Terminal Evaluation Summary

1. Outline of the Project		
Country：Federative Republic of Brazil		Project title：Carbon Dynamics of Amazonian Forests (CADAF)
Issue/Sector：Forest and Nature Conservation		Cooperation Scheme：Technical Cooperation
Division in charge：Forestry and Nature Conservation Division 2, Forestry and Nature Conservation Group, Global Environment Department		Total cost (at the time of evaluation)：400 million yen
Period of Cooperation	(R/D): May 2009-May 2014	Country Partner Implementing Organization： Instituto Nacional de Pesquisa Amazonia-National Institute for Amazonian Research (INPA), Instituto Nacional de Pesquisa Espacial-National Institute for Space Research (INPE)
		Supporting Organization in Japan：(i) Forestry and Forest Products Research Institute (FFPRI), (ii) Institute of Industrial Science, the University of Tokyo, (iii) Remote Sensing Technology Center of Japan (RESTEC)

1-1 Background of the project

Greenhouse gas (GHG) emission from the deforestation was recognized as one of the key issues at United Nations Framework Conservation on Climate Change (UNFCCC), 13th Conference of the Parties (COP13) held in Bali in December 2007. At this conference, a discussion of Reducing Emissions from deforestation and forest degradation in developing countries (REDD) framework was started to conserve forests in the developing countries. Among others, forest in Amazon stores world largest amount of carbon, and deforestation of Amazonian forest became one of the prime global issues.

The REDD scheme, solely is realized with accurate quantitative evaluation of CO_2 (carbon dioxide) emission reduction achieved by the prevention of deforestation and forest degradation. Therefore the development of precise methodologies to evaluate carbon budget of forests is urged.

Under this situation, a project to develop an evaluation technique on a large-scale carbon dynamics of Brazilian Amazon forests was proposed by the government of Brazil and the Forestry and FFPRI in Japan. In response to the request, the government of Japan and Japan International Cooperation Agency (JICA) dispatched a detailed planning survey team in 2009, and agreed with the government of Brazil on the outline of the project, which aims at building a foundation on conserving Amazonian forest to contribute to the countermeasures against deforestation and global climate change, including REDD activities.

1-2 Outline of the Project

(1) Overall Goal

None

(2) Project Purpose

An evaluation technique on a large-scale carbon dynamics of Brazilian Amazon forest is developed.

(3) Outputs

1. A continuous forest inventory (CFI) system to survey carbon dynamics in central Amazon is established.
2. A relationship between forest types and carbon dynamics of primary and selectively logged forest in central Amazon is identified.
3. Carbon dynamics maps for Brazilian Amazon forest are developed, using the data from the CFI system, remote sensing techniques, and satellite images.
4. Techniques developed and information obtained in Output 1 to 3 are shared with organization related to global climate change issues, including REDD+[1] and environmental conservation.

[1] Reducing Emissions from Deforestation and Forest Degradation in developing countries; and the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in developing countries

2. Evaluation Team		
Members of Evaluation Team	＜Japan side＞ JICA: • Mr. Hirohito Takada (Japanese Team Leader) Director, Forestry and Nature conservation Division 2, Global Environmental Department • Mr. Shimpei Akatsuka (Planning Cooperation) Forestry and Nature Conservation 2, Global Environmental Department • Mr. Koji Asano (Analysis & Evaluation) Senior Engineer, Enviromental Science & Engineering Department, Nippon Koei Co., LTD Japan Science and Technology Agency (JST): • Mr. Maiko Nakamura (Senior Staff) Research Partnership for Sustainable Development Division, JST • Dr. Toru Nakashizuka (Program Officer) Program Officer of JST/ Professor of Tohoku University ＜Brazil side＞ • Dr. Luiz Marcelo Brum Rossi (Representive from Brazillian Goverment) Reseacher in Forestry and Forest Management, Brazillian Agricultural Research Corporation(EMBRAPA) – Western Amazon, Manaus/AM	
Period of Evaluation	From 18. January to 9. February 2014	Type of Evaluation: Terminal Evaluation

3. Result of Evaluation

3-1 Achievement of the Project

(1) Results of Inputs (as described above)

(2) Project Progress

1) Output 1

Out of five indicators set for the output 1, three were “achieved”, one was “under progress”, and one was “not achieved yet”.

