地球規模課題対応国際科学技術協力

マレーシア国
生物多様性保全のためのパーム油産業による
グリーン経済の推進プロジェクト

終了時評価報告書

平成29年6月
（2017年）

独立行政法人国際協力機構
地球環境部

環境
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地　図

ラムサール条約
登録湿地
キナバタンガン河・セガマ河流域
クロッカー山脈公園
PHILIPPINES
MALAYSIA
INDONESIA
BRUNEI
South China Sea
Sulu Sea
Sulawesi Sea
Kota Kinabalu
Labuan
Kudat
Marudu Bay
Paitan Bay
Labuk Bay
Marchesa Bay
Kimanis Bay
Cowie Harbour
SULU ARCHIPELAGO
KALIMANTAN TIMUR
STATE OF SARAWAK
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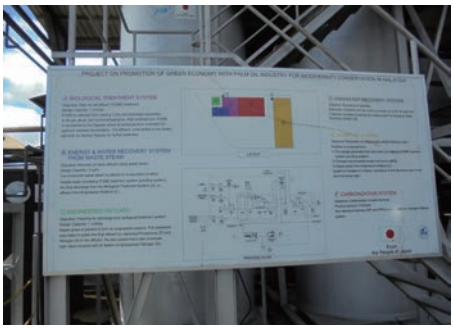
別　図

写　　真

UMS に設置されている供与機材

山仙式炭化炉を用いて
製造されたバイオ炭



ゼロ・ディスチャージシステム
に関する説明

ケニンガウ・パーム油工場内の
山仙式炭化炉

コンポスト用供与機材

サバ州長官への本事業の
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マレーシア評価団からのコメント

JCC での署名の様子

略　語　表

BOD	生物化学的酸素要求量
CO	一酸化炭素
EFB	空果房
JICA	独立行政法人国際協力機構
JCC	合同調整員会
JST	独立行政法人科学技術振興機構
KPOM	ケニンガウ・パーム油工場
MF	中果皮繊維
PDM	プロジェクト・デザイン・マトリックス
SATREPS	地球規模課題対応国際科学技術協力
SDBEC	サバ州を拠点とする生物多様性・生態系保全のための持続可能な開発プロジェクト
UMS	マレーシア国立サバ大学
UPM	マレーシア・プトラ大学

終了時評価調査結果要約表

1．案件の概要		
国名：マレーシア		案件名：生物多様性保全のためのパーム油産業によるグリーン経済の推進プロジェクト
分野：自然環境保全		援助形態：地球規模課題対応国際科学技術協力（SATREPS）
所轄部署：地球環境部森林・自然環境グループ		協力金額（評価時点）：約 3.8 億円（JICA 負担分）
協力期間	(R/D)：2013 年 11 月 21 日～2017 年 11 月 20 日	先方関係機関： マレーシア・プトラ大学（以下「UPM」）、マレーシア国立サバ大学（以下「UMS」）、サバ州天然資源庁
他の関連協力：技術協力プロジェクト「生物多様性・生態系保全のための持続可能な開発プロジェクト」（以下「SDBEC」）		日本側協力機関：九州工業大学大学院生命体工学研究科、独立行政法人産業技術総合研究所、九州大学大学院農学研究院

1-1 協力の背景と概要

マレーシア・サバ州の最大河川であるキナバタンガン河流域には、ラムサール条約登録湿地をはじめ、森林保護区や野生生物保護区が点在しており、希少な野生生物の生息域として重要である。サバ州ではパーム油産業が州の基幹産業であり、キナバタンガン河上流域には、300 以上のアブラヤシ農園と28の搾油工場が存在する。農園で使用される農薬や、旧式の排水処理システムで稼働する搾油工場から排出される処理水等が原因で、河川の水質汚濁が発生しており、地域の生物多様性への影響が懸念されている。九州工業大学とUPMは、バイオマスを原料にしたプラスチック（バイオプラスチック）を製造する技術を共同開発した。その上で、バイオマスの供給源としてアブヤラシに着目した。すなわち、アブラヤシの搾油工場からは安価なバイオマス（空果房、中果皮繊維等）が通年で大量に発生し、品質も安定しているので、これを有効に活用することができれば、新しい産業の創出につながることになる。現在、マレーシアの多くの搾油工場は旧式の非効率な設備を使用しているため、バイオマスはほとんどエネルギー源として消費されており、パーム油圧搾廃液（以下、「廃液」という。）から生じるメタンガスや廃熱も有効活用されていない。このため、搾油工程の見直しや

効率的な設備の導入を通じて生産効率を改善することで、環境負荷を軽減させるとともに、新たに発生する余剰バイオマスや余剰エネルギー（廃液を効率的にメタン発酵させ、エネルギーとして活用）を有価値化して、バイオプラスチック、活性炭、廃液由来の肥料等の新製品を開発することにより、新たなビジネスモデルを創出することが期待される。

マレーシア側の UPM、UMS 及び日本側の九州工業大学、産業技術総合研究所、九州大学により構成される共同研究チームは、上記の技術やビジネスモデルの実現可能性及び有効性を検証するため、SATREPS 事業として本事業を 2013 年 11 月から 4 年間の予定で実施している。2012 年に署名された協議議事録に基づいて本事業終了半年前である 2017 年 5 月～6 月にマレーシア側関係者とともに合同終了時評価が実施された。

1-2協力内容

日馬の研究機関（UPM、UMS、九州工業大学、産業技術総合研究所、九州大学）は合同で、マレーシア（特にサバ州）においてバイオマスや余剰エネルギーの有効活用技術の開発やビジネスモデルの開発を行い、グリーン経済の振興と、パーム油廃液由来の汚染物質の軽減による生物多様保全を目指す。

（1） 上位目標

マレーシアのパーム油産業においてグリーン経済が振興し、パーム油廃液による汚染物質の軽減により、キナバタンガン河流域を含むサバ州の関連地域の生物多様保全に貢献する。

（2） プロジェクト目標

パーム油産業の持続可能なグリーン産業への変容に向けて、ビジネスモデルのための革新的な知見と実行可能な技術が開発され、潜在的ユーザーによって肯定的に共有される。

（3） 成果

1. パーム油搾油工場に設置されるゼロ・ディスチャージ試験設備において、バイオマス・余剰エネルギーのエネルギー効率改善を通して、ゼロ・ディスチャージの効果が実証される。
2. ゼロチャージ及び余剰バイオマスと余剰エネルギーを活用した新しい産業を

通して、ビジネスモデルの有効性が検証される。

3. パーム油搾取工程に起因する環境負荷軽減のためのパーム・バイオマスとエネルギーの有効活用に関する革新的な研究が進む。

4. ビジネスモデルの有効性と研究成果が、サバ州政府とマレーシア国内外の投資・企業により広く共有され認知される。

(4) 投入(評価時点)

日本側:総投入額 3.8億円

長期専門家派遣	2名	機材供与	1.1億円
短期専門家派遣	14名	ローカルコスト負担	635万円
研修員受入	23名		

相手国側:

カウンターパート配置 41名

ローカルコスト負担 155万リンギット(2016年8月時点)

長期専門家用事務局スペース提供(通信費・光熱費含む)

2. 評価調査団の概要

調査者	担当分野	氏名	所属先・職位
	団長/総括	鈴木和信	JICA 地球環境部自然環境第一チーム 課長
	協力企画	飯塚令子	JICA 地球環境部自然環境第一チーム 専門嘱託
	SATREPS 計画・評価	堤敦司	JST 研究主幹 / 東京大学生産技術研究所教授
	SATREPS 計画・評価	上阪圭介	JST 主任調査員
	評価分析	石飛愛	合同会社 適材適所 コンサルタント
	マレーシア側評価団	Dr. Abdul Wahab bin Mohammad	マレーシア・ケバングサン大学 化学・プロセス工学部教授
	マレーシア側評価団	Nur Farahin Fazira binti Mohd Munim	高等教育省高等教育局高等教育機関研究開発推進計画部(HEI Excellence Planning)副主幹

調査 期間	2017年5月28日～ 2017年6月10日	評価種類:終了時評価

3.評価結果の概要

3-1 実績の確認

成果1はほぼ達成されている。活動は一つを残してすべて終了し、成果1に関する指標も達成している。成果2はほぼ達成している。成果2の指標はともに達成しているが、いくつかの活動は終了時評価の時点で終了していない。成果3もほぼ達成されている。終了時評価までに全ての活動は終了し、指標もほぼ達成されている。成果4は達成されている。終了時評価までに全ての活動が終了し、指標も達成しており、ビジネスモデルと研究成果の広報に関しては、一定の成果を上げている。

プロジェクト目標に関しては、概ね達成されている。終了時評価の時点では指標 1は達成していないものの、この指標はそもそも野心的過ぎたと考えられる。研究成果・人材育成に関しては想定以上の成果をあげている。

3-2 評価結果の要約

(1) 妥当性:比較的高い

本事業はマレーシアと日本の政策に合致しており、妥当性は比較的高い。本事業は国家と州の開発政策・プログラム、また国家と州のバイオマス戦略に合致しており、これらの戦略に貢献することができる。本事業は環境管理を含む国民福祉への貢献を目的としている日本のマレーシアへの支援政策とも合致している。上位目標とプロジェクト目標の間に乖離がある。社会実装の為のビジネスの専門性のある人的リソースが限定的である以上、上位目標とプロジェクト目標の指標はやや現実的ではない。

(2)　有効性:比較的高い

プロジェクト目標の達成見込みと中間レビューの提言の実施状況から、本事業の有効性は比較的高いと判断された。本事業により得られた知識や技術が潜在的ユーザーや政策担当者に届けば、プロジェクト目標は事業終了までに達成する可能性がある。本事業はまたマレーシア人研究者の人材育成とバイオテクノロジーと生物多様性の分野での研究の進展に貢献している。中間レビュー時の提言は、ショーケース設備の今後の管理計画の作成以外は全て実施されている。

(3)　効率性:比較的高い

本事業の効率性は投入が概ね初期の成果を達成するために活用されていることから、比較的高い。ほとんどのリソース(日本人専門家の派遣、カウンターパートの配置、本邦研修、活動資金の支出)は質・量ともに問題なく、遅滞なく投入され、事業実施のために効果的に活用された。

供与機材の質・量・供与のタイミングは十分であったが、一部の機材(炭化炉)の活用に課題があり、解決の必要がある。またショーケース設備の建設の遅れにより、ゼロ・ディスチャージ技術の開発に関する活動に支障が出た。

(4)　インパクト:比較的高い

本事業のインパクトは上位目標の達成見込みとこれまでに発現した正の効果により比較的高い。現在の上位目標は社会実装の為のリソースが限定的な状況では実現が難しい指標となっており、3 年以内の達成は困難である。上位目標も本事業から開発された技術を幅広く含めるよう修正される必要がある。本事業により、マレーシアと日本における人材育成、研究の進展、政府や企業のゼロ・ディスチャージ技術に関する認知の向上といった正の効果が発現している。本事業による負の効果は発現していない。

