Technology Fact Sheet

Integrated forest – peat carbon measurement and monitoring technology[i]

1) Introduction

The ICCSR (Indonesia Climate Change Sectoral Roadmap) of forestry sector (BAPPENAS 2009), suggested the most feasible scenario to reach the target of reducing GHG emissions by 26% in the year of 2020 called SC3: increasing sink and creating conditions for preventing further deforestation. Most of the mitigation efforts in this scenario come from the improvement of management practices implemented on 244 newly developed FMU (forest management units) – KPH (Kesatuan Pemangkuan Hutan), in an area extent of 24 million hectares. This scenario has the lowest abatement cost per unit of emission reduction and to reduce annual GHG net emission of 800 abate to 496 $MtCO_2e$ within a time period of 2011 – 2020.

In addition, the ICCSR suggested policy oriented mitigation options for the improvement of peat management practices aimed at "low carbon" peatland management by enforcing existing legal requirement and establishing new standards of best practices. Two main mitigation options are suggested: zero burning and water management best practices to reduce annual emission of 470 $MtCO_2e$, from 1700 $MtCO_2$ e of BAU down to 1230 $MtCO_2e$ within a time period of 2011 – 2020.

Considering the large size of spatial forest extent and the large number of KPH involved for implementing the mitigation scenario, scientifically credible data and information for carbon accounting of the results of implementing the above mentioned mitigation scenario must be available. This implies that a technological system – a proper combination of expertise (knowledge and skills), tools (equipments and models), and institutional framework (working group, task force, teamwork, etc.) – to facilitate integrated forest-peat measurement and monitoring of carbon stock on targeted forest and peatland areas of mitigation measures needs to be newly invented. Furthermore, its technical reliability and economic feasibility need to be demonstrated for the purpose of technology transfer and diffusion.

2) Technology characteristics

Carbon measurement and monitoring technology in the context of CHG mitigation of Forest and Peat Sectors deals with integrating knowledge, tools, and institutional framework aimed at facilitating two in one measurements: timber standing stock inventory and peat deposit survey. This integrated measurement technology would facilitate estimation of carbon stock from proper combination results of conventional forest inventory (above ground biomass) and the result of peat survey (below ground biomass).

Conventional forest inventory is a standardized method of SFM for estimating standing stock of timber volume and re-growth condition of a certain area extent of forest management unit. The method is based on statistical estimation of timber volumes of trees of more than 30 cm Dbh (diameters at breast height).

Forest timber volume of trees and poles is estimated by means of a standardized statistical methodology based on sampling technique and analysis. For this purpose, a nested stripped sample plots are defined. Within each sample plot, trees and poles diameters at breast height and their first branch heights are measured. Timber volume within each sampling plot is calculated from the sum of volume of trees and pole. Finally total volume of the forest extent is statistically estimated from calculated timber volume of the sampling plots.

3) Country specific applicability

The use of conventional forest inventory method has been used for estimating carbon stock of forest biomass (in ton of biomass weight) from standing stock volume (m3 of timber standing stock) multiply by 2.5. Carbon stock (ton of carbon) is estimated about 50% of forest biomass. CO_2 equivalent (ton of CO_2) can be estimated, simply by multiplication of 3.67 to the carbon stock. For the time being, more accurate estimation of carbon stock has been developed using allometric equations from measuring tree diameter at breast height (Dbh) only. An allometric equation is species and site specific, it is developed based on statistical correlation of Dbh and biomass of a single tree of certain species or forest type on a certain geographical site.

In addition to singe tree carbon estimation method, several area methods for forest carbon estimation have been developed by means of remote sensing technology. Multi spectral as well as SAR (Synthetic Aperture Radar) remote sensing technologies have been initially invented for measurement and monitoring of carbon stock. Vegetation indices and leaf area indices are the common methods of multispectral remote sensing for estimation of forest carbon stock, whereas multi polarization and interferometry are the common method of that of SAR remote sensing.