- Indicator 1a: A total of 351 new fixed plots were established in three sites in the central Amazon.
- Indicator 1b: The project added one more site, and conducted inventories in a total of 351 CFI plots until 2013. In eleven areas where were blank areas of research until the date in the central Amazon (Amazonas state), inventories were conducted in 1,212 plots, including previously set 861 plots. Inventories were conducted for not only every trees, but also for fallen trees (dead trees) and fine roots biomass. Among these areas, carbon stock dynamics was analyzed in eight areas by implementing second surveys.
- Indicator 1c: Above- and below-ground biomass was measured for the first time in the upper Negro river basin. Data obtained was integrated into other relevant data of INPA collected in the central and lower Amazon basin, and the project developed common allometric equation, which uses dominant height of trees (average tree height of higher 20%) as a parameter. Carbon stock of each forest inventory plot was estimated using above allometric equation model. By the development of this common equation model, the uncertainty of the estimation of carbon stock by allometric equation model was reduced from 19.1% to 14.2% (western Amazon), and 13.9 % to 12.9% (eastern Amazon).
- Indicator 1d: The project developed data sets of information on GPS[2] and forest stand inventory (forest type and carbon stock). GIS[3]-based forest inventory database for central Amazon is planned to be developed by the end of the project.
- Indicator 1e: Three papers were submitted and accepted in the international scientific journals. Three papers were already submitted, and are in peer-review by international scientific journals.

2) Output 2

Out of two indicators set for the output 2, one was “achieved”, and another was “almost achieved”.

- Indicator 2a: Specific figures of carbon stock and stock change for all the inventory plots were estimated in the central Amazon. The project has been evaluating human impacts and temporal changes in forest

[2] Global Positioning System
[3] Geographical Information System

species composition, structure, carbon stock at chronologically different logged forest. The techniques on cross-dating of tree ring using carbon and oxygen stable isotope ratio enabled INPA to assess tree growth in six different forests in Amazonas state, and helped to understand tropical forest carbon dynamics in Amazon in future.

- Indicator 2b: Three papers were submitted and accepted in the international scientific journals. Five papers are planned to be submitted to international scientific journals by the end of March 2014.

3) Output 3

Out of five indicators set for the output 3, two were "achieved", one was "almost achieved" and two were "under progress".