(5)　持続性:高い

本事業の持続性はあらゆる観点から判断して高い。本事業の政策的・制度的観点における持続性は高い。本事業の政策的環境は事業開始時点から変化はない。各研究機関間の共同研究については、既存の協定があることから今後も継続される見込みである。財政的・体制的持続性も高く、UPM と UMS の過去数年間の大学としての収入にも大きな問題はない。人的資源に関する持続性は高い。チーフアドバイザーとプロジェクト・マネージャーはともに数年後に退官になるものの、後継の研究者は育っており、本事業を通じて国内外の研究者とのネットワークも形成することができた。

技術的な持続性も高い。本事業により移転された技術と知識および供与機材の維持管理に関しては論文やマニュアルを通じて共有されている。機材の維持管理に

関しては担当の学生やスタッフが割り当てられて定期的に維持管理を実施しており、また故障しても現地の業者により修理が可能である。過去のJICA事業による両大学への供与機材もきちんと維持管理がなされている。

3-3 効果発現に貢献した要因

(1) 計画内容に関すること

チーフアドバイザーとプロジェクト・マネージャー(UPM)間の長年の間に培われた信頼関係と、SDBECを含む過去のJICA事業によって築かれた副プロジェクト・マネージャーとJICA間の信頼関係により、本事業の実施がスムーズに行われた。

(2) 実施プロセスに関すること

チーフアドバイザーのカウンターパート機関での長期駐在が活動の実施促進に繋がった。

3-4 問題点及び問題を惹起した要因

(1) 計画内容に関すること

特になし。

(2) 実施プロセスに関すること

ショーケース設備設置予定地域の治安の悪化により、設備設置と関連実験が大幅に遅延した。

また、為替レートの急激な変化により、事業予算が著しく目減りした。これはビジネスコンサルタントの調達予算に影響した。

3-5 結論

結論として、本事業は幾つかの活動に遅れが出たものの、中間レビュー以降問題なく実施されている。本事業に基づいた技術と知識がさらに潜在的ユーザーや政策担当官と共有されれば、プロジェクト目標は事業終了までに達成できる可能性がある。5 項目評価では、妥当性ではプロジェクト・デザインが一部適切でなかったものの、マレーシアと日本の政策に一致していることから妥当性は比較的高い。プロジェクト目標の達成見込みと中間レビューの提言の実施状況から有効性は比較的高い。効率性も比較的高く、ほとんどの投入が所期の成果を達成するために活用されている。インパクトも上位目標の達成見込みと終了時評価までに発現した複数の正の効果によ

り比較的高いと判断された。政策・制度的側面、財政・体制面、技術的側面のすべての側面で持続性が高いことから、本事業の効果の持続性は高い。終了時評価調査団は、本事業によってゼロ・ディスチャージ技術が開発され、関連分野の研究が進展し、本邦研修等を通じて人材育成に大きく貢献したことを確認した。

3-6 提言

ショーケース設備の管理計画の最終化

ショーケース設備での活動の持続性を確保するために、同設備の最終管理計画はUPMによってマレーシア側の本事業の終了時（2018年8月）までに準備される必要がある。

3-7 教訓

(1) 定期的な会議によるPDMの適宜修正

事業の実施期間中にPDMと現実との乖離が認識されがちである。このような乖離を避けるために、定期的に会議を開いて事業の進捗を確認し、進捗状況や課題に沿ってPDMを適宜修正するべきである。

(2) 民間連携による社会実装をプロジェクト目標とする場合、ビジネスの専門家の知見をPDMに反映

民間連携による社会実装をプロジェクト目標とする場合、PDMの設計に際してビジネスの専門家からの知見を反映させるべきである（本プロジェクトに関し、プロジェクト目標の指標として「実際の投資を考慮しはじめる」とあるが、「実際の投資」の定義が曖昧であった）。

終了時評価調査結果要約表（英文）

Summary Results of the Terminal Evaluation Study

I. Outline of the Project	
Country: Malaysia	Project Title：The Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation
Issues/Sector: Nature Conservation	
Division in Charge: Environment Team1, Forestry and Nature Conservation Group, Global Environmental Department, JICA	Estimated Total Cost: Approx. JPY 381 million yen (JICA budget)
	Cooperation Scheme：Science and Technology Research Partnership for Sustainable Development (SATREPS)
Period of Cooperation:(R/D) November 1, 2013 – November 30, 2017 (four years)	Related Organizations in Japan: Kyushu Institute of Technology (Kyutech), Kyushu University, National Institute of Advanced Industrial Science and Technology (AIST)
Counterpart Agency：Universiti Malaysia Sabah (UMS), Universiti Putra Malaysia (UPM)	

1-1. Background of the Project

The Kinabatangan and Segama river basin is the largest watershed in the state of Sabah, Malaysia. It embraces a number of protected areas and forest reserves, which function as important habitats for rare and endangered species. The palm oil industry is a key industry in Sabah. In fact, there are more than 300 oil palm plantations and 28 palm oil mills within the Kinabatangan and Segama river basin. Water pollution has become an issue caused by farm chemicals from the oil palm plantations and by treated water discharged from the outdated treatment system of the mills. These factors are considered to have a negative impact on the biodiversity.

Kyutech and UPM have jointly developed the technology for the production of bio-composite plastics from the palm biomass. For example, in Japan, rice straw and bamboo were used as biomass in a pilot basis, but it is difficult to secure the materials with uniform quality at feasible costs throughout the year. In Malaysia, a large quantity of biomass (e.g. empty fruit bunch and mesocarp fibre) with stable quality has been produced throughout the year from palm oil mills, and a new business/industry can be created by the effective utilisation of biomass. Presently, a major part of the biomass is consumed as energy sources by inefficient facilities at the mills. Surplus biomass and energy can be generated with more advanced, efficient facilities. Excess biomass and energy can be traded and would generate additional profits. The improved energy efficiency and proper utilisation and recycling of palm oil mill effluent would result in the reduction of environmental burden.

The joint research team between UPM and UMS in Malaysia and Kyutech, AIST and Kyushu University in Japan proposed a project to provide evidence on the feasibility of technologies and viability of business model mentioned above (hereinafter referred to as “the Project”) which was approved by the Government of Japan under the scheme of SATREPS.

The Project started in November 2013 and will be completed in November 2017. In May to June 2017, 6 months before the termination of the cooperation period, the Project was required to undergo a terminal evaluation in accordance with the Minutes of Meetings signed for the Project in November 2012. JICA and Japan Science and Technology Agency (hereinafter referred to as “JST”) dispatched the Japanese Evaluation Team to Malaysia for the purpose of conducting the terminal evaluation which was undertaken jointly with Malaysian authorities concerned.

1-2. Project Overview

(1) Overall Goal

Green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through reduction of pollutants due to waste water in relevant areas in Sabah including Kinabatangan.

(2) Project Purpose

Innovative knowledge and viable technologies for business models are developed and shared positively among the potential users for the transformation of palm oil industry into sustainable green industry.

(3) Outputs

1) The effectiveness of zero-discharge is ensured through energy efficiency improvement resulting surplus biomass and excess energy at showcase facilities of zero-discharge established at an oil mill.
2) Viability of business model is verified through the proposed zero-discharge and creation of new industry from surplus biomass and excess energy.
3) The innovative research is pursued on the effective utilisation of palm biomass and energy for the reduction of environmental burden caused by palm oil processing.
4) Validity of business model and the research results are shared extensively and recognised within the Sabah

Government and domestic/international investors and firms.

(4) Inputs (as of Terminal Evaluation)

Japanese Side:

a. Experts: 16 experts were dispatched to Malaysia 115 times (2,205 days in total)
b. Training opportunities: 23 researchers participated in the training in Japan.
c. Provision of equipment and materials: Equipment for laboratory experiments and the showcase facility were provided, which were equivalent to JPY 116 million.
d. Local operational costs: JPY 6.35 million (for fees for vehicles, airfares and other travel expenses)

Malaysia Side:

a. Counterpart personnel assigned to the Project: 43 researchers and government officials
b. Office space and facilities for Project Coordinators by UMS
c. Local operational costs: RM 3 million. As of August 2016, RM 1.55 million was spent.

II. Evaluation

Terminal Evaluation Team

Name	Position	Affiliation
Mr. Kazunobu Suzuki	Leader	Director, Natural Environment Team 1, Forestry and Nature Conservation Group, Global Environment Department, JICA
Ms. Reiko Iitsuka	Cooperation Planning	Technical Advisor, Natural Environment Team 1, Forestry and Nature Conservation Group, Global Environment Department, JICA
Prof. Dr. Atsushi Tsutsumi	SATREPS Planning and Evaluation	Research Supervisor, JST/ Project Professor, Institute of Industrial Sciences, The University of Tokyo
Dr. Keisuke Kosaka	SATREPS Planning and Evaluation	JST
Ms. Ai Ishitobi	Evaluation Analysis	TekizaiTekisyo LLC
Prof. Dato' Ir. Dr. Abdul Wahab bin Mohammad	Evaluation	Professor, Department of Chemical and Process Engineering Universiti Kebangsaan Malaysia
Ms. Nur Farahin Fazira binti Mohd Munim	Evaluation	Assistant Director, HEI Excellence Planning Division, Higher Education Department, Ministry of Higher Education

Period of Evaluation: May 28, 2017 - June 10, 2017 | **Type of Evaluation:** Terminal Evaluation

III. Results of Evaluation

3-1. Achievements

Output 1 : Almost achieved.

All the planned activities except for development of a model operation and maintenance plan for future commercial plants were completed. All indicators of Output 1 were achieved. Based on the results, achievement level of Output 1 at the time of the terminal evaluation is high and the results show that the idea of zero-discharge was proved through energy efficiency improvement resulting surplus biomass and excess energy at the showcase facility.

Output 2 : Almost achieved.

While both indicators were achieved, some activities were not completed at the time of the terminal evaluation. With regard to validation of profitability of business models, although discussions with related firms on business models have been ongoing, it is unknown when profitability can be validated with them since it depends on whether the firms will adopt a business model or not. Given the feedback on the business models from the palm oil industry, however, the models need to be revised to make it more appealing to the industry.

Output 3 : Almost achieved.

Activities were completed by the time of the terminal evaluation. All indicators except for the scientific evaluation on the impact of zero-discharge on the biodiversity recovery were achieved. Based on the evaluation, achievements of Output 3 show that knowledge and technologies for the effective utilisation of palm biomass and energy were developed to reduce environmental burden caused by palm oil processing.

Output 4 : Achieved.

Completion of all activities and achievements of all indicators by the time of the terminal evaluation indicate that the business model and the research results were widely shared and recognized.

