Project Reference Number: ARCP2012-22NSG-Prayitno

Scoping Workshop to Develop Proposal: Vulnerability Assessment of Mangrove Biodiversity to Climate Change in Southeast Asia

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Final Report submitted to APN

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OVERVIEW OF PROJECT WORK AND OUTCOMES

Non-technical summary

A scoping workshop on vulnerability assessment of mangrove biodiversity to climate change in Southeast Asia was conducted in Denpasar, Bali, Indonesia from 23-26 September 2012. The workshop was intended to gather information among collaborators from Indonesia, Philippines and Malaysia to further improve the research framework and methodologies of the full proposal to be submitted to APN in 2013 Annual Calls for Proposals under the ARCP Programme. The main activity of the proposed research is the assessment of mangrove ecosystem sensitivity and adaptability to climate change in Southeast Asia. This will be conducted by studying past and current biodiversity status in selected sites in Indonesia and Philippines, and gathering data on climate change factors such as sea-level rise, temperature, precipitation and CO_2 concentration and their scenarios for 40 years based on available regional climate models. Furthermore, impacts of climate change on the sustainability of fish production in selected mangroves ecosystems will be investigated through historical data collection. Finally, socio-economic dependency on the sustainability of fish poduction in mangrove ecosystems will also be analysed. This scoping workshop was followed by a final workshop in Bali attended by Indonesian collaborators to finalize the proposal. Results of the proposed study will help decision makers in formulating climate change adaptation strategies for maintaining mangrove ecosystems biodiversity and sustainability of fish production.

Keywords

Climate change, mangrove, mangrove biodiversity, fish production

Objectives

The main objectives of the project were:

1. To gather information on what have been studied on mangrove biodiversity and on the impact of climate change to mangrove ecosystem in Southeast Asia
2. To formulate the best methodologies to further study the impacts of climate change on mangrove biodiversity and fish production in Southeast Asia based on data and resources availability.
3. To develop a proposal to assess the vulnerability of mangrove biodiversity to climate change in Southeast Asia.

Amount received and number years supported

The Grant awarded to this project was:
US$ 15,000 for Year 1: 2013

Activity undertaken

1. Meetings among collaborators within country: two small meetings were held in Jakarta for Indonesian participants on 23 August 2012 and 7 September 2013 to discuss data availability and methodologies on fisheries production and remote sensing in mangroves.
2. First Scoping Workshop of Collaborators in Bali Indonesia, 23-26 September 2012: The aims of this workshop were to introduce and get to know prospective collaborators and their expertise for the proposed project among; to share information, experience and knowledge among collaborators in order to identify the impact of climate change on mangrove ecosystem in the region and the appropriate methodology to study it; to discuss the role of each collaborator in preparing the proposal and during project implementation; and to identify prospective study sites in two countries (Indonesia and Philippines) with particular consideration on the availability of climate and biodiversity data for the sites, the availability

of resources and appropriate methodologies to be used.

3. Site Visit: A site visit to mangrove ecosystem in Bali Indonesia was conducted on 26 September 2012. The visit was intended to give collaborators direct visualization of mangrove forests and to stimulate exchange of knowledge and experience among collaborators.
4. Final Scoping Workshop in Bali Indonesia, 18-20 February 2013: The final workshop was attended by Indonesia collaborators to refine and further develop draft proposal. The final proposal was produced after the final workshop and after discussions with collaborators from Malaysia and the Philippines via email.

Results

Major outputs of this project was the production of a proposal titled 'Vulnerability Assessment of Mangrove Ecosystem to Climate Change in Southeast Asia' to be submitted to APN's Call for Proposal 2013. The outline of the proposed activities in the proposal includes kick-off meeting, scenario development, assessment of mangrove ecosystem sensitivity and adaptability to climate change, vulnerability assessment of mangrove-ecosystem dependent communities/sector and final workshop for sharing results and policy recommendations. The proposed study site will be in Segara Anakan, Central Java, Indonesia and Aurora Province in the Philippines.

Relevance to the APN Goals, Science Agenda and to Policy Processes

The Scoping Workshop is relevant to the APN Science agenda of both goal 1, 2 and 3 i.e., supporting regional cooperation by involving three Southeast Asia countries to conduct research on global change impact on mangrove biodiversity in the region and adaptation strategies for its sustainability. It will contribute significantly to the APN Scientific Agenda on climate change and biodiversity, and for making policy recommendations in the Southeast Asia context.

The Scoping Workshop produced a proposal that assess the vulnerability of mangrove biodiversity to climate change in Southeast Asia. There are sizeable mangrove forests along coastlines of Southeast Asian countries that are vulnerable to climate change. Mangrove forests are not only ecologically important for biodiversity sustainability but also have socioeconomic dimensions for humankind. The mangrove forests in Malaysia, Indonesia, and the Philippines are shrinking at an alarming rate due to a combination of natural causes and human exploitation. This in turn has reduced marine productivity in terms of fish, shrimp, crab and many other marine lives. Climate Change impact aggravated this shrinking in the Southeast Asian mangroves. By producing a proposal to address this issue, efforts have been made to understand mangrove vulnerability to climate change in Southeast Asia, which help develop future scenarios for adaptation of mangrove ecosystem.

Self evaluation

The Scoping Workshop allowed all collaborators involved actively in the process of developing the proposal and understood on how the whole proposed project was broken down into sub-tasks such as climate change scenario, mangrove biodiversity, fisheries production and socio-economic status of the community. The workshop also ensure that the tasks in the proposal was allocated according to the strengths of each team member, and that all team members understood that their own part would contribute to the group's success. Although not all team members listed in the proposal attended the workshop, all members were clear about the time frame and their own responsibilities. track.

Potential for further work

Results of this Scoping Workshop provide current information on climate change and mangrove biodiversity and can be a basis for studying the vulnerability of mangrove biodiversity to climate change in Southeast Asia. They also can be used to study mangrove ecology, fisheries production and socio-economic aspects of coastal zone in the region.

Publications

Garcia K, J Prayitno and KF Kwan. 2012. Vulnerability Assessment of Mangrove Ecosystems to Climate Change in Southeast Asia. Poster session presented at First National Conference on Research in Climate Change and Variability, 27 Sept 2012, Manila, Philippines. http://www.apn-gcr.org/ resources/items/show/1761.

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TECHNICAL REPORT

Preface

Climate change has impacts on ecosystems and human life. As part of coastal ecosystems, mangroves are threatened by climate change because of their location at the land-sea margin and because of economic and social pressures. This report describes activities of a scoping workshop to develop a proposal to be submitted to APN's Annual Call for Proposal in 2013. The proposal is aimed to study the vulnerability of mangrove biodiversity to climate change and its impact on fish production and socio-economy status of local people. This scoping workshop and the proposal involved institutions from Indonesia, Malaysia and the Philippines.