The aforementioned conventional forest inventory and its further development of allometric equation and remote sensing methods are utilized for estimating above ground biomass for forest of non peat environment. An additional below ground carbon stock measurements of peat deposit is required for peatswamp forest, timber plantation on peat, tree estate on peat environment. The amount of biomass of peat deposit is usually estimated from the result of soil survey by combining peat depth, peat bulk density, area measurements. Similar to the forest inventory, soil survey has been recently supported by multispectral and SAR remote sensing technology for wide area measurement of estimating peat deposits.

4) Status of technology in country

Within the context of Sustainable Peat Management, measurement and monitoring of carbon stock to estimate CO_2 emission from peat decomposition/subsidence and peat fire using of newly invented of peat soil surveys as well as remote sensing technology for estimating peat deposit have been initially practiced.

Within the context of TTD, particularly from the point of view of ‘Innovation System’, the above mentioned technologies need to be integrated in such a way to make the first chain of innovation process – research and development (R&D) – fully completed. Furthermore, the early stage of second chain of innovation process – the initial phase of diffusion – in which the demonstration of its reliability, practicality and financial feasibility of the integrated technology have to be well prepared. Finally, to complete the whole process of the second chain of innovation of the technology, the diffusion has to be focused on ‘interactive learning’ of the three components of technology for carbon measurement and monitoring:

- Make use of all available knowhow and expertise (software) from the previous R&D experiences on measuring biomass of forest and peatland using the synthesis of forest biometrics, peat deposit estimation, and the integration of the two.
- Utilize the most practical, reliable, credible, and inexpensive tools (hardware) for direct as well as remotely sensed measurement, and the combination of the two
- Define the most effective coordination (org-ware) among the key players (i.e., BPPT, Ministry of Forestry, Ministry of Environment, and Ministry of Agriculture).

5) Barriers

Barriers of Technology Transfer and Diffusion (TTD) for this technology is illustrated as a problem tree presented in Figure A (which can be seen in the Appendix below) of this report. It is important to note that the problem tree was defined by selecting a starter problem*: Lack reference project of viable, credible and reliable integrated forest—peat carbon measurement*. This starter problem roots from a total number of six barriers and propagate to six 'canopy' barriers. In terms of innovation system TTD process, the root barriers correlate with maturing R&D chain and the canopy barriers correlate with technology diffusion chain. In other words, the maturing R&D process deals with barriers to provide a *reference project of viable, credible and reliable integrated forest—peat carbon measurement*, whereas the chain of technology diffusion deals with barriers of adopting this technology in facilitating mitigation measures to achieve a complete data and information for forest-peat carbon accounting at both national and sub national levels.

To assess possible solutions for overcoming barriers, a hierarchical logical framework analysis was applied to objective trees, followed by a rapid benefit cost/consequence analysis, with special consideration of critical and difficult nature of "take off" – the initial phases when the reliability, practicality and financial feasibility of the technology is demonstrated. The results of such assessment recommended the following solution for overcoming barriers:

Table 1 Assessment recommended the following solution for overcoming barriers

Recommended Solutions	
Maturing R&D Phase	**Technology Diffusion Phase**
Policy Action: ***Establish a "National Demonstrator" project to demonstrate the reliability, practicality and financial feasibility of newly invented integrated peat-forest carbon measurement and monitoring technology.*** ***Mode of Action:*** ***International Capacity Building for a national expert consultation working group through the development of an operational, reliable, credible, and feasible prototype of integrated peat-forest carbon measurement and monitoring carried out on national demonstrator R&D field stations.***	*Policy Action:* *Establish a "Collaborative Learning" program for technology diffusion to transfer and operationally implement the newly invented prototyped of integrated peat-forest carbon measurement and monitoring technology.* *Mode of Action:* *On the Job Training for personnel of KPH, HTI, HPH, and other local stakeholders carried out on national demonstrator R&D field stations followed by a certain time period of trial and adjustment in their areas. The program is designed and implement by national expert consultation working group*

6) Benefits

The ultimate benefit GHG mitigation measures are

- annual GHG net emission of will be 800 reduced to 496 MtCo2e by implementing KPH-HTI mitigation scenario within a time period of 2011 – 2020

- annual emission of 1700 MtCO2 will be reduced to 1230 $MtCO_2e$ by implementing "low carbon" peatland management (zero burning policy and water management best practice).