Prospects for achieving the Project Purpose:

The business models developed from the Project have been positively recognized by three large Japanese companies and 11 Malaysian and Japanese companies expressed their willingness to apply the technologies and research results that were developed from Output 3. Although Indicator 1 was not achieved at the time of the terminal evaluation, the evaluation team finds that this indicator is rather ambitious. In terms of the output related to researches, outputs have been produced more than planned. The number of peer-reviewed research articles published by the Project team was twice as many as the original target. Some of them were published by scientific journals with high impact factors. The Project also achieved development of human resources more than planned. Through this Project, a total of 22 Malaysian students already received PhD and master's degrees. Some of those students obtained positions as a lecturer nationally or internationally.

Based on the results of Indicator 1 and 2, the project purpose ("Innovative knowledge and viable technologies for business models are developed and shared positively among the potential users for the transformation of palm oil industry into sustainable green industry.") is likely to be achieved by the end of this project if technologies and knowledge generated from the Project are further outreached to potential users and policy makers.

3-2. Evaluation Results by Five (5) Evaluation Criteria

Results of the Terminal Evaluation by the five (5) evaluation criteria are summarized below.

(1) Relevance: Relatively High

The relevance of the Project is relatively high since the Project is aligned well with Malaysian and Japanese policies and has some issues in the project design. The Project is well-aligned with the national and state development policies and programme of Malaysia, and the national and state biomass strategies and can contribute to them. The Project is in line with the Japanese assistance policy for Malaysia too. There is dissociation between the Overall Goal and the Project Purpose, and the indicators of the Overall Goal and the Project Purpose are rather ambitious given the limited resources (e.g. expertise in business) for social application.

(2) Effectiveness: Relatively High

The effectiveness of the Project is assessed as relatively high given the prospects of achieving the Project Purpose and the implementation status of the mid-term review. The Project Purpose can be achieved by the end of the Project if technologies and knowledge generated from the Project are further outreached to potential users and policy makers. The Project also contributed to development of human resources by providing higher education for Malaysian students, and to advancement of researches in the fields of biotechnology and biodiversity. Most recommendations of the mid-term review were followed up except for making the future management plan of the pilot plant.

(3) Efficiency: Relatively High

The efficiency of the Project is assessed as relatively high as most inputs were well utilized to produce the expected outputs. The quality and quantity of most inputs (the dispatch of JICA experts, assignments of Malaysian counterparts, provision of training in Japan, and disbursement of the counterpart and Japanese funds) were sufficient, delivered in a timely manner and well utilized for project activities. Although the quality, quality and timing of the equipment provided were sufficient, a part of equipment (i.e. the carbonization system) has some issues, which needs to be overcome. Delay in the construction of the showcase facility hindered the planned activities on development of zero-discharge technology.

(4) Impact: Relatively High

The impact of the Project can be judged as relatively high because of the prospects for achieving the overall goal and positive impacts observed so far. The current Goal is difficult to be achieved within 3 years due to rather ambitious indicators with insufficient resources for marketing. The narrative summary needs to be revised to incorporate all the technologies developed from the Project. The impacts from the Project are seen in the development of human resources in Malaysia and Japan, the advancement of researches, and the increased awareness of the state government and the public toward the zero-discharge technologies. No negative impacts were observed.

(5) Sustainability: High

The sustainability of the Project is assessed as high since all the aspects of the Project sustainability is high.

Sustainability of the Project from policy and institutional aspects is high. The policy environment for the Project remains unchanged since the Project started. The collaborative research is likely to be carried out among the member universities and research institution due to existing agreements among them. The financial and organizational sustainability is high. The operating revenues of UPM and UMS for the past few years have no major issues. In terms of human capacity, sustainability is high. While Chief Advisor and Project Manager will be retired in a couple of years, their Malaysian successors have been groomed and developed personal connections with other senior researchers across the border through the Project.

Technical sustainability is also high. Knowledge and technologies transferred through the Project and operation and maintenance of equipment provided by the Project are well shared through articles published and manuals. Students and/or staff were assigned to take charge of regular maintenance of equipment. Local contractors are available to fix

them if they are broken. The equipment provided by previous JICA projects has been well maintained.

3-3. Major supporting factors to achieve the Project Purpose

- Physical presence of Chief Advisor at the counterpart university (UPM) to expedite the implementation process

- The trust built through the long relationship between Chief Advisor and Project Manager at UPM, and between JICA and Deputy Project Manager at UMS through the past projects with UMS, including SDBEC.

3-4. Major hampering factors to achieve the Project Purpose

- Security concerns which largely delayed the construction of and the experiments at the showcase facility

- Drastic change of the currency exchange rate, which led to large decrease in the project budget, and then affected the budget for the procurement of business consultants

3-5. Conclusion

In conclusion, the Project has been carried out satisfactory after the mid-term review even though some activities were delayed. The Project Purpose is likely to be achieved by the end of the Project if technologies and knowledge generated from the Project are further outreached to potential users and policy makers. In terms of the evaluation by the five evaluation criteria, relevance is judged as relatively high as the Project is aligned well with Malaysian and Japanese relevant policies while the project design has some issues. The effectiveness of the Project is assessed as relatively high given the prospects of achieving the Project Purpose and the implementation status of the recommendations of the mid-term review. The efficiency of the Project is assessed also as relatively high as most inputs were well utilized to produce the expected outputs. The impact of the Project can be judged as relatively high because of the prospects for achieving the overall goal and positive impacts observed by the time of the terminal evaluation. The sustainability of the Project is assessed as high since all the aspects of the Project sustainability is high.

The evaluation team confirmed that the technologies for zero-discharge are developed, the researches in the relevant areas are advanced, and the Project has greatly contributed to development of human resources in Malaysia as well as in Japan particularly through training courses in Japan.

3-6. Recommendation

- Finalizing the management plan for the showcase facility

The evaluation team suggests that a final management plan for the showcase facility should be prepared by UPM before the end of the Project duration for the Malaysian side (August 2018) to ensure the sustainability of activities at the showcase facility.

3-7. Lessons Learned

The following lessons were obtained from the evaluation of the Project.

(1) During the implementation of a project, gaps between the reality and the PDM tend to be recognized. To avoid such gaps, a project team should hold a meeting regularly to monitor progress of the project and revise a PDM according to the progress and issues.

(2) At the stage of designing a PDM, inputs from business experts should be included if a project purpose aims to link with the private sector for the purpose of practical application of technologies and knowledge (for example, regarding the Project, one of the objectively verifiable indicators for the Project Purpose is “At least 5 firms or investors start considering actual investments based on the business model and model investment plan”. Yet, the meaning of “actual investment” is not clear and this indicator should have been defined from the business perspective.)

-End-

第1章　終了時評価調査の概要

１－１　終了時評価調査団派遣の経緯と目的

マレーシア・サバ州の最大河川であるキナバタンガン河流域には、ラムサール条約登録湿地をはじめ、森林保護区や野生生物保護区が点在しており、希少な野生生物の生息域として重要である。サバ州ではパーム油産業が州の基幹産業であり、キナバタンガン河上流域には、300 以上のアブラヤシ農園と28の搾油工場が存在する。農園で使用される農薬や、旧式の排水処理システムで稼働する搾油工場から排出される処理水等が原因で河川の水質汚濁が発生しており、地域の生物多様性への影響が懸念されている。九州工業大学とマレーシア・プトラ大学（以下、「UPM」という。）は、バイオマスを原料にしたプラスチック（バイオプラスチック）を製造する技術を共同開発した。その上で、バイオマスの供給源としてアブラヤシに着目した。すなわち、アブラヤシの搾油工場からは安価なバイオマスが通年で大量に発生し、品質も安定しているので、これを有効に活用することができれば新しい産業の創出につながることになる。現在、マレーシアの多くの搾油工場は旧式の非効率な設備を使用しているため、バイオマスはほとんどエネルギー源として消費されており、パーム油圧搾廃液（以下、「廃液」という。）から生じるメタンガスや廃熱も有効活用されていない。このため、搾油工程の見直しや効率的な設備の導入を通じて生産効率を改善することで、環境負荷を軽減させるとともに、新たに発生する余剰バイオマスや余剰エネルギー（廃液を効率的にメタン発酵させ、エネルギーとして活用）を有価値化して、バイオプラスチック、活性炭、廃液由来の肥料等の新製品を開発することにより、新たなビジネスモデルを創出することが期待される。

マレーシア側の UPM、マレーシア国立サバ大学（以下、「UMS」という。）及び日本側の九州工業大学、産業技術総合研究所（以下、「産総研」という。）、九州大学により構成される共同研究チームは、上記の技術やビジネスモデルの実現可能性及び有効性を検証するため、地球規模課題対応国際科学技術協力（以下、「SATREPS」という。）事業として本事業を 2013 年 11 月から 4 年間の予定で実施している。本事業終了半年前である 2017 年 5 月から 6 月に独立行政法人国際協力機構（以下、「JICA」という。）は独立行政法人科学技術振興機構（以下、「JST」という。）とともに終了時評価調査団をマレーシアに派遣し、2012 年に署名された協議議事録に基づいてマレーシア側関係者とともに合同終了時評価調査を実施した。

終了時評価の目的は以下のとおり。

(1)　投入実績と成果やプロジェクト目標の達成状況から本事業の進捗を確認する
(2)　評価 5 項目（妥当性・有効性・効率性・インパクト・持続性）に基づいて本事業を評価する
(3)　本事業の残り期間及び終了後に実施すべき手段について提言し、教訓を引き出す

１－２　終了時評価調査団の構成と調査日程

１－２－１　終了時評価調査団の構成

終了時評価調査はマレーシア側と日本側の合同で実施された。調査団の構成は以下のとおり。

(a) マレーシア側

- Dato’ Ir. Dr. Abdul Wahab bin Mohammad マレーシア・ケバングサン大学化学 プロセス工学部 教授
- Nur Farahin Fazira binti Mohd Munim 高等教育省 高等教育局高等教育機関研究開発推進計画部 副主幹

(b) 日本側

・ 鈴木和信（団長／総括）JICA 地球環境部自然環境第一チーム課長
・ 飯塚令子（協力企画）JICA 地球環境部自然環境第一チーム・専門嘱託
・ 堤敦司 (SATREPS 計画・評価) JST 研究主幹 / 東京大学生産技術研究所教授
・ 上阪圭介 (SATREPS 計画・評価) JST 主任調査員
・ 石飛愛（評価分析）合同会社 適材適所 コンサルタント

１－２－２ 調査の日程

終了時評価の現地調査は 2017 年 5 月 28 日から 6 月 10 日にわたって実施された。

１－３ プロジェクトの概要

プロジェクト・デザイン・マトリックス（以下、「PDM」という。）の第 2 版に記載されている本事業の概要は以下のとおり。

(1) 上位目標

マレーシアのパーム油産業においてグリーン経済が振興し、パーム油廃液による汚染物質の軽減により、キナバタンガン河流域を含むサバ州の関連地域の生物多様保全に貢献する。