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1.0 Introduction

Southeast Asia (SEA) harbours 35% of the world's total mangroves on earth (Giri et al., 2011). Mangroves are unique ecosystems found in estuaries, sheltered bays and coastlines within tidal areas. Mangrove ecosystems are host to various kinds of marine organisms such as fishes, crabs, zooplanktons and phytoplanktons. SEA's mangroves are the most species-diverse in the world with 52 species endemic to SEA's mangrove habitat including 42 trees and shrubs (Giesen et al., 2007). Other important functions of mangroves include protecting coastal area from abrasion, storm surge and tsunamis (McLeod and Salm, 2006). Because of their significant role, conservation of mangrove is vital to socio-economic development including sustainable fish production.

Being located in archipelago countries, mangroves in SEA are vulnerable to sea-level rise and ocean warming resulted from climate change. Sea-level rise and ocean warming affect mangrove biodiversity and fishery sectors (Gilman et al., 2008), although the scale of this has yet to be determined. Increase in sea level will lead to inundation of mangroves and reduce available areas for recruitment of associated fauna that have fisheries value (Boquiren et al., 2010). Increase of sea surface temperature will affect most of the fisheries target species through disruption in timing of reproduction and decrease in reproductive output, leading to changes in fisheries productivity (Boquiren et al., 2010). As a consequence, climate change may also have impacts on socio-economic of local people living close to mangrove ecosystems.

Studies on the impacts of climate change on mangrove ecosystems have been conducted in SEA region (PEACE, 2007; Boquiren et al., 2010), however its impact on the sustainability of fish production is not known. Further studies are needed to assess the past and current level of biodiversity on

important species of mangrove plants and fishes in Southeast Asia in response to climate change. Before such studies can be initiated, identifications of data availability, appropriate methodology used and available resources needs to be established in advance. Therefore, a scoping workshop is required to allow a research team consisting of experts from various related fields to discuss and develop approaches to address the problems.

The aims of this scoping workshop were to gather information on what have been studied so far and to formulate the best methodologies to further study the vulnerability of mangrove biodiversity and fish production in surrounding areas to climate change in SEA region. Outputs of this scoping workshop will help the research team to develop the full proposal to assess the vulnerability of mangrove biodiversity to climate change in the region in terms of habitat sensitivity, biodiversity and sustainability of fish production.

2.0 Methodology

The Scoping Workshop involved literature review, sharing information by presentation and discussion during the meeting, and site visit to mangrove forest near Denpasar, Bali. Topics presented in the workshop included current climate change issues and climate change projection over southeast Asia, mangrove biodiversity, fish production in mangrove, application of remote sensing for mangrove and fisheries, and proposal development. A site visit to mangrove ecosystem in Bali Indonesia was conducted to allow direct visualisation of mangrove ecosystem while promoting discussion on site for exchange of knowledge and experience among collaborators. After site visit, a meeting was held to discuss the methodology to be used, the availability of data and resources, and study site for the proposed activity. Further development of the proposal was conducted after the workshop by discussion via email, and during the final meeting in Bali among Indonesian collaborators.

3.0 Results & Discussion

3.1 Pre-Workshop meeting

As part of Project activities, two meetings among Indonesian participants were held in Jakarta in August and September 2012 before the scoping workshop to discuss the topics to be included in the proposal and the preparation for the scoping workshop. The first meeting in BPPT Jakarta on 23 August 2012 was attended by 4 participants (Dr. Joko Prayitno, Dr. Titin Handayani, Ms. Titiresmi and Prof. Asikin) to discuss data availability and research methodology on fish production at particular mangrove site in Indonesia. Prof. Asikin and his colleauges had conducted a series of experiments on fish biodiversity in mangrove from 1979 - 2012 in three different locations, i.e. Pari Island in Jakarta Bay, Musi Banyuasin in South Sumatera, and Mahakam Delta in East Kalimantan. Fishes were catched using nets and their abundance in mangrove were counted based on transect method.There were some data remain unpublished and data gap on those three locations based on time series. Some available data were presented in the scoping workshop. The second meeting in LAPAN Jakarta on 7 September 2012 was attended by 7 participants from BPPT and LAPAN to discuss data and methodology on GIS, remote sensing and field data collection on mangrove species diversity and distribution.

3.2 The Scoping Workshop

The scoping workshop was held from 23-26 September 2012 in Denpasar, Bali. The workshop was attended by 13 participants including collaborators from the Philippines and Malaysia and Scientific Planning Group (SPG) members of Indonesia and Malaysia (Figure 1). The workshop was opened by Dr. Joko Prayitno Susanto, the Director of Center of Environmental Technology BPPT. At the first day of the workshop, seven topics related to proposal were presented, such as climate change, mangrove biodiversity, fish production and proposal development.

Figure 1. Participants of The Scooping Workshop at Denpasar, Bali, Indonesia, 23-26 September 2012.

The proponent of the project, Dr. Joko Prayitno, gave the background information about climate change issues and objectives of the proposal submittted to APN in 2011 titled 'Impact of Climate Change on Mangroves Biodiversity in Southeast Asia'. Problems associated with developing the proposal were also addressed such as data availability on mangrove biodiversity in the past, the correlation of climate change data with changes in mangrove biodiversity, data on fish production in mangrove area and the socio economic impacts of of changes in mangrove biodiversity to local communities.

APN proposal review and selection process

Dr. Erna S. Adiningsih, the APN SPG member of Indonesia, presented the topic about APN's Science Agenda 2010-2015, the process of proposal reviews and selections, and key indicators of strong proposal. Comments of reviewers to the original proposal submittted in 2011 (titled Impact of Climate Change on Mangroves Biodiversity in Southeast Asia) were also discussed in her presentation, including comments on general matters, methodologies and outcomes. Dr. Erna emphasized that the proposal must follow the APN's Guidelines and address the reviewer comments to increase the chance of the proposal to be selected.

Mangrove biodiversity

Mr. Komang from Mangrove Management Center Region I, Ministry of Forestry, presented topics on mangrove biodiversity in Indonesia, structure of mangrove forests, diversity of mangrove flora and fauna in Indonesia and importance of mangrove ecosystems to people (Figure 2). It had been recorded that about 101 mangrove species from 45 families and 75 genera were dispersed in islands from Sumatera to Papua. The major genera of mangrove found in Indonesia were Rhizopora, Bruguirea, Ceriops, Kandelia, Avicenia, Sonneratia and Nypah. Mr. Pat Malabrigo from University of the Philippines presented about the current status of mangrove biodiversity in the Philippines. There are 37 species of true mangroves in the Philippines belong to 13 families and 18 genera, including genera Acanthus, Avicenia, Nypha, Sonneratia, Bruguiera, and Rhizopora. The largest mangrove area was in the Palawan and Sulu islands with total area about 76,826 hectares.

