote sensing and GIS: A case study of Amphur Khlung, Chantaburi Province, Eastern Thailand. ~~Conference paper at the~~ 22nd Asian Conference on Remote Sensing , Singapore 5 – 9 November 2001~~, Singapore~~ Available in: http://www.crisp.nus.edu.sg/~acrs2001/pdf/019manas.pdf

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Malik A, Fensholt R, Mertz O (2015a) Economic valuation of mangroves for comparison with commercial aquaculture in South Sulawesi, Indonesia. Forests 6(9): 3028–304. doi: 10.3390/f6093028

Malik A, Fensholt R, Mertz O (2015b) Mangrove exploitation effects on biodiversity and ecosystem services. Biodivers Conserv 24: 3543-3557. doi: 10.1007/s10531-015-1015-4

Masda Y, Magi M, Nanao H, Kogo M, Miyagi T, Kanzawa N and Kobashi D (2002) Coastal erosion due to long –term human impact on mangrove forests. Wetl Ecol Manag 10: 1-9

Millennium Ecosystem Assessment (MA) (2005) Ecosystem and human well-being: Synthesis. Island Press, Washington DC. Available in: http://www.millenniumassessment.org/documents/document.356.aspx.pdf

Murdiyarso D, Donato D, Kauffman JB, Kurnianto S, Stidham M, and Kanninen M (~~2009~~2010) Carbon storage in mangrove and peat~~-~~land ecosystems: A preliminary account from plots in Indonesia. Working paper 48. CIFOR, Bogor. doi: 10.17528/cifor/003233

Murdiyarso D, Purbopuspito J, Kauffman JB, Warren M, Sasmito S, Donato D, Manuri S, Krisnawati H, Taberima S, and Kurnianto S (2015) The potential of Indonesian mangrove forests for global climate change mitigation. Nat Clim Chang 5, 1089-1092. doi: 10.1038/nclimate2734

Noor YR, M Khazali ~~M~~, and INN Suryadiputra ~~I NN~~ (2006) Panduan pengenalan mangrove di Indonesia. 2nd ed. P~~H~~KA/WI-IP (Wetlands International-Indonesia Programme), Bogor

Nurkin B (1979) Beberapa ~~Catatan~~ catatan tentang ~~Aspek~~ aspek ~~Pengusahaan~~ pengusahaan ~~Hutan~~ hutan ~~Mangrove~~ mangrove di Sulawesi Selatan. In: ~~Soemidihardjo S, Nontji A and Djamali A (eds)~~ Prosiding seminar ekosistem hutan mangrove. LON-LIPI, Jakarta

Nurkin B (1994) Degradation of Mangrove Forests in South Sulawesi, Indonesia. Hydrobiologia 285: 271-276. doi: 10.1007/BF00005673

Onrizal A. Purwoko, and Mansor M (2009) Impact of mangrove forests degradation on fisherman income and fish catch diversity in eastern coastal of North Sumatra, Indonesia. ~~Conference paper at~~ International Conference on Natural and Environmental Sciences 2009 (ICONES'09) ~~in~~ Banda Aceh, Indonesia, ~~on~~ 6-8 May 2009

Onrizal (2010) Perubahan tutupan hutan mangrove di pantai timur Sumatera Utara periode 1977 – 2006. Biologi Indonesia 6 (2): 163-172. Available in: http://www.biologi.lipi.go.id/bio_indonesia/mTemplate.php?h=30&id_publikasi_jurnal=163

Palacios MP, Haman D Z, Del-Nero E, Pardo A, Pavon N (2000) Banana production irrigated with treated effluent in the Canary Islands. Transaction of the ~~American Society of Agricultural Engineers~~ ASAE 43(2): 309-314

Patton M Q (1990) Qualitative evaluation and research methods. ~~Sage~~SAGE, ~~California~~ Publications, inc.