(2) プロジェクト目標

パーム油産業の持続可能なグリーン産業への変容に向けて、ビジネスモデルのための革新的な知見と実行可能な技術が開発され、潜在的ユーザーによって肯定的に共有される。

(3) 成果

1) パーム油搾油工場に設置されるゼロ・ディスチャージ試験設備において、バイオマス・余剰エネルギーのエネルギー効率改善を通して、ゼロ・ディスチャージの効果が実証される。
2) ゼロチャージ及び余剰バイオマスと余剰エネルギーを活用した新しい産業を通して、ビジネスモデルの有効性が検証される。
3) パーム油搾取工程に起因する環境負荷軽減のためのパーム・バイオマスとエネルギーの有効活用に関する革新的な研究が進む。
4) ビジネスモデルの有効性と研究成果が、サバ州政府とマレーシア国内外の投資・企業により広く共有され認知される。

(4) 事業実施期間

2013 年 11 月～2017 年 11 月（4 年間）

第２章　評価の方法

２－１　評価の枠組み

終了時評価は「新 JICA プロジェクト評価ガイドライン第 2 版（2014 年 5 月）」に基づき、PDM（Ver. 2）を参照して実施した。また同ガイドラインの指示に従って評価グリッドを作成し、グリッドに沿って情報収集を行った。評価グリッドには評価質問、指標、収集データ、情報源、情報の収集方法を明記し、調査前にプロジェクト関係者と共有した。また、事業報告書や聞き取り調査の結果から PDM に記載されている各活動と各指標の実施状況をまとめた表を作成し、チーフアドバイザーを始めとしたメンバー研究者の確認を経て内容を修正した。この表は各成果の進捗確認に使用された。評価グリッドに基づいて情報を収集するため、質問票を現地調査前にメンバー研究機関の研究代表者・企業・政府系機関に送付し、現地調査では回収した質問票に基づいて聞き取り調査を行った。さらに UPM と UMS の研究室やケニンガウのショーケース設備において、供与機材の使用状況を確認した。

２－２　評価 5 項目

本事業は経済協力開発機構開発援助委員会（OECD-DAC）によって提案された評価 5 項目に基づいて評価を実施した。それぞれの項目の詳細は以下のとおり。

評価 5 項目

妥当性	開発インターベンションの目標が、受益者の要望、対象国のニーズ、地球規模の優先課題及びパートナーやドナーの政策と合致している程度。
有効性	開発インターベンションの目標が実際に達成された、あるいはこれから達成されると見込まれる度合いのことであり、目標の相対的な重要度も勘案しながら判断する。
効率性	資源及び（又は）インプット（投入）（資金、専門技術（知識）、時間など）がいかに経済的に結果を生み出したかを示す尺度。
インパクト	開発インターベンションによる貢献が期待されている、より高次の目標。
持続性	開発インターベンションの終了時における、開発インターベンションによる便益の持続性。長期的便益が継続する見込み。時間の経過に伴う純益の流出というリスクに対する回復力。

出所: JICA 事業評価ハンドブック（Ver1.1）(2016 年 5 月)

２－３　終了時評価のポイント

終了時評価対処方針に沿って、以下の点に留意して終了時評価を実施した。

1)　全般進捗確認
2)　研究に関する成果の確認
3)　政策策定議論への反映

4)　社会実装の見込み
5)　活動の持続性
6)　パイロットプラントへの対応

２－４　情報収集手段

情報収集に際しては、以下の方法が用いられた。

1)　文献調査

プロジェクト関連資料を収集し、分析した。主な参照資料には詳細計画策定調査報告書、中間レビュー報告書、年間報告書、終了報告書、マレーシアの政策関連資料、プロジェクト関係者提供のデータやプレゼンテーション資料、JICA の類似案件のプロジェクト関連資料などが含まれる。

2)　質問票調査

現地調査開始前に質問票が準備され、プロジェクト・マネージャー、副プロジェクト・マネージャー、チーフアドバイザー、九州大学、産総研、本事業の開発技術に関心のある日本またはマレーシア企業、マレーシアの政府機関に送付された。

3)　聞き取り調査

研究者・企業関係者・サバ州長官に対して聞き取り調査を実施した。

4)　現場視察

UPM と UMS の研究室の供与機材の使用状況やケニンガウのショーケース設備の稼働状況を確認した。

第３章　プロジェクトの実績と実施のプロセス

３－１　投入の実績

(1)　マレーシア側

1) カウンターパート人員の配置

プロジェクト・ダイレクター　: Husaini Omar 教授、UPM 副学長（研究とイノベーション担当）
副プロジェクト・ダイレクター : Shahril Yusof 教授、UMS 副学長（研究とイノベーション担当）
プロジェクト・マネージャー　: Mohammed Ali Hassan 教授、生物工学・分子生物科学部、UPM
副プロジェクト・マネージャー: Charles Santhanaraju Vairappan 教授、熱帯生物学・保全研究所所長、UMS

その他のカウンターパート：4 人のサブリーダーと約 35 名の UMS と UPM の研究者（学部生を除く）が本事業の研究に参加している。

2) 日本人長期専門家へのオフィススペースの提供

UMS は家具とインターネット環境を含む通信設備の整ったオフィススペースを長期専門家に提供した。

3) 現地活動費

マレーシア政府は研究補助金としては異例に大きな額である 300 万リンギット（約 7,800 万円）を本事業のために用意し、このうち 155 万リンギット[1]（2016 年 8 月時点）が支出されている。

(2)　日本側

1) 専門家派遣

表 1 のとおり、2017 年 3 月末の時点で延べ 16 名の専門家がマレーシアに 115 回（2,025 日）派遣された。

表 1　専門家の派遣実績

専門分野	派遣人数	派遣回数	派遣日数
短期専門家			
チーフアドバイザー	1	81	698
環境開発	3	5	39
バイオマス利活用	8	20	135
微生物叢の解析法	1	6	54
生物多様性	1	1	5

[1] 為替レート: 1 マレーシア・リンギット（以下、「リンギット」という。）＝26.14 円（2017 年 5 月 26 日時点）

専門分野	派遣人数	派遣回数	派遣日数
小計	14	113	931
長期専門家			
業務調整	2	2	1,094
計	**16**	**115**	**2,025**

出所: JST と JICA による提供資料

2) 機材供与

実験室とショーケース設備用の実験機材が主に調達された。調達金額総計は 1 億 1600 万円（2017 年 6 月時点）となっている。

3) 本邦研修

計23名のマレーシア人研究者が日本での研修に参加した（2017年6月時点）。

4) 現地活動費

事業開始時から、日本側は活動実施に必要な資金として 635 万円（2017 年 3 月末時点）を支出している。活動費の主な内訳は車両借上げ費、航空賃、その他の旅費等である。

３－２　活動実績

活動	2017 年 5 月時点での進捗
1-1 ショーケース設備設置先の工場を選定する。 1-2 ショーケース設備の基本・詳細設計をする。 1-3 ショーケース設備の建設と設置をする。	ショーケース設備は、治安の悪化により予定していたサバ州東部のサンダカンのパーム油搾油工場からサバ州西部のケニンガウ・パーム油工場（以下、「KPOM」という。）に設置されることとなった。ショーケース設備の基本・詳細設計が行われ、その設計に基づいて KPOM 内に設備が建設・設置された。ショーケース設備はゼロ・ディスチャージシステム、炭化炉、コンポスト製造システムから成っている。
1-4 ショーケース設備設置と運転のためのマニュアル作成とその適用のモニタリングを実施する。	ショーケース設備設置と運転のためのマニュアルが作成され、現場エンジニアによってその適用がモニタリングされている。
1-5 ショーケース設備の運転をする。	ショーケース設備は 2016 年 2 月より運転されている。
1-6 運転・指標に関するデータ収集をする。	運転を確認するデータは毎週現場エンジニアによって収集されている。水質に関するデータは月に一度収集され、UMS で分析されている。データの種類によっては外部の企業に分析を委託している。
1-7 データ分析とゼロ・ディスチャージの有効性の検証をする。	収集データによると工場の廃液の生物化学的酸素要求量[2]（以下、「BOD」という。）は 30,705 ppm から 8 ppm にまで減少した。ゼロ・ディスチャージシステムを通した最終廃液の色は、通常の廃液よりはるかに透明となった。したがって、ゼロ・ディスチャージの有効性は BOD の値と廃液の色によって実証された。
1-8 将来的な商業プラントへの適用のための操作・維持管理計画のモデルを準備する。	終了時評価の時点で、ショーケース設備に関心を持っている企業と合同で同設備内にて実験を行っており、この実験結果がモデル操作・維持管理計画の作成に貢献すると予想されている。
2-1 成果1のゼロ・ディスチャージ分析結果を関連企業・団体と精査する。	成果 1 のゼロ・ディスチャージ分析結果は KPOM 内で分析結果に関心のある関連企業・団体と精査した。多くの企業が KPOM 内のショーケース設備を見学に訪れており、そのうち 4 社が 2 回以上再訪している。また、分析結果は活動 4-1 のセミナーやワークショップにおいても共有されている。
2-2 潜在的ビジネスモデルのための費用対効果分析を行う。	4 つの潜在的ビジネスモデルが開発された（1. 基本ユニットモデル、2.基本ユニット＋ミクロコンポジットモデル、3. 基本ユニット＋

[2] 河川における有機物による水質汚濁の指標となっている。出所：横浜市環境創造局（2013）「用語解説 ：生物化学的酸素要求量（BOD）」http://www.city.yokohama.lg.jp/kankyo/mamoru/kanshi/wordw/bod.html 2017 年 6 月 15 日にアクセス

	野菜工場モデル、4. 基本ユニット＋エコリゾートホテルモデル)。各モデルの費用便益分析も実施された。
2-3 関連企業・団体とビジネスモデルの利益性を確認する。	ビジネスモデルの収益性は作成したビジネス・コンサルティング企業と確認され、同モデルに関心のある企業と検証した。これらの企業とビジネスモデルに関する協議は継続しており、本事業終了数年後には収益性の確認がなされる可能性がある。
2-4 ビジネス提案書・投資計画書のモデルを作成・修正する。	費用便益分析(活動 2-2)の結果に基づいたビジネス提案書・投資計画書のモデルが作成され、企業からのフィードバックに基づいて修正された。
2-5 ショーケース設備からの温室効果ガス削減効果を検証する。	ショーケース設備の廃液の嫌気処理によって生成されたメタンの量は計測されており、本事業終了時までに計測データを用いてショーケース設備からの温室効果ガス削減効果が検証される予定である。
3-1 共同研究チームの形成と方法論を決定する。	UPM・UMS・九州工業大学・九州大学・産総研は研究テーマに沿って共同研究チームを形成した。研究方法について議論し、合意した。
3-2 パーム油搾油工場による生物多様性と水系生態系への影響についてベースライン調査を行う。 3-3 水質の定期モニタリングの実施、結果分析と報告書作成を行う。	生物多様性・微生物多様性・水系生態系に関するベースライン調査が実施された。また、アブラヤシ農園を含む様々な種類の森林におけるボルネオ産霊長目の生態に関するベースライン調査も実施された。 2015 年 3 月から 2016 年 2 月まで毎月サンプルを収集した。そのモニタリング結果を分析し、報告書を作成した。分析結果に基づいた論文を査読付き学術誌に提出した。
3-4 パーム油搾油工場の生物多様性への影響を調査する。 3-4-1 水質と微生物多様性の相関関係を調べる。 3-4-2最終廃液の化学的・微生物学的特性を調べる。	廃液による生物多様性(水系生態系の指標生物)と微生物多様性への影響を 1)アブラヤシ農園に隣接する川や池等の水、2)様々な種類の森林の土壌について細菌群集構造と機能の観点から調査した。最終廃液の化学的特性についても調査した。
3-5 余剰バイオマスと廃水/熱蒸気の有効利用に関するさまざまな基礎研究を行い、実施を検討する。 3-5-1 パーム・バイオマスからのコンポストの質向上のための研究、すなわち次世代DNAシーケンサーを利用した有益	以下の基礎研究を行った。 - パーム・バイオマスからのコンポストの質向上のために次世代 DNA シーケンサーを利用した有益な微生物を特定した。 - 常在微生物と栄養素を含有する廃液嫌気性スラッジの連続追加は、リグノセルロース空果房(以下、「EFB」という。)の急速なコンポスト化に貢献することを明らかにした。 - EFB や中果皮繊維(以下、「MF」という。)のノンケミカル処