These benefits are not the direct benefits of carbon measurement and monitoring technology, however, they cannot be properly quantified without the use of reliable carbon measurement and monitoring technology. Further qualitative assessment of specific benefits of TTD of unified peat mapping technology suggested the followings:

Table 2 Goal: To make data and information available for forest—peat carbon accounting

Goal: ***To make data and information available for Forest—Peat carbon accounting***							
Maturing R&D				**Technology Diffusion**			
Objective *To establish a reference TTD project of Forest—Peat carbon measurement and monitoring*				Objective *To provide complete and updated information system on forest carbon stock covering sub-national level*			
Measure (M)	P	C	B	Measure (M)	P	C	B
M1. Establishment of Forest—Peat carbon measurement national task Force	M	L	H	Carry out sub-national collaborative learning program to transfer knowhow of and facilitate access to proven integrated carbon measurement and monitoring technology:			
M2. Establishment of expert working group for growth modeling biomass measurement	H	L	M	M6. Establish coordination forum of relevant ministries , KPHs, and other stakeholders	M	L	H
M3. Establishment of expert working group for peat biomass measurement modeling	H H	L H	M H	M7. Carry out on-site job training for development and implementation of Integrated national-sub national carbon measurement model	H	H	H
M4. Establish international capacity building for Forest—Peat carbon measurement prototype development	H	M	H	M8. Develop and implement organization mechanism to distribute information	L	M	M
M5. Provide adequate R&D field stations and facilities for carbon measurement prototyping (hardware and software)	H	L	2				
Notes: : P= Priority, C= Cost, B =Benefit , H= High, M= Moderate, L=Low							

7) Operations

At local area levels, carbon measurement and monitoring technology need to be operated by well trained personnel of KPHs, HTIs, HPHs and tree estate enterprises. At wide areas levels, this technology needs to be operated by personnel of the Ministry of Forestry and Ministry of Agriculture supported by local area personnel. The personnel of both levels have to be well equipped with adequate tools and equipment accordingly. In other words, trained personnel and adequate tools and equipments are the hearth and prerequisite for the operations of this technology.

To maintain the operation of this technology in an optimum performance, therefore, should cover maintaining and improving personnel's knowledge and technical expertise as well as maintaining and improving supporting measurement and monitoring tools and equipment. Several possible maintenance and improvement efforts are:

- Operate local area measurement field stations as a network of field stations which can be functioning as sub national and national carbon monitoring permanent sampling plots. This effort will improve the performance of sub national and national carbon monitoring information system

- Establish a regular (e.g., once a year) meeting at national level as a forum of experts and technical personnel for communication and sharing experience of implementing their works. This effort will broaden knowledge and improve technical expertise of the local area personnel as well as wide area personnel
- Maintain tools and equipment always in a ready to use condition to prevent them from fail to operate. Establish a 'station help station' servicing network at sub national as well as at national levels.

8) Costs

The estimation of cost of this technology faces with selecting a wide variety of options of the combination of capital costs, operations and maintenance costs, administration costs, and other costs associated with developing an enabling environment.