Phan NH and Quan TQD (2004) Environmental impacts of shrimp culture in the mangrove areas of Vietnam. Annual Report of FY 2003, The Core University Program between Japan Society for the Promotion of Science (JSPS) and National Science and Technology (NCST), 195-203

~~Purnomo A (1992) Pemilihan Lokasi Tambak Udang Berwawasan Lingkungan. Seri Pengembangan Hasil Pertanian No. PHP/ KAN/ PATEK /04/1992. 40p~~

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Primavera JH (1998) Tropical shrimp farming and its sustainability. ~~In: SS De Silva (Ed) Tropical Mariculture. Academic Press, California, pp~~Tropical Mariculture 8,~~.~~ 257-289

Primavera JH (2006) Overcoming the impacts of aquaculture on the coastal zone. Ocean Coast Manage 49: 531- 545. doi: 10.1016/j.ocecoaman.2006.06.018

Purnomo A (1992) Pemilihan Lokasi Tambak Udang Berwawasan Lingkungan. Pusat Penelitian dan Pengembangan Perikanan Badan Penelitian Pengembangan Pertanian, Jakarta.

Restoring Coastal Livelihoods (2011). Kajian Risilian [Resilience Assessment]. Situational and Contextual Field Assessment and Analysis Restoring Coastal Livelihoods Project. Prepared by Jajang Agus Sonjaya. Makassar, Indonesia.

Rönnbäck P (2001) Shrimp aquaculture - State of the art. Swedish EIA Centre, Report 1. Swedish University of Agricultural Sciences (SLU), Uppsala. ISBN 91-576-6113-8

Rönnbäck P (2002) Environmentally sustainable shrimp aquaculture. Sweden, Swedish Society ~~for Nature Conservation, 24pp.~~

Sathirathai S and Barbier EB (2001) Valuing mangrove conservation in Southern Thailand. Contemp Econ Policy 19 (2): 109-122. doi: 10.1111/j.1465-7287.2001.tb00054.x

Seto KC and Fragkias M (2007) Mangrove conversion and aquaculture development in Vietnam: A remote sensing-based approach for evaluating the Ramsar convention on wetlands. Glob Environ Chang 17, 486-500. doi: 10.1016/j.gloenvcha.2007.03.001

Sidik AS (2008) The changes of mangrove ecosystem in Mahakam Delta Indonesia: A complex social-environmental pattern of linkages in resources utilization. The South China Sea Conference Kuantan, Malaysia ~~Conference paper at The South China Sea Conference 2008, Kuantan, Malaysia~~, 25-29 November 2008

~~Sonjaya JA (2011) Kajian risilian (Situational and contextual field assessment and analysis - restoring coastal livelihood project), MAP-Indonesia~~

Sremongkontip S, Hussin YA and Groenindijk L (2000) Detecting changes in the mangrove forests of Southern Thailand using remotely sensed data and GIS. International Archives of Photogrammetry and Remote Sensing, 33 (1), 567~~SPRS Archives 8, B7, Amsterdam, pp. 569~~-574. Available in: http://www.isprs.org/proceedings/XXXIII/congress/part7/567_XXXIII-part7.pdf

Suryono CA (2006) Struktur populasi vegetasi mangrove di laguna Segara Anakan Cilacap, Jawa Tengah. Ilmu Kelautan: Indonesian Journal of Marine Sciences 11(2): 112-118

Tangko AM dan Pantjara B (2007) Dinamika pertambakan perikanan di Sulawesi Selatan kurun waktu 1990-2005. Media Akuakultur 2 (2): 118-123. Available in: http://www.sidik.litbang.kkp.go.id/index.php/searchkatalog/byId/33316

Sutrisno Y (2011) Pengembangan budidaya udang dan potensi pencemarannya pada perairan pesisir. Jurnal Teknologi 5(3): 187-192

Taslim RSA (2006) Hutan bakau pesisir Sulsel perlu direhabilitasi. http://opini-kelautan.blogspot.com/2006/08/hutan-bakau-pesisir-sulsel-perlu.html. Accessed 23 March 2015