Figure 2. Mr. Komang from Mangrove Management Centre Region I, Ministry of Forestry, Denpasar Bali presented about mangrove biodiversity on Scooping Workshop at Denpasar, Bali, Indonesia, 23-26 September 2012.

Application of remote sensing on mangrove biodiversity

The last speaker of the workshop, Dr. Ety Parwati from LAPAN, talked about the principle of spectral reflectance in remote sensing and the application of remote sensing for mangrove and fisheries. Spetral data for mangrove and fisheries can be obtained from low, middle and high spatial resolution satellite, as well as from aerial photography. In her presentation, Dr. Ety explained about the potential use of high resolution satellite such as Worldview-2 in studying mangrove vegetations. The Worldview-2 satellite, launched in 2009, have a multispectral sensor with several additional spectral bands not available on previous multispectral sensors for species discrimination (Tabel 1).

Dr Ety said that remote sensing applications in mangrove management came into three categories and were used for three main purposes: resource inventory, change detection, and biodiversity. Spectral data can be used to discriminate biodiversity of mangrove species, although this could be limited to a particular number of species. Previous study reported by Kamaruzzaman and Kasawani (2007) identified spectral signatures in discriminating five mangrove species (*Rhizophora apiculata*, *Brugiuera cylindrica*, *Avicennia alba*, *Heritiera littoralis* and *Hibiscus tiliaceus*) at two different locations. Those mangrove species were discriminated according their unique spectral reflectance in the visible and near infrared region into four bandspectra which were in the blue (400 -500 nm), green (500 - 600 nm), red (600 -700 nm) and near infrared (700 - 800 nm) regions (Figure 3). However, these spectral signatures were also influenced by several factors such as cloud cover changes, atmospheric condition, leaf internal structure and chlorophyll content. This study implies that individual mangrove species can be identified and mapped with a narrow contiguous wavelength bands in the green and near infra red region.

Another study highlighted the hyperspectral characteristics of leaf surfaces of four prominent tropical mangrove species, *Avicennia alba*, *Avicennia marina*, *Rhizophora mucronata* and *Sonneratia caseolaris*, found in the tidal forests of India using a field spectroradiometer (Sushma et al., 2012). This study confirmed that unique spectral signatures of the four species were attributed to their unique leaf properties.

Furthermore, to obtain a higher separation for discriminating mangrove species, the spectral data used should be from high resolution satellite, although spectral data from moderate resolution satellite could also be used. The choice of resolution on medium-resolution imagery for mangrove mapping was depend on its benefits and limitations as shown in Table 2. In addition to spectral data from satellite, spectral data from aerial photograph could also be used for studies on

mangrove biodiversity. Benefits and limitations of aerial photography for mangrove mapping is shown in Table 3.

Table 1. Spectral characteristics of satellite WorldView 2

Spectrum	Characteristics
Coastal Blue (400-450 nm)	- New band - Absorbed by chlorophyll in healthy plants and aids in conducting vegetative analysis - Least absorbed by water, very useful in bathymetric studies - Substantially influenced by atmospheric scattering and has the potential to improve atmospheric correction techniques
Blue (450-510 nm)	- Identical to QuickBird - Readily absorbed by chlorophyll in plants - Provides good penetration of water - Less affected by atmospheric scattering and absorption compared to the Coastal Blue band
Green (510-580 nm)	- Narrower than the green band on QuickBird - Able to focus more precisely on the peak reflectance of healthy vegetation - Ideal for calculating plant vigor - Very helpful in discriminating between types of plant material when used in conjunction with the Yellow band
Yellow (585-625 nm)	- New band - Very important for feature classification - Detects the “yellowness” of particular vegetation both on land and in the water
Red (630-690 nm)	- Narrower than the red band on QuickBird and shifted to longer wavelengths - Better focused on the absorption of red light by chlorophyll in healthy plant materials - One of the most important bands for vegetation discrimination - Very useful in classifying bare soils, roads
Red-Edge (705-745 nm)	- Centered strategically at the onset of the high reflectivity portion of vegetation response - Very valuable in measuring plant health and aiding in the classification of vegetation
NIR1 (770-895 nm)	- Narrower than the NIR1 band on QuickBird to provide more separation between it and the Red-Edge sensor - Very effective for the estimation of moisture content and plant biomass - Effectively separates water bodies from vegetation, identifies types of vegetation and also discriminates between soil types
NIR2 (860-1040 nm)	- New band Overlaps the NIR1 band but is less affected by atmospheric influence - Enables broader vegetation analysis and biomass studies

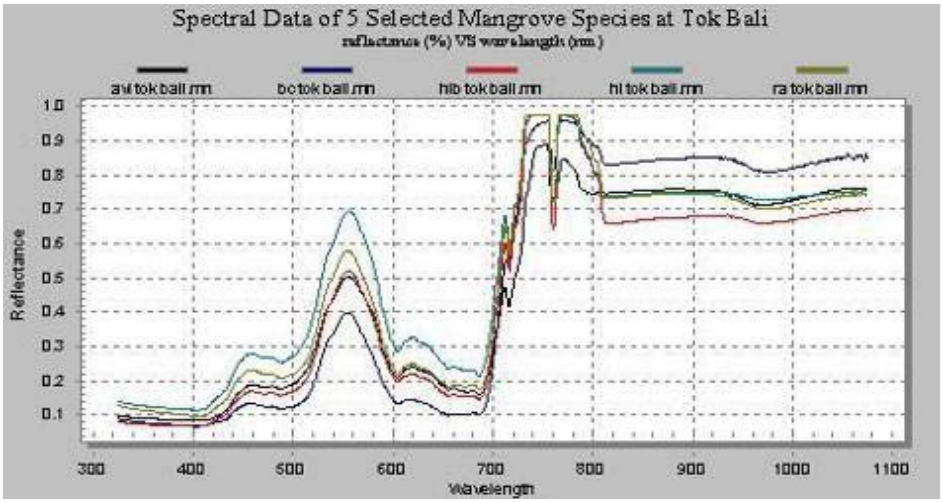

Figure 3. Spectral signatures of 5 mangrove species, *Rhizophora apiculata*, *Brugiuera cylindrica*, *Avicennia alba*, *Heritiera littoralis* and *Hibiscus tiliaceus* (Kamaruzzaman and Kasawani, 2007).