- Indicator 3a: To be the fundamental data sets for the estimation of large area carbon stock, cloud-free MODIS[4] data, which are generated from high frequent observation data, were obtained and stored in order in time series. By using the method for above data sets, the project generated data sets of variables concerning forest site environment conditions, such as flood period, day and night ground temperature, variation of vegetation index, etc, based on MODIS data. By integrating various environment map and terrain information (SRTM[5]) into the cloud-free MODIS data sets, the project developed method to elaborate site environment map. A technique for the evaluation of carbon stock using the large-scale spatial data such as satellite images, with integrating ground data, was developed and carbon stock maps were created. The prototypes for biomass maps for the entire Amazon were elaborated: (1) maps of environment parameters, (2) a map of site environment, and (3) map of canopy height. Technology for a time series processing of large area satellite data using General Purpose Graphic Processing Unit (GPGPU) was developed, and high speed (26.6 times higher) data processing using PC became possible. By this system, cloud-free images of MODIS data were developed.
- Indicator 3b: Average carbon stock of central Amazon forests was estimated to be approximately 160 Mg C/ha by the forest inventory team. The project clarified that it is in the saturated level by the optical sensor and radar estimation. As for now, the only reliable parameter for the forest biomass estimation is canopy height, the project initially planned to survey by airborne LiDAR[6]. However, during the FY 2012, it was concluded that the implementation of airborne LiDAR observation would be impossible during the project period because of the unpredictable prospects to obtain permission from Brazilian government in near future, instead, following alternative methodologies were developed:
  1. Satellite LiDAR of ICESat[7]/GLAS[8] was introduced.
  2. Existing airborne LiDAR data were obtained and used.
  3. UAV[9] camera/laser system, in which an UAV equipped with a camera and a laser sensor (hereinafter UAV system) was developed.
- New software for processing full-wave form data of ICESat/GLAS was developed for canopy height estimation. Combined this information with site-environment conditions, methodology to estimate the canopy height of large areas was developed. By analyzing existing airborne LiDAR data and ground observation data, estimation accuracy of canopy height was clarified. The newly developed UAV system enabled to conduct LiDAR observation with ground observation.
- Indicator 3c: The project elaborated a model to estimate carbon stock of large area by integrating biomass data obtained by ground inventory with canopy height estimated by ICESat/GLAS and the variables concerning forest site-environment conditions. A large area carbon stock map (2007) with uncertainty for all pixel of 500m mesh was made using the model elaborated by the project. By the project end, Brazilian Amazon forest's carbon stock maps for 2000, 2005, and 2010 will be created.
- Indicator 3d: Carbon reduction/change map in the Amazon will be elaborated using forest carbon stock maps of 2000, 2005 and 2010.
- Indicator 3e: Three papers are planned to be submitted to the international scientific journals.

[4] Moderate Resolution Imaging Spectroradiometer
[5] Shuttle Radar Topography Mission
[6] Light Detection and Ranging
[7] Ice, Cloud and land Elevation Satellite
[8] Geoscience Laser Altimeter System
[9] Unmanned Aerial Vehicle

4) Output 4

Out of three indicators set for the output 4, one was “achieved”, and two were “not achieved yet”.

- Indicator 4a: CADAF website was designed and opened in INPA and FFPRI. The inventory dataset (2010-2013) will be uploaded as soon as possible after the project end.
- Indicator 4b: Restricted access to the remote sensing dataset is currently available for the staff of CADAF in the FTP site of UT. The remote sensing dataset will be uploaded as soon as possible after the project end.
- Indicator 4c: Seminars were held every year in Japan (four times), and Brazil (three times), and final seminar is planned to be held in April 2014. Workshops were held in Japan (two times). Every year, information dissemination regarding the project achievements has been conducted in the booth in the Asia Remote Sensing Conference, with many participants related to remote sensing in Asia (2010 Vietnam, 2011 Taiwan, 2012 Thailand, 2013 Indonesia).

(3) Progress towards the Project Purpose

Out of three indicators set for the project purpose, one was “almost achieved”, one was “under progress” and one was “not achieved yet”. All indicators are predicted to be achieved before the termination of the project.

- Indicator Project Purpose a: Evaluation of large-scale carbon stock and carbon stock change, using field and remote sensing data became possible by the project. For this continuous evaluation is planned to be conducted at INPA and INPE even after the project end. By the integration of detailed monitoring data obtained from the INPA’s experimental forests and the data from forest inventory (ground survey in multipoint plots) of the project, carbon dynamics of Amazonian forests under natural/human disturbance regimes was elucidated by the project. By analyzing the relevance between forest environment and forest stand structure information combined with ground observations, the project developed methodology for mapping carbon stock of forests and its dynamics in broad areas using satellite image and GIS data. By this, the project evaluated carbon stock change of whole Amazon in relation to deforestation.
- Indicator Project Purpose b: The final seminar is planned to be organized by the project in April 2014. For the seminar, related organizations to REDD+ and environmental conservation in Brazil are envisaged to participate [such as Chico Mendes Institute for Biodiversity Conservation (ICMBIO), EMBRAPA, private sector, etc.].
- Indicator Project Purpose c: INPA’s forest inventory technique is already well known among Brazilian governmental institutions and the results have been used on REDD+ policy development in the state level such as Amazonas, Acre and Amapa states. The large-scale evaluation techniques on carbon dynamics is based on the ground data of INPA’s long time forest inventory and its utilization by concerned institutions is envisaged to continue in future.