な微生物の特定 3-5-2 前処理、糖化、EFB・MFからの付加価値物質製造技術に関する研究開発 3-5-3 山仙炭化炉を使用した発電のための炭化とバイオ炭製造に関する研究	理（過熱水蒸気処理と加圧熱水処理）・糖化・付加価値物質（ナノ・コンポジット、炭、アセトイン等）製造技術を研究し、開発した。 - UPM と KPOM に設置した山仙炭化炉を使用して、発電のための炭化とバイオ炭製造について研究した。
3-6 ナノ技術を活用したバイオプラスチック素材のサンプルの生産と民間企業への提供を行う。 3-6-1 EFB とMFからのナノファイバー製造技術の研究開発と企業へのサンプル提供、セルロースナノファイバー素材製造の研究開発を行う。 3-6-2 ナノ・インターフェース、過熱水蒸気処理技術を使用して汎用プラスチックより高強度でナノスペースを有するナノファイバー製造の研究開発とマスター・バッチ製造に関する基礎研究、及び廉価で供給できる、母材プラスチックと同等あるいはより品質の高いバイオコンポジットの開発	- EFB と MF からのナノファイバー製造技術の研究開発と、セルロースナノファイバー素材製造の研究開発を行い、技術に関心のある企業数社へのサンプル提供を行った。 - ナノ・インターフェース、過熱水蒸気処理技術を使用して汎用プラスチックより高強度でナノスペースを有するナノファイバー製造の基礎研究を行い、マスター・バッチを製造した。 - 母材プラスチックと同等あるいはより品質の高いバイオコンポジットが 20%以上廉価で製造できることを証明した。
4-1 ビジネスモデルやモデル投資計画書、研究成果に関するワークショップ・セミナー・見本市などを実施する。	2014 年 1 月から 2017 年 3 月にかけて、ビジネスモデルやモデル投資計画書、研究成果に関するワークショップ・セミナーを合計 17 回、日本とマレーシアで実施した。
4-2 SDBEC や関連事業と協働の可能性について定期的に議論する。 4-3 現地政府の能力向上と開発した技術の利用促進のために、SDBEC と協力する。	チーフアドバイザーは協働の可能性について SDBEC（「サバ州を拠点とする生物多様性・生態系保全のための持続可能な開発プロジェクト」）と必要に応じて議論した。SDBEC のチーフアドバイザーは本事業の合同調整委員会（以下、「JCC」という。）にも参加している。SDBEC との協働は論文としてまとめられ、インパクトファクターの高い学術誌（*Biomass and Bioenegy*）で発表された。協働の結果、本事業と SDBEC の主要研究メンバーは両事業の研究成果に基づいて、別の SATREPS 事業への応札を共同で行った。

4-4 メディアを通じた広報を実施する。	本事業を紹介する新聞記事がマレーシアの新聞（Daily Express, Borneo Times）に 2014 年に 3 回掲載された。研究成果の一つが大分合同新聞に 2016 年に掲載された。

３－３　成果の達成状況

本事業開始時からの各成果の終了時評価時における達成状況は以下のとおり。

(1) 成果 1: パーム油搾油工場に設置されるゼロ・ディスチャージのショーケース設備において、バイオマス・余剰エネルギーのエネルギー効率改善を通して、ゼロ・ディスチャージの効果が実証される。

指標	進捗と達成状況
1.1 ゼロ・ディスチャージを目指したショーケース設備が実際に稼働するパーム油工場に設置される。 [進捗状況: 完了]	2015 年 10 月に KPOM 内にゼロ・ディスチャージを目指したショーケース設備が設置され、2016 年 2 月から稼働している。設備は 1 年以上特に大きな問題はなく稼働しているが、炭化炉に関しては環境局の一酸化炭素（以下、「CO」という。）と PM10 に関する規制を満たす必要がある。
1.2 ショーケース設備の運転記録が適切に管理される。 [進捗状況: 完了]	ショーケース設備の運転は記録され、運転記録は現場エンジニアによって適切に管理されている。
1.3 余剰のエネルギー、バイオマス、高温蒸気、メタンガスが有効に利用されることが示される。 [進捗状況: 完了]	パーム油工場は主製品である粗パーム油と種子に加えて、廃液や EFB、MF、殻などのパーム・バイオマスも生み出す。本事業では廃液処理から生まれたメタンガスはパーム油工場が必要とする以上の発電に活用することができ、現在活用されていない余剰の蒸気は最終廃液を清澄化するために活用できることを明らかにした。また、余剰のバイオマスは指標 1.4 に記載されているとおり、有効利用が可能であることを証明した。
1.4 バイオコンポジット、炭、コンポストが余剰のバイオマスから製造される。 [進捗状況: 完了]	バイオコンポジット、炭、コンポストなどのバイオ製品が余剰のバイオマスから製造できることを証明した。
1.5 ショーケース設備で排出された水が完全にリサイクルできることが示される。 [進捗状況: 完了]	本事業では廃液のゼロ・ディスチャージのための新しい処理システムを新しく提案し、費用のかからない既存の適正技術の組み合わせで河川水のレベルにまで廃液を清澄化した。ショーケース設備の廃液は完全にはリサイクルされていないものの、持続的にリサイクル可能であることを示した。また提案した新システムでの実験では廃液の BOD を 30,705 ppm から 8ppm へと、サバ州の廃液処理基準（20ppm 以下）より著しく低い値

	にまで低下できることを証明した。また、ショーケース設備のゼロ・ディスチャージシステムでリサイクルされた水の色は現在のシステムの廃液よりはるかに透明である。 終了時評価の時点で、廃液処理に関する新たな実験が日本企業と共同してショーケース設備内で実施されている。この実証実験の結果によっては現在の大型好気池を小さくしたうえで、さらに効率的な廃液処理ができるようになると予想されている。

＜成果 1 の総合評価＞

成果 1 に関しては、「将来的な商業プラントへの適用のための操作・維持管理計画のモデルを準備する。」以外の活動をすべて終了し、成果 1 に関する指標も達成している。これらの成果から、終了時評価時点での成果 1 の達成度合いは高く、ゼロ・ディスチャージ試験施設において、バイオマス・余剰エネルギーのエネルギー効率改善を通してゼロ・ディスチャージの効果が実証されたと言える。

(2) 成果 2: ゼロ・ディスチャージ及び余剰バイオマスと余剰エネルギーを活用した新しい産業を通して、ビジネスモデルの有効性が検証される。

指標	進捗と達成状況
2.1 有効なビジネスモデルとモデル投資計画が費用便益分析法に基づいて提案される。 [進捗状況: 完了]	中間レビューの提言に応えて、ビジネスモデルの作成、費用便益分析の実施、分析結果に基づいたモデル投資計画の作成を行うコンサルタントを雇用した。為替の急激な変化により事業予算が著しく目減りし、ビジネスコンサルタントの雇用が難しかったが、JST の平成 28 年度 SATREPS 企画提案（プラン B）に採択され、提言を実行することができた。 活動 2-2 に記載のとおり、コンサルタントによって 4 つのビジネスモデルが提案された。ビジネスモデルに基づいて、モデル投資計画も作成された。ビジネスモデルとモデル投資計画はワークショップやセミナーを通じて日馬の企業と共有された。
2.2 余剰バイオマスによって作られた新製品が試作される。 [進捗状況: 完了]	成果 1 の活動を通じて余剰バイオマスからバイオコンポジット、スラッジオイル、ナノ繊維、バイオ炭が製造できることを証明し、試作品が製造された。

＜成果 2 の総合評価＞

成果 2 の指標はともに達成しているが、いくつかの活動（「関心表明企業・機関とのビジネスモデルの収益性の確認」、「ショーケース設備からの温暖化効果ガス排出削減効果に関する研究」）は終了時評価の時点で終了していない。関心表明企業とビジネスモデルに関する議論はなされているものの、企業がビジネスモデルを採用して初めて収益性が検証されるため、いつ検証されるかは不明である。また、パーム油産業からのビジネスモデルに関するこれまでのフィードバックから判断して、ビジネスモデルをさらに魅力あるものに修正する必要がある。

(3) 成果 3: パーム油搾取工程に起因する環境負荷軽減のためのパーム・バイオマスとエネルギーの有効活用に関する革新的な研究が進む。

指標	進捗と達成状況
3.1 ベースラインになる環境調査報告がなされる。 [進捗状況: 完了]	パーム油工場による生物多様性と水系生態系への影響に関するベースライン調査結果が論文としてまとめられ、学術誌に提出された。
3.2 ゼロ・ディスチャージの結果(ショーケース設備での再生水)の生物多様性への影響を調査するためのサンプリング地点が決定される。 [進捗状況: 完了]	生物多様性への影響を調査するためのサンプリング地点が 14 カ所(ケニンガウ 9 カ所、キナバタンガン流域 5 カ所)決定された。これらの地点にはアブラヤシの育成するマングローブ林、マングローブ林、川辺林、アブラヤシ農園、パーム油工場に接する河川、廃液処理池、処理済み廃液冷却池、ショーケース設備等が含まれる。
3-3 ゼロ・ディスチャージの結果(ショーケース設備での再生水)の生物多様性の回復への影響が科学的に評価される。 [進捗状況: 継続中]	本事業の研究結果から、最終廃液が流出河川の上・下流域河川水の細菌濃度と群集構造の変化に影響していることが明らかになった。土壌の調査に関しては、ボルネオ島の熱帯土壌は土壌細菌の巨大な宝庫であること、多様性構造とその菌の構造特性を理解するにはさらなる検証が必要であることを示した。微生物多様性(腸のマイクロバイオームの多様性)のモニタリングを通じたボルネオ産霊長目の生態のモニタリング方法を開発した。この成果によりボルネオ産霊長目の生態の理解を促進し、サバ州のエコツーリズムに貢献する貴重な情報を提供することができる。 ゼロ・ディスチャージ技術による生物多様性の“回復”は科学的に評価されていないが、これはそもそも数年間(つまり事業実施期間)では実現不可能である。 生物多様性の研究に関しては、本事業では事業開始時に想定外の成果を達成している。最初に、本事業による調査から、これまでほとんど調査されてこなかったアブラヤシ農園の生態循環を含むサバ州の生物多様性に関して新しい知見を提供できる可能性が非常に高い。この知見はサバ州の生物多様性の回復とパーム油産業の促進に効果的に活用することができる。次に、本事業では微生物多様性の調査を通じて生物多様性を研究する新しいアプローチを提案した。このアプローチにより、生物多様性に関する伝統的な調査方法よりもはるかに短期間で生物多様性への影響を評価することができる。 .