Table 2. Benefits and limitations of medium-resolution imagery for mangrove mapping.

Features	Benefits	Limitations
Spectral resolution	Several multispectral bands, always including R,G,B; near-infrared; and oftentimes even mid-infrared; and thermal bands	Skilled trained personnel are required to best exploit the information content of the multiple bands (considering transformations, etc.)
Spatial resolution	Ideal for mapping on a large regional scale	Too coarse for local observations, requiring in-depth species differentiation and parameterization
Temporal resolution	Frequent mapping (e.g., rainy season and dry season within 1 year; or repeated annual mapping) is possible	Repetition rate may be too low to record impact of extreme events (e.g., cyclones, floods, tsunamis); furthermore, very weather dependent (clouds) = critical in subtropical and tropical regions
Cost	Depending on sensor, freely available (e.g., Landsat), very cost efficient (ASTER), or expensive (e.g., SPOT); but all are cost efficient compared with field surveys and airborne campaigns	Software for image processing needed (common software, such as Erdas, ENVI, and ArcGIS, have high license fees), but usually not a real limitation
Long-term monitoring	Data availability over three decades	Depending on the future duration of the systems and subsequent comparable sensors
Purposes	Inventory and status maps; change detection, such as assessment of impact damages; assessment of reforestation and conservation success	For some species-oriented botany-focused studies, resolution may already be too coarse

Table 3. Benefits and limitations of aerial photography for mangrove mapping

Features	Benefits	Limitations
Spectral resolution	Red–near-infrared spectral information with red-edge slope	None at all or very low (R,G,B; near-infrared)
Spatial resolution	Very high (centimeter to meter range)	Only small area is covered
Temporal resolution	Always available on demand	Complex acquisition of equipment and flight campaign planning is needed
Cost	Low costs for small areas	Increasing costs with increasing spatial coverage; high costs if professional flight campaign planning and multispectral camera
Long-term monitoring	Data available for >50 years	
Purposes	Local maps of mangrove ecosystems, parametrization, change detection	Only local-scale studies
Discrimination level	Species communities, density parameters	Sometimes too much detail (hampering unbiased image processing)
Methods	Visual interpretation with on-screen digitizing and object-oriented approaches	Automatization usually not possible; considerable analyst bias and, thus, hampered transferability or comparability

Finally, in addition to conventional spectral images, hyperspectral images from airborne or satellite sensors could be used to distinguish species of mangroves which were difficult to separate in conventional, moderate-spatial resolution, and multi-spectral satellite images. Most of hyperspectral applications for mangrove species composition were conducted using pixel-based mapping approach, such as maximum likelihood, spectral angle mapper (SAM), and spectral unmixing, and object-based approaches (Kamal and Phinn, 2011). Hyperspectral data allow for a better separation of feature types based on their unique spectral reflectance and absorption characteristics. Therefore, hyperspectral data may improve the ability to differentiate mangrove species composition.

The application of remote sensing on mangrove studies has been conducted by LAPAN since 1994, including mangrove mapping, normalized difference vegetation index (NDVI), change detection and reflectance optimization. During the year of 1994-2004 and 2009-2010, LAPAN conducted studies on mangrove identification in Segara Anakan, Central Java, and on mangrove sedimentation in Berau, East Kalimantan, Riau and Delta Mahakam using remote sensing. Spectral data in LAPAN were available from NOAA, MODIS, LANDSAT and SPOT which were operational until recently, and ALOS and JERS which were used for special research topics.

Fish Production in Mangroves

Prof. Asikin Djamali was initially scheduled to present the topic of fish production in mangroves. However, he was unable to attend the workshop due to his other activities, but he kindly provided a slide presentation for the workshop. His slides were then presented by Dr. Titin Handayani on the topic of fish production in mangroves. Prof. Asikin and his colleauges had conducted a series of experiments on fish biodiversity in mangrove from 1979 - 2012 in three different locations, i.e. Pari Island in Jakarta Bay, Musi Banyuasin in South Sumatera, and Mahakam Delta in East Kalimantan.

Pari island is a member of islands located on north Jakarta Bay forming a cluster of islands called Thousand Island (Figure 4). Pari island and its neighbouring islands harbour natural mangrove forests and had been used by research organizations and universities for site studies. Musi Banyuasin is located in the eastern coastal lowlands of Sumatra in the Bayung Lincir and Sungsang

sub-districts, Musi Banyu Asin District, South Sumatra Province (Figure 5). More than 30 species of mangrove are known to occur in this region. The main species are *Rhizophora mucronata*, *R. apiculata*, *Avicennia alba*, *A. marina*, *Sonneratia alba*, *S. acida*, *Ceriops tagal*, *C. candoleana* and *Xylocarpus* spp. There are also some extensive swamps of *Nypha fruticans*. Mahakam Delta is a configuration of 46 small islands forming a unique fan-shaped lobate which stretches out into the coastal area of the Makassar Strait of East Kalimantan (Figure 6). Mangrove forests in Mahakam Delta is predominantly consists of pedada (*Sonneratia caseolaris*) zone, Rhizophora zone, transition zone, Nypha zone and nibung (*Oncosperma tigillarium*) zone.

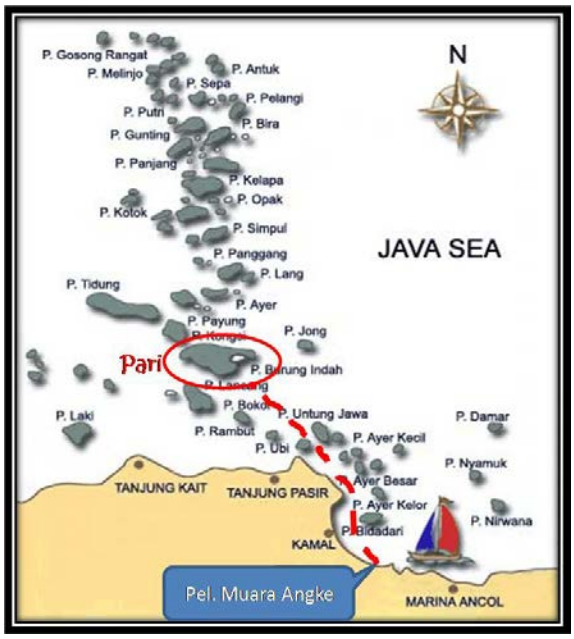

Figure 4. Pari island as part of Thousand islands on north of Jakarta.