3-2 Review by the Five Criteria

Value judgment from the view points of the five evaluation criteria was rated as: A = Excellent, B = High, C = Medium, D = Low, E = None to be valued:

(1) Relevance

The relevance of the project was evaluated as “A” from the following reasons.

- In the latest Multi-annual Plan (PPA) of the government of Brazil (2012-2015), climate change is identified as one of the key issues in thematic program for productive development and environmental policy. In comparison with the starting time of the project, attitude toward REDD+ of the Brazilian government became more obvious, to have an interest in the development of MRV[10] system, such as the techniques being implemented in this project.
- The project purpose; an evaluation technique on a large-scale carbon dynamics of Brazilian Amazon forests is developed, is consistent with INPA's organizational mission. Alignment of the project meets the needs and expectation of relevant institution/personnel in charge of research in carbon dynamics of Amazonian forests.
- Since the mid 1990s, JICA has been accumulated knowledge and experience for the conservation of

[10] Measurement, Reporting and Verification

Brazilian Amazon forests in the past 18 years, through: 1)"Brazilian Amazon Forest Research Project" (1995-1998), 2)"Brazilian Amazon Forest Research Project Follow-up" (1998), 3)"Brazilian Amazon Forest Research Project Phase II" (1998- 2003), 4)"Sustainable Use of Forest Resources in Estuary Tidal Flood plains in Amana" (2005-2009), 5) "The project for utilization of ALOS[11] images to protect Brazilian Amazon and combat against illegal deforestation" (2010-2013). Among them, three were implemented jointly with INPA. The past results and cooperation relationship acquired through the three projects could be utilized in the project.

- Modeling of biomass estimation and up-scaling techniques of plot data to GIS is more advanced in Japan. Modeling with time-series remote sensing data for surface environment mapping is more advanced in Japan. Forest carbon stock modeling by combining various kinds of data (high-low resolution remote sensing data, airborne-satellite LiDAR, numerical and categorical map and field GIS data) is advanced in Japan.
- Japan's Official Development Assistance Charter addresses global warming and environmental problems as one of the priority issues. Japan's Medium-Term Policy of Official Development Assistance (2005) states environmental sector as one of the most important sectors. Japan's Country Assistance Policy for Brazil (2012) states environmental conservation as one of priority areas.

(2) Effectiveness

The effectiveness of the project was evaluated as "B" from the following reasons:

- By assessing the attainment level of indicators for each output, it is concluded as: 1) Output 1 would be fully achieved by the end of the project, 2) Output 2 would be fully achieved by the end of the project, 3) Output 3 would be produced by the end of the project, but the level would be lower than originally planned due to external factor beyond control of the project (i.e. obtaining permission on airborne LiDAR) and 4) Output 4 needs to have special efforts for its achievement.
- Dedicated efforts have been made towards the achievement of outputs and the progress is presumably as expected in achieving the project purpose by the project end with continuous effort of the Brazilian and Japanese sides. Although their level of achievement of outputs varies at this moment (Feb 2014), they will contribute to the achievement of the project purpose.
- Considering the importance of the Amazon forests, sharing the results of the project for the practical benefit in local and global society is desirable, for that, promoting the information dissemination by using a database or other medium was scheduled in the Project Design Matrix (PDM). The project is expected to deepen the cooperative relationship between INPE and INPA, and to promote information dissemination and the practical application of technology to help the society.