Thampanya U, Vermaat J, Sinsakul S and Panapitukkul N (2006) Coastal erosion and mangrove progradation of Southern Thailand. Estuar Coast Shelf Sci 68 (1-2): 75–85. doi:10.1016/j.ecss.2006.01.011

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Ukkas M (2001) Pemetaan potensi/zonasi wilayah pesisir dan pulau-pulau kecil kabupaten Takalar. Laporan penelitian; Universitas Hasanuddin, Makassar

Unsworth RKF, de Leon PS, Garrard SL, Jompa J, Smith DJ and Bell JJ (2008) High connectivity of Indo-Pacific seagrass fish assemblages with mangrove and coral reef habitats. Mar Ecol Prog Ser 353: 213–24. doi: 10.3354/meps07199

Unsworth RKF, Garrard SL, de Leon PS, Cullen LC, Smith DJ, Sloman KA and Bell JJ. (2009) Structuring of Indo-Pacific fish assemblages along the mangrove-seagrass continuum. Aquat Biol 5, 85-95. doi: 10.3354/ab00139

Unsworth RKF, Hinder SL, Bodger OG, and Cullen-Unsworth LC (2014) Food supply depends on seagrass meadows in the coral triangle. Environ Res Lett 9 094005. doi:10.1088/1748-9326/9/9/094005

Valderrama D, Hishamunda N, and Zhou X (2010) Estimating employment in world aquaculture. FAO Aquaculture Newsletter 45, 24-25

Van TT, Wilson N, Thanh-Tung H, Quisthoudt K, Quang-Minh V, Xuan-Tuan L, Dahdouh-Guebas F and Koedam N (2015) Changes in mangrove vegetation area and character in a war and land use change affected region of Vietnam (Mui Ca Mau) over six decades. Acta Oecol 63: 71-81

Wang Y, Bonynge G, Nugranad J, Traber M, Ngusaru A, Tobey J, Hale L, Bowen R, and Makota V (2003) Remote sensing of mangrove change along the Tanzania coast. Mar Geod 26: 35-48. doi: 10.1080/01490410306708

To editor (Dr. Virginia Burkett):

We would like to sincerely thank to you for this constructive and thorough second round of feedback provided. We have implemented all these suggestions in the revised version - thanks again for your enthusiasm in this process, very much appreciated!

- Page 2, Line 21 – for subject/verb agreement, change "produces" to "produce"

  Response: We have changed it.

- Page 2, Line 36 – insert a comma before the words "according to available data"

  Response: We have inserted it.

- Page 2, Line 42 – a decrease from 500,000 hectares of forest to 256,185 is roughly a 50% decrease not a 100% decrease.

  Response: Thanks, you right, we have changed to roughly a 50%.

- Page 5, Line 17 – the precise number may have been 272,316 in 2012 but it is no doubt different today. Please insert in the sentence the date that the population was reported to be 272,316 in the source document (BPS-Kab.)

  Response: We have inserted the date in the source document (BPS Kab. Takalar 2012, Agustus)

- Page 5, Line 27 – insert period at end of sentence

  Response: We have inserted the period.

- Page 6 footnote – italicize both genus and species, capitalize only the genus as follows: Nypa fruticans

  Response: We have italicized both genus and species and capitalized only the genus.

- Page 7, Line 42 – the authors have not addressed the problem with this sentence, which still states that mangrove losses were in the highest density mangrove class and the loss was "approximately 1.812 hectares during 2006-2011". The decimal place or the total number must be wrong. How can this class have decreased the most when only 1.8 hectares was actually lost?

  Response:

  You right, the decimal or the total number was wrong. We have corrected the number to 1,812 hectares as mentioned on Table 3.

- Page 8, line 24 – river should be capitalized in “Papa river”

  Response: We have capitalized the word of ‘river’ in Papa river

- Page 8, line 38 – please insert the word “with” between the words “associated replanting”

  Response: We have inserted “with” between the words.