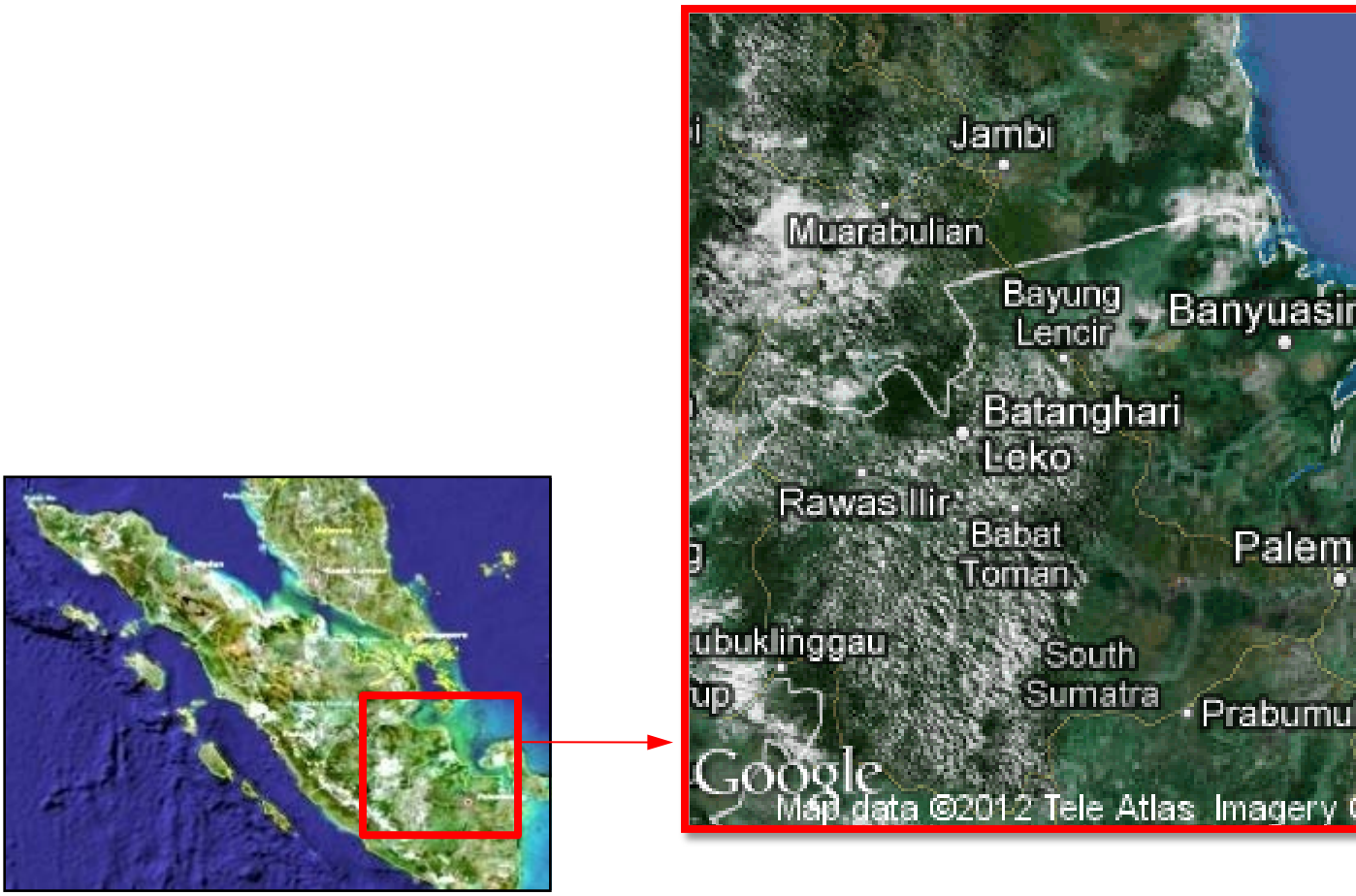

Figure 5. The location of Musi Banyuasin, South Sumatera.

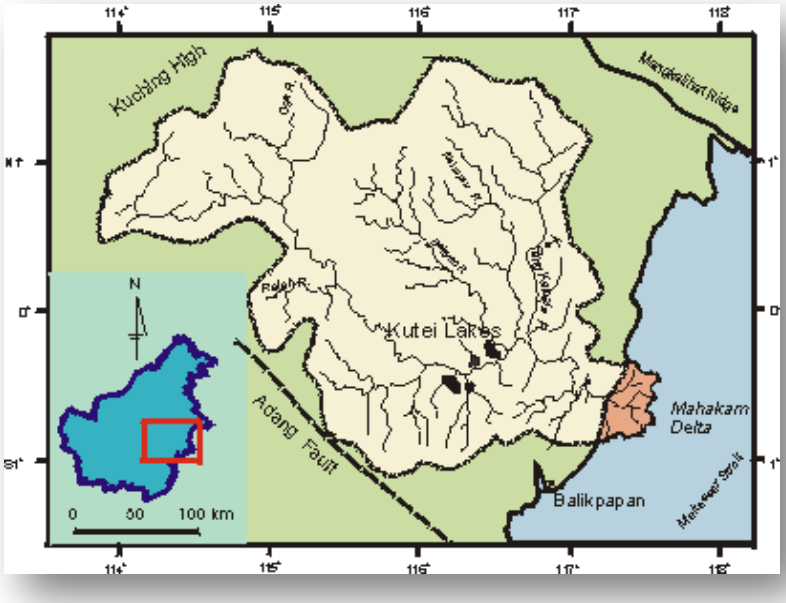

Figure 6. Delta Mahakam, East Kalimantan

Studies conducted by Prof. Asikin in Pari island, Musi Banyuasin Estuari, and Mahakam Delta showed that the number of fish species found in mangroves varied from 24 to 131 species, which belong to 16-61 families (Table 4). Fish abundance in Musi Banyuasin Estuari and Mahakam Delta were higher or more than doubled than those found in Pari island Jakarta Bay. The number of species in Musi Banyuasin Estuari and Mahakam Delta were ranged 57-99 and 80-131 species.

Tabel 4. Fish abundance in three mangrove locations in Indonesia.