(3) Efficiency

The efficiency of the project was evaluated as "A" from the following reasons:

- Inputs from the Brazilian and Japanese sides have been mostly appropriate in producing the outputs in terms of timing, quality and quantity. The Inputs are considered to have contributed to the production of the outputs mostly. All Japanese experts are concluded to be with appropriate experiences and sufficient technical skills by the Counterpart (C/Ps). Man-Day (MD) for each expert is considered to be efficiently assigned based on the necessity arisen in the project.
- The number of the participants, duration and timing of the C/P trainings were considered to be appropriate. All of the training participants have been directly involved in the project, and their contribution for the project became more obvious after the trainings. They were keen to share knowledge and skills obtained with their colleagues that contributed to have outputs efficiently.
- Technology/knowledge transfer was done mainly through collaborative work of staff members from INPA, INPE and JET, which was valued to have synergy effects in the researches. All of the respondents of interviews in INPA and INPE believe that technology/knowledge transfer and exchange by JET were excellent and efficient. Many of field works have been conducted in close collaboration among staff members of INPA and JET. Besides, in counterpart training in Japan, under the express purpose, such as to present research results at international scientific journals or academic conferences in near future,

[11] Advanced Land Observing Satellite

many biomass related analysis was jointly conducted. By conducting entire process, from the primary data collection in the field to compilation of data in laboratory, in collaborative manner, INPA staff members became technically self-sustainable to conduct surveys/studies by themselves.

- The project was originally planned to conduct airborne LiDAR observation over all the forest inventory sites during project period. However, LiDAR observation was not conducted due to complexity of bureaucratic process to obtain the permission from the government of Brazil, as well as the optimistic prospect observed by JICA and JET at the initial stage of the project.

(4) Impact

The impact of the project was evaluated as "A" from the following reasons:

- The project introduced a lot of new techniques, thus made positive impact in the fields of researches (for specific techniques, please refer to Annex 13). Besides, the project achieved to establish 1,212 plots in the central Amazon where were blank areas of research until the date. It is assumed to contribute researches in various aspects of Amazonian forests significantly in future. The project enhanced significantly the quantity and quality (accuracy and reliability) of data owned by INPA, regarding Amazonian forest biomass and remote sensing. INPA and Forest Management Laboratory is now are taking a vital role as a representative institution of Brazil for the negotiation for REDD issues with international agencies.
- JICA's Third Country Training was conducted three times (2011-2013) in INPA, principally by C/Ps of CADAF, using techniques and knowledge introduced by the project. It contributed to share project results with organizations in Latin America related to global climate change issues including REDD+ and environmental conservation.

(5) Sustainability

The prospect of sustainability was evaluated as "A" from the following reasons:

<Prospect from institutional and organizational viewpoint>

- Brazil's current legislative framework and policy/strategy for the management of Amazonian forest will continue after the termination of the project. Also, INPA's institutional role and mandate regarding the research/study of the project is most likely to continue.
- Six out of nine researchers/technicians who have been involved in the project are permanent position, whose future employments would be ensured. Eight out of eighteen C/Ps are post-doctoral staff, masters' or doctors' students whose future employment is not guaranteed. Only one permanent staff member for remote sensing group in the Forest Management Laboratory of INPA.
- INPE's concern on deforestation of Amazon forests started with PRODES[12] and DETER[13] in 1998. The policy/program will continue after the termination of the project. INPE has been participating in the project as a part of its institutional role or mandate, therefore institutional support is most likely to continue in future. Also, current organizational structure would not have major alternation in near future. All of three C/Ps in INPE are permanent employees, which employment will be sustained even after the project termination.