3-4 ナノ・バイオコンポジットとして利用できるナノファイバー製造における過熱水蒸気の効果が確認される。 [進捗状況: 完了]	過熱水蒸気がパーム・バイオマスの粉砕やヘミセルロースの分解、シリカの除去や残留油分の水蒸気蒸留、ナノ繊維の表面改質とそれによるナノ繊維の性能の向上に効果的であることが明らかになった。また過熱水蒸気処理されたMFの存在によってバイオコンポジットの強度・曲げ特性・耐衝撃性と寸法安定性が著しく向上することが明らかになった。
3-5 パームバイオマスファイバーとプラスチック母体の間のナノサイズの界面の気相重合による制御が確認される。 [進捗状況: 完了]	気相重合は従来の方法に比べてよりセルロースの界面を制御できることを証明した。
3-6 ナノ・バイオコンポジットのマスター・バッチが提供される。 [進捗状況: 完了]	ナノ・バイオコンポジットのマスター・バッチ製造が気相重合により可能であることを示した。これにより、関心企業へのナノ・バイオコンポジットのサンプル提供が可能となった。
3-7 汎用プラスチックと比較してナノ・スペース（<100nm）とより高い強度（50%以上）を持つナノ・バイオコンポジット（MFI>5）の製造がなされる。 [進捗状況: 完了]	気相重合により汎用プラスチックと比較してナノ・スペース（<100nm）とより高い強度（50%以上）を持つナノ・バイオコンポジット（MFI>5）の製造が可能であり、マスター・バッチとして活用可能であることを証明した。
3-8 母材プラと同等以上で20%以上廉価なバイオコンポジットが供給される。 [進捗状況: 完了]	本事業では、2 軸エクストルーダーを活用したワン・ポットでナノ繊維コンポジットを作製する技術を開発した。この技術により、バイオコンポジットの機械特性が向上した。研究チームのシミュレーションによると、20%以上廉価なバイオコンポジットの供給も可能であることが明らかになった。この研究成果に基づいて、特許が申請された。
3-9 ナノ・セルロースファイバーの製造法が提案される。 [進捗状況: 完了]	ナノ・セルロースファイバーの製造法が 3 つ提案された。1）湿式粉砕処理アプローチや押し出しアプローチを用いた物理的プロセス、 2)イオン液体処理と気相重合または相溶化剤を用いて界面制御を行う化学的プロセス、そして 3) 物理的解繊に化学処理を組み合わせた新しい解繊方法である。この新しい方法により、ナノ・セルロースファイバーの引っ張り強度が 80%以上改善された。
3-10 パーム・バイオマスからの糖化収率が	酵素糖化の前処理として水熱・機械科学的処理を実施することで、パーム・バイオマスのすべてのサンプル（EFB、MF、フルーツ・

80%以上になる。 [進捗状況: 完了]	ファイバー)からの糖化収率が 80%以上になることを証明した。
3-11 パーム・バイオマスから製造されたバイオ炭(発熱量 20MJ/kg)とコンポスト(NPK5%)が製造される。 [進捗状況: 完了]	山仙式炭化炉を用いて、パーム・バイオマスから発熱量 20MJ/kg のバイオ炭と NPK5%のコンポストの製造に成功した。 炭化炉はショーケース設備で運転されているが、環境局の排煙規制(CO とPM10)を満たす必要がある。

＜成果 3 の総合評価＞

終了時評価までに全ての活動は終了し、研究成果に関する指標は「ゼロ・ディスチャージの生物多様性回復に関する効果が科学的に評価される」以外は達成している。生物多様性の「回復」に関しては、その効果を科学的に評価するためには何十年もかかるため、指標が事業期間中に達成されることは不可能である。終了時評価時点での成果から判断して、成果 3 はパーム油搾油工程に起因する環境負荷軽減のためのパーム・バイオマスとエネルギーの有効活用に関する知識と技術が開発されたと言える。

(4) 成果 4: ビジネスモデルの有効性と研究成果が、サバ州政府とマレーシア国内外の投資・企業により広く共有され認知される。

指標	進捗と達成状況
4-1 本事業のビジネスモデルと研究成果に関するワークショップ、セミナー、見本市等が少なくとも年に 2 回は開催される。 [進捗状況: 完了]	2014 年 1 月から 2017 年 3 月にかけてワークショップやセミナーが計 17 回日本とマレーシアで開催された。つまり年に 5 回以上開催されたことになり、指標は達成している。ビジネスモデルは 2017 年 3 月にクアラルンプール、コタキナバル、大阪市で開催されたセミナーで共有された。
4-2 少なくとも、計 100 団体・機関がこれらのイベントに参加する。 [進捗状況: 完了]	民間セクター、研究機関、政府機関を含む 100 以上の団体・機関から計 1,015 名が上記のイベントに参加し、ビジネスモデルや研究結果が共有され、議論された。
4-3 これらイベントが マスメディアに報道される。 [進捗状況: 完了]	研究結果の一つが日本の新聞(大分合同新聞)に掲載された。

＜成果 4 の総合評価＞

終了時評価までに全ての活動が終了し、指標もすべて達成しており、ビジネスモデルと研究成果の広報に関しては、一定の成果を上げている。ビジネスモデルはクアラルンプール、コタキナバル、大阪の三都市で一度共有された。また政策担当官の支援を得て投資家にとって好ましい投資環境を整え、投資を呼び込む為に、サバ州政府・国内外の投資家や企業とビジネスモデルをさらに検証する必要がある。マ

スメディアの広報に関しては、日本の新聞で研究成果が掲載された実績があるが、ビジネスモデルの妥当性と研究成果の広報はマレーシアのマスメディアを通じても広報する必要がある。

３－４　プロジェクトの目標達成見込み

プロジェクト目標: パーム油産業の持続可能なグリーン産業への変容に向けて、ビジネスモデルのための革新的な知見と実行可能な技術が開発され、潜在的ユーザーによって肯定的に共有される。

指標	2017 年 6 月までの進捗	達成状況
1. 少なくとも 5 社が本事業提案のビジネスモデルや投資モデルに基づいて現実に投資を考えはじめる。	質問票調査と聞き取り調査の結果によると、3 社がビジネスモデルと投資モデルに基づいた投資を検討し始め出ている。	継続中
2. 少なくとも 2 社が成果 3 により達成された研究結果や新技術の利活用を表明する。	質問票調査の結果によると、11 社が成果 3 による技術や研究成果の適用に関する意思を表明している。	達成済み
3. 本事業の課題やトピックスに関連した査読付き学術論文を 50 報以上出版する。	本事業に関連する内容で 99 報の論文が発表された。	達成済み
4. 本事業の課題やトピックスに関連した研究によって 10 人以上のマレーシア人の博士、10 人以上のマレーシア人の修士を輩出する。	終了時評価までに関連分野を研究した 12 名のマレーシア人の研究生に博士号、10 名に修士号が授与された。本事業の終了期間までには、さらに 7 名に博士号、3 名に修士号が授与される予定である。	達成済み

本事業によって開発されたビジネスモデルは日本の大企業 3 社によって前向きに検討され、マレーシア企業と日本企業 11 社が成果 3 から開発された技術や研究成果の応用に関心を示している。終了時評価の時点では指標 1 （「ビジネスモデルに対して実際の投資を検討し始めた企業数」）は達成していないものの、この指標はそもそも野心的過ぎたと考えられる。研究成果に関しては想定以上の成果を達成し、目標としていた査読付き論文数の約 2 倍の数の論文を発表した。その一部は、*Bioresource Technology* や *Biomass and Bioenegy* 等のインパクトファクターの高い学術誌で発表されている。また本事業は人材育成においても目標以上の高い成果を上げており、本事業終了時までに 32 名のマレーシア人学生が博士号と修士号を取得予定（22 名が既に取得済み）である。彼らの一部は、国内外で講師として教職についている。また九州工業大学では本事業の研究に関連して博士号を取得した日本人学生が 2 名おり、その他にも日本やマレーシアで本事業を通じて日本人研究者の育成にも貢献した。

指標 1 と 2（「成果 3 から開発された技術の応用に関心を表明した企業数」）の達成状況から、

本事業から開発された技術と知識がさらに政策担当官や潜在的ユーザーと共有されれば、プロジェクト目標は事業終了までに達成する可能性がある。

３－５　上位目標達成の見込み

上位目標	マレーシアのパーム油産業においてグリーン経済が振興し、パーム油廃液による汚染物質の軽減により、キナバタンガン河流域を含むサバ州の関連地域の生物多様性保全に貢献する。
指標	1. 本事業で提案または得られた技術が、少なくとも 2 社のパーム油産業で、彼らのパーム油工場で彼ら自身によって適用される。
	2. 本事業で提案または得られた技術が、投資家の主導により、10 社のパーム油工場で採用される。
	3. 本事業の成果の活用がマレーシア・サバ州の関係行政機関により議論され始める。

限られた調査期間内に得られた質問票や聞き取り調査の結果によると、幾つかの企業がビジネスモデルや本事業の開発技術に関心を表明しているものの、売り込むためのリソースが限られていることから、実際の投資に繋がるまでには当初想定していたよりも時間がかかる可能性が高い。したがって現在の指標（10 社以上のパーム油工場での開発技術の採用）は 3 年で達成するにはやや難しいと考えられる。最初の投資により収益性が確認されれば更なる投資が誘引されると考えられるが、それが事業終了後 3 年以内に行われる可能性は低いと予想される。プロジェクト目標と上位目標の間には大きな乖離があることから、3 年以内の上位目標の達成は困難である。

さらに、本事業ではバイオコンポジットを含むバイオマスの有効活用のための様々な技術を開発しているが、現在の上位目標は廃液による汚染物質の減少に関連した知識や技術に焦点が当てられており、本事業の成果の範囲が狭められている。したがって、本事業の対象範囲に適切に対応するよう、上位目標の表現を修正する必要がある。