Location	Year	Number of Families	Number of Species	Number of Specimen	References
Pari Island, Jakarta Bay	1979	16	24	760	Hutomo & Djamali (1979)
	1981	18	27	1224	
	1984	18	29	1719	Adrim, Djamali & Toro (1984)
Musi Banyuasin, South Sumatera	1980	10	70	NA	Burhanuddin (1980)
	1994	38	99	925	Genisa (1995)
	1998	29	57	NA	Djamali (1999)
	March 2009	NA	72	NA	Prianto & Aprianti (2012)
	June 2009	NA	81	NA	Prianto & Aprianti (2012)
Mahakam Delta, East Kalimantan	2006	44	80	NA	Genisa (2006)
	2009	61	131	NA	Suyatna (2010)

Note: NA = data not available

Ten dominant species found in Musi Banyuasin Estuari in 1980 were wolf-herring (parang-parang, Chirocentridae), slender sanding (Dussumieridae), gizzard shad (Dorosomatidae), anchovy (Engraulidae), sardine (Clupeidae), cat fish (manyung, Ariidae), common Grinner (Synodontidae), threadfin (senangin, *Eleutheronema tetradactylum*), hair tail (Trichiuridae) and puffer fish (Tetraodontidae). The dominant species found in the same location in 1999 were mullet (belanak, *Valamugil seheli*), cat fish (manyung, Ariidae), croakers (gulamah, *Johnius trachycephalus*), threadfin (senangin, *Eleutheronema tetradactylum*), black pomfret (bawal hitam, *Parastromateus niger*), barramundi (kakap putih, *Lates calcarifer*), tripletail (kakap batu, *Labotes surinamensis*), cat fish (sembilang, Plotosidae) and grouper (kerapu, Serranidae). In Mahakam Delta, the dominant species found in 2006 were *Sardinella fimbriata*, *Leiognathus elongata*, *Rastrelliger kanagurta* and *Apogon caramensis*. Individual distribution of each species at each observation sites was nearly equal. Species diversity index (H) ranged between 0.5300 – 1.5547, evenness index ranged 0.3308 – 0.9198 and richness index (d) ranged 13.1801 – 23.7026 (Genisa, 2006).

The most abundance species found in Pari Island in 1979 was *Gerres macrosoma* (Silver-Biddy) made up 80.92 % of total abundance. Fish abundance in mangrove ecosystems is depend on the location of the mangrove. Overall, studies conducted in Pari island, Musi Banyuasin Estuari, and Mahakam Delta showed that mangrove close to estuaries had higher number of fish species compared to mangrove in small island such Pari Island.

Regional Climate Change Data

Mr. Kwan Kok Foo from Malaysian Meteorigical Departement presented about climate change data availability, processing and projection over Southeast Asia. Data on regional temperatures over several past decades were shown and its projection for 40 years was shown. It was also possible to obtain other climate factors such as sea-level rise, extreme weather, temperature and CO_2 concentration from IPCC reports and developed their scenario for 40 years using HadCM3 PRECIS climate model.

3.3. Site visit to mangrove forest

As part of the Scoping Workshop activities, the participants undertook a half-day site visit to mangrove forests on 25 September 2012. The mangrove forest was located in the southern part of Denpasar and under the management of Mangrove Management Centre Region I, Ministry of Forestry (formerly Mangrove Information Center). The aim of this site visit was to give visualization of mangrove forest to team members involved in the proposed project. Before site visit, Mr. Komang from Mangrove Management Centre Office gave a brief presentation about the history of mangrove forest in Denpasar Bali and the Mangrove Management Center in Denpasar Bali.

During the year 2001-2006, the Center conducted a program to increase the awareness among stakeholders on the importance of mangrove forest to community and environment. The program included training of trainers on sustainable mangrove management, education and socialization to the public by providing experience and knowledge about the mangrove ecosystem and management, the development of ecotourism at mangrove site by establishing a information center, museum, touch pool and trail, and conducting tour guide training with aims to disseminate information on mangrove ecosystems to general public.

The site visit included trip to mangrove nursery and mangrove forest along the wooden path (Figure 7). The forest covered 1,373 hectares of coastal zone, including 200 hectares allocated for recreational site and Mangrove Management Centre office. For educational and conservational purposes, the Center had established nursery plots of approximately 7,700 square meters, wooden trails, huts to rest and floating decks. The forest consisted of 13 major mangrove species found in Benoa Bay, Bali, including Rhizophora, Sonneratia, Bruguiera, Avicennia and Ceriops, 9 minor mangrove species such as *Xylocarpus Aegiceras* and Heritiera, 28 associated mangrove species including Acanthus, Ipomea, Barringtonia and Clerodendron, 62 types of birds, 32 types of Crustaceans and 10 types of reptile. These flora and fauna was displayed in exhibition rooms of the Center.

Figure 7. Site visit to mangrove forest

3.4 Discussion of Draft Proposal

After the presentations and site visit, intensive discussions among participants were undertaken to improve the weight of the proposal. Main topics to be discussed were the framework of proposed study, appropriate methodologies and parameters to be used, and selection of study sites. There were four main subjects of the proposed program extracted from the discussion, i.e. climate change, mangrove biodiversity, fish production and socio-economy condition. The link between those subjects is shown in Figure 8. Climate change as the result of increasing atmospheric temperature will have a

global impact on many ecosystems. Since mangroves are the most prominent coastal ecosystem in tropical and subtropical area, the impact of climate change on these areas is likely to have great environmental, economic and social significance. Therefore, in this proposed project the impact of climate change on mangrove biodiversity would be first studied. It has been known that mangrove forests had positive impacts on fish abundance and provide nutrients to many type of fishes including Belanak (*Liza subviridis*) (Sewiko, 2011; Ramli, 2012). In this case, the impact of changes in mangrove biodiversity to fish abundance would then be assessed. Finally, the impact of changes in mangrove biodiversity on socio- economy of local community would be studied.

Figure 8. Main ideas of the proposed program

In discussion session, all collaborators agreed to choose two site locations for mangrove studies, one in Segara Anakan Central Java, Indonesia, and another one in Aurora Province, the Philippines. Mangroves in Segara Anakan has been studied for decades and high number of literatures for this site are avaliable. Accordingly, current habitat and biodiversity status of mangrove ecosystems in those sites will be assessed through primary and secondary data gathering.

The methodologies and appropriate parameters to be studied were also discussed. Four parameters to be studied would be climate, mangrove, fish production and socio-economic parameters (Table 5). Important climate parameters include salinity, pH, ocean acidification, sea-surface and air temperature, and climate extreme events for at least the last 30 years. Secondary data of climatic parameters would be collected from publications, government agencies and research institution reports. A regional climate modelling system, PRECIS, would be used for the projection of climate change scenarios until 2100. PRECIS contains two regional climate models, HadRM3P and the HadRM3Q0. PRECIS is designed to construct high-resolution climate change scenarios for the region of interest on impact, vulnerability and adaptation studies. IPCC projection would be used for sea-level rise and sea-surface temperature projections. Data on those climatic factors and their scenarios for 40 years based on several regional climate models would be used for impact assessment.