- Page 9, Line 50 - The Abstract states that mangrove forests were reduced by 66.05% (3,344 hectares) during 1979-2011, but this line states that 77.54% of the total mangrove forests were converted to shrimp farms. On page 11, lines 31-33, you state that 77.54% of the total mangrove forest losses were associated with conversion to aquaculture ponds. Please correct Line 50 on page 9 to state that “77.54% of the loss of mangrove forests were associated with aquaculture development.”

  Response: Maybe you meant line 50 on page 8, not page 9. We have revised this.

- Page 9, line 38 – this line is still not clear. Don’t you mean five bundles per month per harvester (not harvest)? The next sentence implies that you are talking about individual people (harvesters).

  Response: Yes, you right, per harvester. We have revised it.

- Page 9, line 52 – were hats sold to more than one “trader”? If there was only one trader, please ignore this comment.

  Response: Yes, we have revised it.

- Page 10, line 25 – this part does not make sense: “income source where has conducted in the coastal area”.

  Response: We have deleted the sentence.

- Page 11, line 17 – suggest changing “this has become” to “cultured shrimp have become”

  Response: Thanks, we have changed accordingly.

- Page 13, Line 5 – suggest deleting “The” at the beginning of the sentence.

  Response: Thanks, we have deleted it.

- Page 13, Line 56 – suggest deleting the word “respondents” in this phrase, “shrimp farmer respondents reported, since it is assumed that the observation was from your household surveys.

  Response: Thanks, we have deleted it.

- Page 14, Line 13 – need to insert the word “shrimp” after the word “juvenile”

  Response: We have inserted the word.

- Page 14-line 31 – sentence gives a precise statistic 12,648 hectare of mangrove infected by the disease as if it were a current statistic. Provide date of the observation of the 12,648 hectare of mangrove infected in the sentence (it looks like it was around 2007, which is the date of the source document).

  Response: No, it was year 2005. We have provided date of the observation in the sentence.

FW: REEC: Submission Confirmation for REEC-D-15-00193R2

Abdul Malik

Wed 5/4/2016 4:58 PM

Sent Items

To: Rasmus Fensholt <rf@ign.ku.dk>; Ole Mertz <om@ign.ku.dk>;

1 attachments (2 MB)

REEC-D-15-00193_R2.pdf;

Dear Rasmus and Ole

I just let you know that the manuscript has re-submitted to the REEC journal (attached the manuscript).
Hopefully the manuscript is accepted for publication.

Best wishes,
Malik

From: em.reec.0.4af32d.f3bb87fa@editorialmanager.com [em.reec.0.4af32d.f3bb87fa@editorialmanager.com] on behalf of Editorial Office [em@editorialmanager.com]
Sent: Wednesday, May 04, 2016 4:46 PM
To: Abdul Malik
Subject: REEC: Submission Confirmation for REEC-D-15-00193R2

Ref.: Ms. No. REEC-D-15-00193R2
Mangrove forest decline: Consequences for livelihoods and environment in South Sulawesi

Dear Dr. Malik,

Regional Environmental Change has received your revised submission.

You may check the status of your manuscript by logging onto Editorial Manager at http://reec.edmgr.com/.

Kind regards,

Editorial Office
Regional Environmental Change

RE: Proofs for your article in Regional Environmental Change (989)

Rasmus Fensholt

Tue 5/24/2016 3:14 PM

Inbox

To:Abdul Malik <malik@ign.ku.dk>;

Cc:Ole Mertz <om@ign.ku.dk>;

Dear Malik,
I have gone through the queries (including query No5) and everything should be fine by now. So please go ahead and submit these (under the "online correction" pane).