３－６　プロジェクトの実施プロセス

(1) モニタリング

PDM に沿って本事業の全体的な進捗のモニタリングは行われた。事業の進捗や課題を関係者間で話し合うために、JCC が 2014 年 10 月、2015 年 11 月、2017 年 5 月に開催され、PDM の改定や活動の進捗について話し合われた。第 4 回 JCC は本評価の最後に評価結果の共有や活動の進捗を共有するために開催された。

加えて、チーフアドバイザーはマレーシアに頻繁に（81 回）、また長期間（698 日間）派遣され、本事業の全体的なモニタリングを行い、進捗に影響を及ぼしそうな事態が起きれば迅速に対応した。これによって数々の困難にも関わらず進捗の遅れを取り戻すことができた。また各分野の研究代表者間の非公式ミーティングにおいても、それぞれの担当分野の研究の進捗について確認した。

(2) 事業の進捗

治安の悪化によりサバ州西部サンダカンでのショーケース設備の設置を断念し、同設備の設

置を許可する搾油工場を新たに探し、最終的にサバ州東部ケニンガウの工場に設置しなければならなかった。この予期せぬプロセスは、成果 1 と 2 の活動を大幅に遅れさせることとなった。この期間は成果 3 と本邦研修に焦点を当てて活動が行われた。炭化炉の排煙規制や地下水の侵入等解決すべき問題はあるものの、関係者の不断の努力によって終了時評価までにほぼ遅れを取り戻すことができた。

(3) コミュニケーション

プロジェクト・マネージャー（マレーシア側研究代表）とチーフアドバイザー（日本側研究代表者）の間には過去 20 年間にわたって築いた関係がありコミュニケーションは非常に良好である。その他のマレーシア人研究者と日本人研究者、及び日本人研究者間のコミュニケーションにも大きな問題は見られない。チーフアドバイザーと業務調整員間のコミュニケーションもまた良好である。

(4) カウンターパートのオーナーシップと参加

マレーシア側研究機関（UPM と UMS）は他のメンバー研究機関と共同しながら担当分野の研究を主導している。また必要なコスト（炭化炉の追加部品等）を自発的に負担したり、警察と交渉してケニンガウでの作業中に警察署の敷地内に事業用車が停車できるよう交渉するなど、主体的に事業実施を支援している。さらに事業成果の社会実装に関しては、UPM は独自に同大の技術移転オフィスやプロジェクト・マネージャーの人脈を通じて本事業から得られた技術に関心を持つマレーシア企業を探し、協議を進めている。またサバ州政府と UMS も同様にサバ生物多様性協議会やサバ・バイオテクノロジー諮問委員会といった他の政府機関とも積極的に本事業の研究成果を共有し、「サバ生物多様性戦略」の実施に貢献する予定である。したがって、カウンターパートの本事業に対するオーナーシップは非常に高い。特にカウンターパート機関の代表者であるプロジェクト・マネージャーと副プロジェクト・マネージャーがこれらの活動の実施に主体的に関わっており、カウンターパートの責任者の本事業への参加の度合いも非常に高い。

第４章　５項目評価[3]

４－１　妥当性

本事業の妥当性は比較的高い。

(a)　マレーシアの国家・州政策との一致

本事業はマレーシアの国家・州政策と十分に一致している。マレーシアの国家開発計画である「第 11 次マレーシア計画（2016-2020）」の重点分野の一つが“持続可能な消費と生産概念の採用”である。戦略の一つが、バイオマスを発電に使うなど、廃棄物の資源としての投資であり、本事業の活動内容と一致している。また、「国家経済転換プログラム」の重要経済分野の一つ、エントリーポイント事業 5（パーム油搾油工場でのバイオガス設備の開発）とも一致しており、この分野の発展に貢献することができる。また本事業はサバ州の開発計画である「サバ州開発及び発展の指針」 とも一致している。同指針では経済開発を達成しながらも健全な生態系を支える自然資源保全のために特定の地域を保存することを示し、この指針に則って「サバ生物多様性戦略」などの環境や生物多様性保全に関する政策が打ち出されている。また、「サバ州の戦略的長期行動計画（2016-2035）」においても、サバ州の開発を経済、社会、環境面から進めることが明記されている。加えて、中央政府・サバ州政府ともにバイオマスの効果的な活用を支持し、「国家バイオマス戦略 2020」や「サバ・バイオマス産業開発計画」をそれぞれ策定している。

(b)　日本の支援政策との一致

「対マレーシア国別援助方針」（2012 年 4 月策定）及び「対マレーシア事業展開計画」（2016 年 4 月策定）の重点分野の一つは“先進国入りに向けた均衡のとれた発展の支援”であり、“国内経済格差の是正、高齢化社会への対策、環境、障害者福祉、防災対策等の国民福祉向上に資する支援を行う”と記されている。本事業は環境管理の向上への貢献を目的としていることから、日本の支援政策とも合致している。

(c)　プロジェクト・デザインの適切性

上位目標とプロジェクト目標には乖離があり、社会実装のためのリソースが限定的であることを考慮すると指標の内容はやや現実的ではなく、そもそもの達成が難しいと考えられる。

４－２　有効性

本事業の有効性は比較的高い。

「3.4　プロジェクト目標の達成見込み」に既述のとおり、本事業により得られた知識や技術が潜在的ユーザーや政策担当者に届けば、プロジェクト目標は事業終了までに達成する可能性がある。本事業はまたマレーシア人研究者の人材育成とバイオテクノロジーと生物多様性の分野での研究の進展に貢献している。

[3]評価 5 項目は、「高い」「比較的高い」「中程度」「比較的低い」「低い」 の 5 段階で判断した。

中間レビューの提言の実施状況は以下のとおり。

(1) UPM研究者・学生による配置を含むゼロ・ディスチャージ実験用のパイロットプラントのモニタリングを担当するアシスタントの早急な割り当て

ショーケース設備を担当している現場エンジニアが雇用され、配置されている。彼はショーケース設備を毎日モニターし、モニタリング結果を毎週報告している。UPMの研究者と学生は月に一度同設備においてデータを収集し、UMSでそのデータの分析を行っている。

(2) 費用便益分析及びゼロ・ディスチャージ用ビジネスモデルのためのモデルビジネス投資計画書の作成を行う専門要員の確保

提言どおりに専門要員が雇用され、ゼロ・ディスチャージ用ビジネスモデルのための投資計画書（費用便益分析含む）が作成された。この投資計画書は日本やマレーシアのセミナーで共有された。

(3) マレーシア側及び日本側の研究者間におけるインフォーマルな会議の設定

マレーシア・日本側研究者間のインフォーマルな会議は必要に応じて実施された。研究者間のコミュニケーションに関しては、終了時評価時点で特に問題は見受けられない。

(4) パーム油搾油工場のパイロットプラント（ショーケース設備）に係るプロジェクト終了後の運営管理計画の作成

終了時評価時点で、パイロットプラントの今後の運営管理計画については3つの案が検討されている。第1にUPMに持ち帰る案で、移送用の予算（10万リンギット=約260万円）も既に確保されている。第2案はKPOMに維持する案で、来年度末（2018年8月）に工場のオーナーと議論する予定である。第3案は設備に関心を持つ企業に使用を許可する案である。
マレーシア側の本事業の事業期間は2018年8月に終了予定のため、UPMはそれまでに今後の運営管理計画を文書にまとめる予定である。

(5) PDM の改定

PDM は 2017 年 4 月の第 3 回 JCC で中間レビューの提言に沿って改定された。
したがってほとんどの提言は終了時評価までに実施されている。

４－３　効率性

本事業の効率性は比較的高い。

(a) 日本人専門家の派遣

2017 年 4 月までに様々な専門分野の日本人専門家のべ 16 名がマレーシアを計 115 回（計 2,025

日）訪問し、共同研究を促進した。質問票の結果によると、マレーシア側・日本側実施機関ともに日本人専門家の派遣の量・質・タイミングに満足している。

(b) 機材供与

研究室での実験やショーケース設備のための機材が供与された。炭化炉は商業化に向けて解決すべき課題があるものの、ほとんどの機材は予定された活動を実施ために活用された。

(c) 現地活動費

「3.1 投入実績」に記載のとおり、マレーシア側と日本側は本事業の実施に必要な資金を支出している。マレーシア政府は本事業のために 300 万リンギット（約 7,800 万円）という異例に大きな額を研究資金として用意しており、現地活動費は十分であると言える。

(d) 本邦研修

本邦研修はマレーシア人研究者の知識と技術の向上に効果的に貢献した。約 23 名のマレーシア人研究者が研修に参加し、既に卒業した参加者を除き、全ての研修参加者が終了時評価時点で UPM または UMS で研究を続け、毎日の研究業務において得た知識や技術を活用している。研修参加者はマレーシアでは得られない知識や技術を本邦研修で身につけており、それらは所期の研究成果を達成するにあたり不可欠であった。さらに、参加者の一部は講師として勤務しており、本邦研修を通じて得た知識はマレーシアの大学の講義やセミナーにおいて共有されている。

(e) カウンターパートの配置

41 名のマレーシア人研究者が本事業に参加しており、所期の研究成果の達成状況と人材育成に関する成果から、カウンターパートの人的資源の配置は質量ともに十分であったと考えられる。

成果達成の貢献要因は以下のとおり。

- チーフアドバイザーのカウンターパート機関での長期駐在が活動の実施促進に繋がった。
- チーフアドバイザーとプロジェクト・マネージャー（UPM）間の長年の間に培われた信頼関係と、SDBEC を含む過去の JICA 事業によって築かれた副プロジェクト・マネージャーと JICA 間の信頼関係により、本事業の実施がスムーズに行われた。

一方、阻害要因は以下のとおり。

- ショーケース設備設置予定地域の治安の悪化により、設備設置と関連実験が大幅に遅延した。
- 為替レートの急激な変化により、事業予算が著しく目減りした。これはビジネスコンサルタントの調達予算に影響した。

ほとんどの投入の量・質・タイミングともに問題はなかったが、一部の供与機材の活用に解決すべき課題（炭化炉の排煙規制等）がある。また、ショーケース設備設置の遅れは、ゼロ・ディスチャージ技術の開発に関する活動を遅らせることとなった。

４－４ インパクト

本事業のインパクトは比較的高い。

(a) 上位目標達成見込み

「3.5 上位目標達成見込み」に既述のとおり、現在の上位目標は営業のための予算が不十分な状況では現実的ではない指標となっており、事業終了以内 3 年に達成が難しい。また、上位目標の表現についても、本事業から得られた技術がすべて含まれるように修正する必要がある。

(b) 本事業のインパクト

以下の本事業による正の効果の発現が確認された。

- ほとんど調査されていないアブラヤシ農園の生態系サイクルを含む、サバ州の生物多様性に関する貴重な知見の提供
- 微生物多様性の調査を通じた生物多様性を研究する新しいアプローチの開発
- マレーシア内外の関連分野での科学技術の進展に貢献するマレーシア人研究者の育成
- 革新的な技術の開発（特許 2 件の国内登録、特許 3 件の海外申請）
- 研究機関間の協力関係の強化による日本人研究者の国内外での育成
- 研究成果に関するワークショップ参加者数が徐々に増えていることから、ゼロ・ディスチャージ技術に関する認知の向上
- サバ州におけるゼロ・ディスチャージ技術の促進に関するサバ州政府の政治的意思の向上