<Prospect from technical viewpoint>

- Specialists of INPA are already equipped with high-level technical capacity. The techniques and methods transferred through the project as well as the deliverables are relevant with the needs and technical levels of INPA, so that they are expected to be continuously utilized after the project end.
- For the isotope analysis in dendrochronology field and fine root analysis, collaboration with Japanese researchers on sample collection and analysis is planned to be continued after the project termination, and expected to submit several scientific papers in future. Also, new techniques transferred from JET will be shared with others researchers and students in INPA.
- To ensure technical sustainability of the remote sensing group of the Forest Management Laboratory of INPA, continuous updating of techniques is needed. External assistance will be required especially for LiDAR data analysis and processing.
- INPE's project staff members are already highly equipped with technical skills, so that they will continue

[12] Project for Monitoring of Deforestation in Legal Amazon
[13] System for Detection of Deforestation in the Legal Amazon in Real Time

concerned works by themselves.

<Prospect from financing viewpoint>

- During the project period, almost all the cost for project implementation (forest inventories, workshops, seminars, trips, employments, etc.) has been borne by JICA. After the termination of the project, cost for continuous activities in full scale as the project has been conducted should be secured by Brazilian side.
- The government budget, except staff emolument, is limited in INPA. External financial source, such as academic grants, scholarship, etc. will be continuously required in future. Also, continuous financial input will be required to replace broken parts or corrective maintenance of unexpected system failure for technical equipment such as UAVs provided by the project.
- Travel cost to visit INPA as a part of project requirement was borne by INPE. Later, nobody from INPE participated in the second workshop because of its financial constraints. Although, INPE's budget, except staff emolument, is limited, extra financial input will be required to enhance man to man communication and interaction with INPA.

4. Recommendation and Lesson Learned

4-1 Conclusion

The project successfully revealed large-scale carbon stock dynamics of Amazon, using field data obtained in 1,212 inventory plots and remote sensing data by dedicated efforts and innovative methodologies. By this, continuous evaluation on carbon dynamics became possible to be conducted by INPA and INPE that will give great impact on the discussions on REDD+ and sustainable management of Amazon forests in not only Brazil also worldwide.

Considering the importance of the Amazon forests, sharing the results of the project for the practical benefit in local and global society is desirable, for that, the project is expected to deepen the cooperative relationship between INPA and INPE to promote synergy effects in researches, and also to further promote information dissemination.

Based on the long time cooperation between Brazil and Japan for the sustainable forest management of Amazon since 1995, this project has successfully achieved most of expected results, and presumably will achieve the project purpose before the end of the project. The terminal evaluation team would like to express sincere appreciation to all the members of the project, and deems that the cooperation between Brazil and Japan will continue in future.

4-2 Recommendations (specific measures, proposals and advice to the project)

(1) Recommendations by the project termination

1) Further strengthening the collaborative relationship between INPA and INPE

At the time of the mid-term review, the necessity of further strengthening collaborative relationship between INPA and INPE was pointed out; however the terminal evaluation team concluded that it is not fully achieved.

After the mid-term review, m spite of dedicated efforts made by INPA and INPE, the permission of Airplane LiDAR was not granted according to unexpected circumstances, as a result, necessity of collaborative work became lower, and the actual collaboration has not occurred sufficiently. Both institutes are expected to further strengthen the collaborative relationship through joint implementation of the technical meeting and the final seminar as mentioned below

2) Strengthening of the management structure for UAV-LiDAR

Two UAV-LiDARs were introduced by the project, and investigation using UAV-LiDAR has been carried out by INPA. However, since the management structure appeared to be not robust, there is a concern that after the end of the project, related activity will stagnate by unexpected circumstances. Therefore, by the end of the project, INPA is expected to consider matters relating to strengthen management structure for UAV-L1DAR especially in the points listed below. The Japanese side should consider for further dispatch of Japanese researchers and technology transfer as needed.

i) Increasing the number of UAV operator (currently one person)

ii) Increasing the number of UAV team (currently three persons, including the operator)

iii) Securing of maintenance costs, including cost for repairs when accident occurred

iv) Securing the cooperation of INPE and INPA, including the improvement of the algorithm of analysis

software

3) Data sharing between INPE and INPA

In order to further develop the carbon stock map as a principle project achievement, continuous collaboration between INPA, as a responsible institute for ground inventory, and INPE, as a responsible institute for remote sensing, is essential. For that, data sharing between both institutes is required. Therefore, INPA and INPE are expected to have an agreement formally by the project end, regarding data sharing method and sharing contents (e.g., time, scope, item, etc.) for after the end of the project.