Best wishes
Rasmus

-----Original Message-----
From: Abdul Malik
Sent: 24 May 2016 14:37
To: Rasmus Fensholt
Cc: Ole Mertz
Subject: RE: Proofs for your article in Regional Environmental Change (989)

Dear Rasmus

I have nearly answered all of the queries including attached a new version of figure 1 (just left the AQ5).
Please email me back if you have answered the AQ5 and checked other.

best regards,

Malik

From: Rasmus Fensholt
Sent: Monday, May 23, 2016 8:03 PM
To: Abdul Malik
Cc: Ole Mertz
Subject: Re: Proofs for your article in Regional Environmental Change (989)

Dear Malik,
Please read through the manuscript version given by the link and make sure that figures are located in the appropriate places and that the manuscript generally appears as you expect it.
The journal correction team has come across 9 issues to be addressed by you/us. Please go through these and correct them using the online tool (most are hopefully easily done - relates to references used I can see). If there are queries where you are not sure what/how to respond just let me know and I will have a look at it tomorrow (Tuesday). They operate with a tight deadline to get it published ASAP, hopefully you have time to look at it soon.

Best wishes
Rasmus

> Den 23. maj 2016 kl. 17.16 skrev Abdul Malik <malik@ign.ku.dk>:
>
> Dear Rasmus and Ole
>
> Below is email from REEC regarding Article proofs of our manuscript.

> Please put your corrections by this link:
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> Best regards,
> Malik
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> _____
> From: spr_corrections@sps.co.in [spr_corrections@sps.co.in]
> Sent: Monday, May 23, 2016 2:45 PM
> To: Abdul Malik
> Subject: Proofs for your article in Regional Environmental Change (
> 989)
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> Article Title: Mangrove forest decline: consequences for livelihoods
> and environment in South Sulawesi
> DOI: 10.1007/s10113-016-0989-0
> REEC-D-15-00193.2
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FW: REEC: Your manuscript entitled Mangrove forest decline: Consequences for livelihoods and environment in South Sulawesi

Abdul Malik

Mon 5/16/2016 6:22 PM

Sent Items

To:Rasmus Fensholt <rf@ign.ku.dk>; Ole Mertz <om@ign.ku.dk>;

Dear Rasmus and Ole

I just forwarded email from REEC that mentioned our manuscript has been accepted.
I am so happy with this and I would like to say thank you so much for your working, guidance and contribution for this achievement.

Best regards,

Malik

From: em.reec.0.4b32d2.55430210@editorialmanager.com [em.reec.0.4b32d2.55430210@editorialmanager.com] on behalf of Editorial Office [em@editorialmanager.com]
Sent: Monday, May 16, 2016 12:20 AM
To: Abdul Malik
Subject: REEC: Your manuscript entitled Mangrove forest decline: Consequences for livelihoods and environment in South Sulawesi

CC: virginia_burkett@usgs.gov

Ref.: Ms. No. REEC-D-15-00193R2
Mangrove forest decline: Consequences for livelihoods and environment in South Sulawesi
Regional Environmental Change

Dear Dr. Malik,

our handling editor Dr Virginia Burkett now recommends acceptance of your paper and I am pleased to follow her recommendation.

You will be contacted by a representative of our publisher concerning copyright transfer agreements and page proofs later in the production process. Please contact the editorial office if you have questions or need more information in the interim.

Thank you for submitting your work to Regional Environmental Change.

With kind regards,

Wolfgang Cramer
Editor-in-Chief
Regional Environmental Change
Reviewers' comments:

RE: Your article in Regional Environmental Change (989): Information Required

Ole Mertz

Wed 5/18/2016 6:06 PM

Inbox

To: Abdul Malik <malik@ign.ku.dk>; Rasmus Fensholt <rf@ign.ku.dk>;

Dear Malik

You just say no to the first 4 bullets - these are all expensive to say yes to ☺

You say yes to the last bullet about transfer of copyright and do this on behalf of all of us.

Best regards
Ole

From: Abdul Malik
Sent: 18. maj 2016 17:23
To: Rasmus Fensholt
Cc: Ole Mertz
Subject: FW: Your article in Regional Environmental Change (989): Information Required

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