Primary and secondary data on biotic factors in mangrove biodiversity such as number of dominant species, species density and sediment/nutrient flow, and vegetation cover; and physical factors affecting mangrove biodiversity such as relief, substrate, and water circulation would be obtained from field samplings, satellite images and government reports. We would consider the components and measures of exposure, sensitivity, and adaptive capacity of mangrove ecosystems to impacts of climate change and then assess their vulnerability. Indicator fish species, dominant species, crab and shrimp abundance in mangrove area were important parameters for fish production study. Primary and secondary data would be collected from government agencies and from field samplings. The impacts of climate change on the sustainability of fish production in selected mangrove ecosystems will be investigated and analyzed through historical data collection and will include the degree that it is exposed to social-economic demand. Finally, socio-economic status of local community would be studied including fish revenue, shifting jobs, demography, harvesting practices, relevant policies and ecological value of mangrove ecosystems.

Comments of reviewers on the submitted proposal were also discussed. It is possible that the impact of mangrove ecosystem on fisheries production is the loss of mangroves area in general rather than the loss of particular biodiversity within the mangroves themselves. Therefore, the link between mangrove biodiversity and fisheries production will be studied using correlation analysis between the identified parameters of mangrove biodiversity and fish production. Also, impacts associated with

overfishing or land-based pollution and sedimentation on fisheries production and revenue will be studied using identified socie-economic parameters.

Output from this first scoping workshop was a two-pages summary proposal and a draft of full proposal. The draft of full proposal was further developed after the scoping workshop among collaborators by communicating via email. Timeline and budget of the proposed activities were discussed in the final scoping workshop in Februari 2013.

Table 5. Parameters and methods of the proposal

Factors	Method of data collection	Source of data
a. Climate parameters		
• observed		
- salinity, pH, ocean acidification	Secondary data	Publications, government agencies, research institutions
- sea-surface and air temperature (in at least one station per project site for the last 30 years)	Secondary data	Publications, government agencies, research institutions
- climate extreme events (El Nino, typhoon, etc) for the last 30 years	Secondary data	Publications, government agencies, research institutions
• projections		
- climate change scenarios until 2100	Secondary data	PRECIS
- Sea-level rise and sea-surface temperature projections	Secondary data	IPCC Projections
b. Mangrove parameters		
• Biotic		
- number of dominant species (species sensitive to salinity)	- Secondary data (ground data if available for past data) - Primary data for current data	- Publications, government records - Transect method (20m x 50m)
- species density	- Secondary data (ground data if available for past data) - Primary data for current data	- Publications, government records - Transect method (20m x 50m)
- sediment/nutrient flow	- Secondary data (for past data for the last in at least 30 years)	- Landsat or SPOT at 20m resolution
• Physical		
- relief/morphology/elevation	Secondary data including remote sensing data	Relevant government agencies/researches/ publications
- river sources	Secondary data including remote sensing data	Relevant government agencies/researches/ publications
- substrates	Primary data	- Field observations - Soil sampling and analysis
- tectonic movement	Secondary data	Relevant government agencies/researches/publications
- water circulation	Secondary data	Relevant government agencies/researches/publications
- landuse	Secondary data including remote sensing data	Relevant government agencies/researches/publications
- landsat image of the area (30m resolution)- last 30 years and present for the vegetation cover	Remote sensing	Landsat image at 2m resolution for the past 30 years
c. Fish production		

- indicator species - Acer fish	- Secondary data - Primary data	- Literature - Field sampling using nets (coordinates of occurrence to be specified)
- dominant species	- Secondary data - Primary data	- Literature - Field sampling using nets (coordinates of occurrence to be specified)
- Frequency count	- Secondary data - Primary data	- Literature/records - Field sampling using nets (coordinates of occurrence to be specified)
- crab production	- Secondary data - Primary data	- Literature/records - Field sampling using nets (coordinates of occurrence to be specified)
- shrimp	- Secondary data - Primary data	- Literature/records - Field sampling using nets (coordinates of occurrence to be specified)
d. Socio-economic		
- fisheries revenue (total harvest - USD or tons/year)	- Secondary data - Primary data	- Records/publications - Household/ stakeholders interview
- socio-economic activities/demography - potential impact on shifting jobs (construction of fish ponds, illegal logging, migration, etc)	- Secondary data - Primary data	- Relevant government agencies/research institutions/publications - Household/ stakeholders interview
- harvesting practices	- Secondary data - Primary data	- Relevant government agencies/research institution/publications - Household/ stakeholders interview (how many respondents?)
- relevant policies to mangrove conservation (supporting data for recommendations)	Secondary data	- Relevant government agencies/ research institution/ publications
- ecological-economic value of mangrove ecosystem (supporting data, could be used to emphasize the significance of the project in the development of full proposal)	Secondary data	- Literatures

3.5. Final Workshop

The final workshop was held on 18 -20 February 2013 in Kuta, Bali, Indonesia and was attended by Indonesian collaborators. The aim of the final workshop was to finalize the draft proposal, particularly on budget and timeline of the proposed project. Since the proposed study will include socio-economic aspect, then the duration of project was proposed to be three years. In the first and second year, the activities will be to devise and implement a communication among team member, kick-off meeting, climate scenario development, GIS and model analysis of mangrove biodiversity vulnerability to climate change, data collection and analysis of mangrove biodiversity and fish production. Socio-economic study

on mangrove biodiversity vulnerability to climate change will be studied in third year. Progress meetings will be conducted at the end of first and second year, while final workshop will be conducted at the end of third year. The data collection on mangrove biodiversity will be conducted both in Indonesia and the Philippines. Since the final workshop was attended only by Indonesian collaborators, the budget for the proposed activities in the Philippines were sent to Ms. Kristine Garcia after the workshop to be completed.

3.6. Discussion

The role and importance of mangroves as a coastal resource is well established. Mangroves are essential for maintaining coastal environment, not only characterize the ecosystem, but also define an economic resource for the surrounding communities. They also provide an important nursery area for the juveniles of many commercial fish and crustacean species and play important roles in coastal protection and water quality (Gilman *et al*., 2008). Although extensive studies have been conducted on mangrove biodiversity, studies on the impact of climate change on mangrove biodiversity is still limited, particularly in Southeast Asia.

The scoping workshop has established activities to study the impact of climate change on mangrove biodiversity, fish production and socio-economic status in southeast Asia. Important parameters and methodologies for study have been identified and will be used for the proposed project. Appropriate correlation analysis between identified parameters will be used to study the link between mangrove biodiversity and fisheries production. Overall, the scoping workshop has increased knowledge among collaborators and develop appropriate strategies to study the vulnerability of mangrove biodiversity to climate change.