4) Dissemination of project results to relevant institutes

The project succeeded to reveal the carbon stock in the Amazon which is a matter of great interest worldwide. It is desired to spread the results of the project to relevant agencies involved in REDD+ in Brazil. Therefore, the project should ensure the activity 4a and 4b, "web publishing of inventory and remote sensing datasets" as soon as possible since it is not yet achieved. Furthermore, in the final seminar to be held in April 2014, the project should invite REDD+ related organizations of Brazil [Ministry of the Environment, Ministry of Foreign Affairs, Ministry of Science and Technology, the state governments of Amapa, Acre, Amazonas, EMBRAPA, Brazilian Institute of Environment and Renewable Natural Resources (IBAMA), etc.], conduct the seminar with close consultation among INPA, INPE, FFPRI, and the University of Tokyo, and work on publication to spread the project results.

(2) Recommendations after the project termination:

1) Continuous dissemination of project results to REDD+ related organizations

It is predictable that the federal government, research institutes, state governments, private companies, NGOs in Brazil, are considered to play an important role in implementation of the carbon credit mechanism in the framework of the future REDD+. As carbon credit mechanism is a course of discussion in the international community today, presenting multiple options of evaluation method of carbon dynamics is a valuable. Thus dissemination of research results of the project should be continued even after the end of the project.

2) Continuation and development of inventory

By overcoming the various difficulties, the project installed 1,212 inventory plots in systematized method in the central Amazon where required more detailed investigation, and achieved to have an estimate of carbon stock with practically low uncertainty. This is one of great results of the project, therefore continues efforts are required to develop it even after the project end. The inventory plots should be utilized for the researches not only on carbon dynamics, but also various other researches which lead to sustainable forest management of Amazon in future.

3) Utilization of the carbon stock map

The project results and importance of sustainable Amazon forest management should be widely known by public to raise awareness. INPA with collaboration of other institutes if necessary is expected to conduct concerned act1v1ties such as follows:

i) Extended project homepage with access to publications (theses, dissertations, presentations, lectures and papers published during the project), and maps of carbon stocks, forest type, and others.
ii) Summarized publications (executive summaries) to municipal governments to be utilized for their decision making.
iii) Environmental education booklets and publications for sustainable Amazon forest management with technical language for students of different levels, from elementary level (children 8-14 years) to technical courses (agricultural and/ or forest) and university level.

4-3 Lesson learned

(1) Management for the project assumption

Permission for the aerial survey could not be obtained from the military, as the project is involved by the foreign agency, and airborne-LiDAR survey was not conducted. As a result, it had a profound negative impact on subsequent activities. In case that the project assumption was recognized not to be fully reasonable at the start of

the project, it should be adequately aware of as a risk factor, and to have prior consensus among prior consensus stakeholders about the timing of decision-making and alternative activities is essential to minimize the risk.

(2) Promotion of regular management meeting

SATREPS[14] has the tendency that the researchers promote their own researches. Therefore, the leadership of the principal investigators in both countries is necessary for the promotion of project management. However, there are presumably difficult matters to be solved only in this way. Especially in this project, there was a need of support from JICA in the process of acquirement of permission for airborne L1DAR flight, the intercommunication between INPA and INPE, and the implementation of Joint Coordinating Committee (JCC) meetings. For the future, in similar cases/projects, we see the necessity to promote management meetings among the local office and headquarters of JICA and the principal investigators.

[14] Science and Technology Research Partnership for Sustainable Development