Given the rather high level of uncertainty that accompany technology cost estimates, the list of cost estimation of this technology (low, mid, and high estimates) are as follows:

Table 3 Accompany technology cost estimates forest-peat carbon measurement and monitoring technology

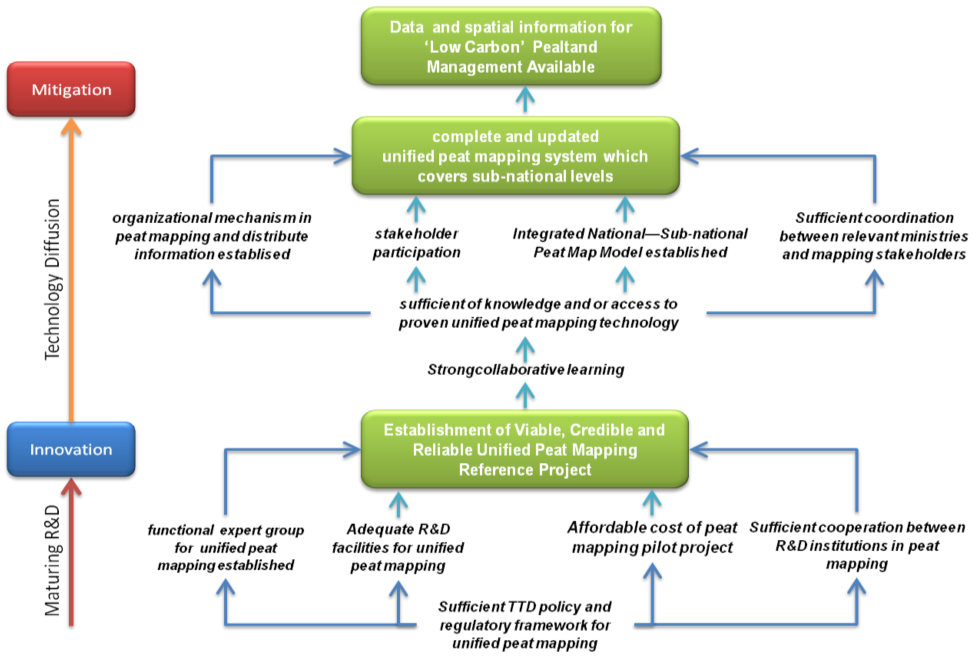
Item	Estimated Cost (USD)		
	Low	Medium	High
A. Capital costs (1 set of measurement and monitoring equipments) 1. Additional forest inventory equipments and facilities 2. Peat survey equipment and facilities 3. Allometric and peat biomass lab equipment and facilities 4. GIS, Remote sensing, and biomass modeling facilities and equipments 5. Allometric and biomass modeling development	**720,000**	**800,000**	**880,000**
B. Annual operations and maintenance cost 1. Forest inventory operation cost and supplies 2. Peat survey operation cost and supplies 3. Allometric and peat biomass lab operation and supplies 4. GIS, RS, and modeling operation and supplies	**36,000**	**40,000**	**44,000**
C. Annual administration costs 1. Data processing and analysis for forest inventory 2. Data processing and analysis for peat survey 3. Data processing and analysis for allometric and biomass modeling 4. Data processing, analysis, and cartographic for GIS and RS	**18,000**	**20,000**	**22,000**
D. Annual costs for developing and enabling environment 1. National Workshops 2 times per year @15,000 2. National Seminar and Conference once per year@25,000		 **30,000** **25,000**	

9) References and additional information

http://www.irmforestry.com/services_forest_inventory_systems.php
http://www.fao.org/docrep/007/y5490e/y5490e05.htm#TopOfPage
http://www.benmeadows.com/Eijkelkamp-Peat-Sampler_31220745/
http://en.wikipedia.org/wiki/Forest_inventory
http://www.hubbardbrook.org/w6_tour/biomass-stop/how-to-quantify.htm
http://indonetwork.co.id/MitraGunaInstrument/2478853/digital-geo-resistivity-meter-geolistrik-hp-081380328072.htm

Appendix

Figure A Objective tree of prioritized technology PRM



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[i] **This fact sheet has been extracted from TNA Report - Mitigation for Indonesia. You can access the complete report from the TNA project website http://tech-action.org/**