4.0 Conclusions

The aim of this scoping workshop is to develop a proposal on mangrove vulnerability to climate change in Southeast Asia. Outputs of the first workshop were draft of summary proposal and a draft of full proposal, outline of proposed activities and proposed project sites in Indonesia and Philippines. The final summary proposal was completed in October 2012 and the draft of full proposal was further developed during the final meeting in Bali by Indonesia collaborators in February 2013. The outline of the proposed activities includes kick-off meeting, scenario development, assessment of mangrove ecosystem sensitivity and adaptability to climate change, vulnerability assessment of mangrove-ecosystem dependent communities/sector and final workshop for sharing results and policy recommendations. Major output of this project was a full proposal to be submitted to APN's Call for Proposal 2013.

5.0 Future Directions

The scoping workshop will help the collaborators to clearly define activities of the proposed project to study the vulnerability of mangrove biodiversity to climate change in Southeast Asia. It is expected that the results of the proposed study will help decision makers in formulating climate change adaptation strategies for maintaining mangrove ecosystem biodiversity and sustainability of fish production, particularly in Southeast Asia.

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Appendix 1

Programme Schedule

Scoping Workshop To Develop Proposal :
Vulnerability Assessment of Mangrove Biodiversity to Climate Change in Southeast Asia
23-26 September 2012, Denpasar, Bali, Indonesia

Day 1 : Sunday, 23 September 2012
Venue : Hotel IBIS KUTA Denpasar Bali

Time	Program	Subject
08.00 – 18.00	Travel to Denpasar and Check in to the Hotel	All Team Members

Day 2 : Monday, 24 September 2012
Venue : Hotel IBIS KUTA Denpasar Bali

Time	Program	Speaker
08.30 – 08.45	**Registration**	
08.45 – 09.00	**Welcoming Remarks** : The Director of Center of Environmental Technology BPPT	Dr. Joko Prayitno Susanto
09.00 – 09.30	**Self Introduction** of each participant and **Photo Session**	
09.30 – 10.00	Tea Break	
10.00 – 10.45	**Presentation 1 :** Current Climate Change Issue and Overview of Proposal ARCP2012-22SNG-Prayitno	Dr. Joko Prayitno (BPPT)
10.45– 11.30	**Presentation 2** : APN and Proposal Development	Dr. Erna S. Adiningsih (APN SPG Member for Indonesia)
11.30 – 12.15	**Presentation 3** : Mangrove biodiversity in Indonesia	Mr. Komang (Mangrove Management Center Region I, Ministry of Forestry)
12.15 – 13.15	Lunch Break	
13.15 – 14.00	**Presentation 4** : Mangrove in Philippines	Ms. Kristine Garcia (Uni Los Banos Philippines)
14.00 – 14.45	**Presentation 5** : Fish production in Mangrove	Prof. Asikin Djamali (Fish-Mangrove Expert)
14.45 – 15.15	Tea Break	
15.15 – 16.00	**Presentation 6** : Climate change projection over south east Asia (data availability and processing)	Mr. Kok Foo Kwan (Malaysian Meteorogical Department, Malaysia)
16.00 – 16.45	**Presentation 7** : Application of remote sensing for mangrove and fisheries including data availability	Dr. Ety Parwati (LAPAN)
16.45 – 17.00	Wrap Up	Dr. Titin Handayani (BPPT)

Day 3 : Tuesday, 25 September 2012
Venue : Mangrove Information Center, Denpasar Bali

Time	Program	Speaker
08.00 – 08.30	Preparation for Site Visit	
08.30 – 09.00	Travelling to Mangrove Site	
09.00 – 10.00	Presentation about mangrove Site	Mangrove Information Center Bali
10.00 – 12.00	Site Tour	Mangrove Information Center Bali

12.30 – 13.30	Lunch Break	
13.00 – 15.00	Brainstorming on Proposal Improvement	Dr. Joko Prayitno (BPPT)
15.00 - 15.30	Tea Break	
15.30 – 17.00	Discussion of Draft Proposal	Dr. Joko Prayitno (BPPT)
17.00 – 17.30	Travel to Hotel	

Day 4 : Wednesday, 26 September 2012
Venue : Hotel IBIS KUTA Denpasar Bali

Time	Program	Coordinator
08.30 – 11.30	Discussion of Draft Proposal	Dr. Titin Handayani (BPPT)
10.00 – 10.15	Tea Break	
11.30 – 12.00	Wrap Up and Closing of Workshop	Dr. Joko Prayitno (BPPT)
12.00 – 12.30	Lunch Break	
12.30 – 13.00	Packing Up and Checking Out	
13.00 –	Travel back Home	

List of Participants

Scoping Workshop To Develop Proposal :
Vulnerability Assessment of Mangrove Biodiversity to Climate Change in Southeast Asia
23-26 September 2012, Denpasar, Bali, Indonesia

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Appendix 2

Programme Schedule

Workshop to Finalize the Proposal:
Vulnerability Assessment of Mangrove Biodiversity to Climate Change in Southeast Asia
Kuta, Denpasar, Bali, 18-20 February 2013

Day 1 : Monday, 18 February 2013
Venue: Adhi Jaya Sunset Hotel, Kuta, Bali

Time	Program	Subject
08.00 – 13.00	Travel to Denpasar and Check in to the Hotel	All Team Members
14.00 – 17.00	Discussion on Draft Proposal : Review on Draft	All Team Members

Day 2 : Tuesday, 19 February 2013
Venue : Adhi Jaya Sunset Hotel, Kuta, Bali

Time	Program	Speaker
08.30 – 10.30	Discussion on Draft Proposal : Timeline	All Team Members
10.30 – 11.00	Tea Break	All Team Members
11.00 – 12.00	Discussion on Mangrove Management with Mr. Murdoko (Mangrove Management Center Region I, Ministry of Forestry)	All Team Members, Mr. Murdoko
12.00 – 13.00	Lunch Break	
13.00 – 15.00	Discussion on Draft Proposal : Timeline	All Team Members
15.00 – 15.30	Tea Break	
15.30 – 17.00	Discussion on Draft Proposal : Budget	All Team Members

Day 2 : Wednesday, 20 February 2013
Venue : Adhi Jaya Sunset Hotel, Kuta, Bali

Time	Program	Speaker
08.00 – 10.00	Discussion on Draft Proposal : Budget	All Team Members
10.00 – 10.30	Tea Break	
10.30 – 12.30	Discussion on Draft Proposal : Finalizing draft	All Team Members
12.30 – 13.30	Lunch and check out	
13.30 – 15.00	Travel to Airport and leaving Denpasar Bali	All Team Members

List of Participants

Workshop to Finalize the Proposal:
Vulnerability Assessment of Mangrove Biodiversity to Climate Change in Southeast Asia
Kuta, Denpasar, Bali, 18-20 February 201

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