本事業による負の効果は発現していない。

４－５ 持続性

本事業の持続性は高い。

■ 政策的・制度的観点

本事業の政策的・制度的観点における持続性は高い。

政策的な環境は本事業が開始してから大きな変化はない。共同研究はメンバー研究機関間で既存の協定があることから、本事業終了後も共同研究が継続する見込みである。

■ 財政的・組織的観点

本事業の財政的・組織的観点における持続性も高い。UMS の過去 3 年間（2013-2015）の収入は下表のとおり増加している。UPM の収入は 2015 年に一旦減収になってはいるものの、UPM/UMS 両大学ともにその他の収入は年々増加しており、政府補助金のみに頼らず経済的自立を促進していると言える。さらに両大学の本事業担当研究機関は関連研究を継続するための外部資金を大企業から得ている。したがって、本事業の効果の財政的な持続性も高いと考えられる。

表 2. UMS と UPM の収入(単位: 百万リンギット)

	UMS			UPM		
	2013	2014	2015	2013	2014	2015
政府補助金	332.48	348.92	363.95	745.22	772.4	627.37
手数料収入	29.35	30.92	33.54	102.8	107.04	106.25

その他の収入	0.94	4.2	6.1	159.44	150.42	175.57
合計	362.77	384.03	403.56	1007.46	1029.86	909.19

出所: UMS 年間報告書 2015, UPM 年間報告書 2014

人的資源の観点からも、持続性は高い。チーフアドバイザーとプロジェクト・マネージャーはともに数年後に退官になるものの後継の研究者は育っており、本事業を通じて国内外の研究者とのネットワークを形成することができた。

■ **技術的観点**

技術的な持続性は高い。

本事業により移転された技術と知識や、供与機材の維持管理に関しては論文やマニュアルを通じて共有されている。機材の維持管理に関しては担当の学生やスタッフが割り当てられて定期的に維持管理を実施しており、責任者（講師レベル）が毎年新しく機材の維持管理担当の学生を割り当て、維持管理の状況に関してもモニタリングを行っている。マニュアルはきちんと保管され、維持管理の方法も幅広く共有されている。また故障しても現地の業者により修理が可能である。過去の JICA 事業による両大学への供与機材もきちんと維持管理がなされていたことから、本事業で供与された機材も適切に維持管理されていくと推測することができる。

第５章　結論

結論として、本事業は幾つかの活動に遅れが出たものの、中間レビュー以降問題なく実施されている。本事業に基づいた技術と知識がさらに潜在的ユーザーや政策担当官と共有されれば、プロジェクト目標は事業終了までに達成できる可能性がある。

5 項目評価の結果の要約は以下のとおり。

評価項目	結果	要約
妥当性	比較的高い	本事業はマレーシアと日本の政策と一致している。上位目標とプロジェクト目標の間に乖離があり、社会実装のためのリソースが限られていることから両目標の指標はやや現実的ではなく、プロジェクト・デザインに一部適切ではない。
有効性	比較的高い	プロジェクト目標は本事業に基づいた技術と知識がさらに潜在的ユーザーや政策担当官と共有されれば、達成される可能性がある。中間レビューの提言は KPOM の今後の運営管理計画の作成（2018 年 8 月までに作成予定）以外は実施されている。
効率性	比較的高い	ほとんどの投入の質・量・タイミングは十分であったが、一部の機材の活用に課題があり、商業化に向けて解決する必要がある。ショーケース設備設置の遅れはゼロ・ディスチャージ技術開発に関する活動を遅延させることとなった。
インパクト	比較的高い	現在の上位目標は営業のためのリソースが限られている中で、やや現実的でない指標設定になっており 3 年以内の達成は困難である。また目標自体も本事業により生み出されたすべての技術を含む内容に修正する必要がある。本事業の正の効果として人材育成・研究の進歩・ゼロ・ディスチャージ技術に関する認知度の向上などが発現している。負の効果は発現していない。
持続性	高い	持続性は全ての観点において高い。本事業に関連する研究は研究機関の内部・外部資金や機関間の既存の協定により、今後も継続される見込みである。

*評価 5 項目は、「高い」「比較的高い」「中程度」「比較的低い」「低い」の 5 段階で判断した。

終了時評価調査団は、本事業によってゼロ・ディスチャージ技術が開発され、関連分野の研究が進展し、本邦研修等を通じて本事業がマレーシアと日本の人材育成に大きく貢献したことを確認した。これは関係機関（九州工業大学・九州大学・産総研・UPM・UMS）間の良好な関係と、マレーシア政府・サバ州政府の支援に起因していることを明記しておきたい。

第６章　提言

終了時評価調査の結果に基づいた合同終了時評価調査団によるプロジェクト・チームへの提言は以下のとおり。

(1) PDM における上位目標とその指標、外部条件の修正

評価時点の PDM（第 2 版）の上位目標、指標、外部条件は以下のとおり変更することを提案する。（下線は変更部分）

上位目標	
変更前 （第 2 版）	マレーシアのパーム油産業においてグリーン経済が振興し、パーム油廃液による汚染物質の軽減により、キナバタンガン河流域を含むサバ州の関連地域の生物多様性保全に貢献する。
変更後 （第 3 版）	マレーシアのパーム油産業においてグリーン経済が振興し、ゼロ・ディスチャージ技術により、キナバタンガン河流域を含むサバ州の関連地域の生物多様性保全に貢献する。
指標	
変更前 （第 2 版）	1. 本事業で提案または得られた技術が、少なくとも 2 社のパーム油産業で、彼らのパーム油工場で彼ら自身によって適用される。 2. 本事業で提案または得られた技術が、投資家の主導により、10 社のパーム油工場で採用される。 3. 本事業の成果の活用がマレーシア・サバ州の関係行政機関により議論され始める。
変更後 （第 3 版）	1. 本事業で提案または得られた技術が、少なくとも 2 社のパーム油産業で、彼らのパーム油工場で彼ら自身によって適用される。 2. 本事業に基づく技術を活用したビジネスモデルの費用便益分析が、商業化の可能性を想定して、投資家の主導によって実施される。 3. 少なくとも一つのビジネスモデルが、少なくとも一つのパーム油工場において投資家の主導によって採用される。 4. 本事業の成果の活用がマレーシア・サバ州の関係行政機関により議論され始める。
外部条件	
変更前 （第 2 版）	アブラヤシ農園が事業期間中及び実施後に劇的に拡大または劣化しない。
変更後 （第 3 版）	• アブラヤシ農園が事業期間中及び実施後に劇的に拡大または劣化しない。 • 連邦政府とサバ州政府において、パーム油産業を取り巻く政策環境と経済環境が劇的に悪化しない。 • サバ州の治安が安定している。

(2) 現在提案されているビジネスモルと投資計画の修正

ビジネスモデルをパーム油産業・関連産業・投資家にとってさらに魅力的なものにするために本事業終了時（2017 年 11 月 20 日）より前に、プロジェクト・チームは日本とマレーシアのビジネス及び工学の専門家と、JST からの技術的な助言をもとに現在のビジネスモデルを修正することが望ましい。

(3) 研究成果の政策対話への組み込み

本事業で実施している研究の一部は既に「国家バイオマス戦略 2020」に採用されている。上位目標の達成には政府の関与が重要であることから、継続して研究成果や開発技術を政策対話の中に組み込むことが重要である。したがって、プロジェクト・チームは引き続き本事業の研究成果や技術をサバ生物多様性協議会やサバ・バイオテクノロジー諮問委員会、バイオマス委員会等の政府の関連委員会と共有することが重要である。研究成果は「サバ多様性戦略」の実施に貢献する必要がある。

(4) セミナーや利用可能なプラットフォーム及びマスメディアを通じた潜在的投資家への接触

ビジネスモデルに関するセミナーはマレーシアと日本で開催されているが、今後も継続して本事業により得られた知識と技術をターゲット層と共有することが重要である。共有の方法としては、1)本事業の成果に関心のあるパーム油産業や関連企業、潜在的投資家との対話を引き続き強化する、2)ビジネスモデルを民間企業にとってより受け入れられやすいものにするための議論を重ねる、そして 3)ビジネスモデルや投資計画を含む本事業の成果を「UMS エコキャンパス」のような利用可能なプラットフォームやマスメディアを通じて潜在的投資家やキナバタンガン流域の旅行業者に広報すること、が想定される。

(5) ショーケース設備の炭化炉の排煙規制（CO と PM10）を満たす

商業化に向けて、ショーケース設備の炭化炉の排煙規制を満たすことが重要であり、JICA の事業期間が終了するまでにこの課題を解決することが望ましい。

(6) ショーケース設備の管理計画の最終化

ショーケース設備での活動の持続性を確保するために、同設備の最終管理計画はUPMによってマレーシア側の本事業の終了時（2018 年 8 月）までに準備される必要がある。

第７章　教訓

本事業の評価を通じて、以下の教訓が得られた。

(1) 定期的な会議による PDM の適宜修正

事業の実施期間中に PDM と現実との乖離が認識されがちである。このような乖離を避けるために、定期的に会議を開いて事業の進捗を確認し、進捗状況や課題に沿って PDM を適宜修正するべきである。

(2) 民間連携による社会実装をプロジェクト目標とする場合、ビジネスの専門家の知見を PDM に反映

民間連携による社会実装をプロジェクト目標とする場合、PDM の設計に際してビジネスの専門家からの知見を反映させるべきである。

別添資料

1. Joint terminal Evaluation Report
2. Project Design Matrix（PDM）(Version 3)
3. Appendix1
4. Appendix2
5. Appendix3
6. Appendix4
7. Appendix5
8. Appendix6

Joint Terminal Evaluation Report

for the Project

on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation

Malaysia

8 June 2017

Mr. Kazunobu SUZUKI
Leader
Japanese Terminal Evaluation Team
Japan International Cooperation Agency

Prof. Dato' Ir. Dr. Abdul Wahab bin Mohammad
SATREPS Panel Member,
Ministry of Higher Education Malaysia

Joint Terminal Evaluation Report

for the Project

on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation

8 June, 2017
Joint Terminal Evaluation Team

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Abbreviations

AIST	National Institute of Advanced Industrial Science and Technology
BOD	Biochemical Oxygen Demand
C/P	Counterpart
DOE	Department of Environment
EFB	Empty Fruit Bunches
JICA	Japan International Cooperation Agency
JCC	Joint Coordination Committee
JPY	Japanese Yen
JST	Japan Science and Technology Agency
KPOM	Keningau Palm Oil Mill
Kyutech	Kyushu Institute of Technology
MF	Mesocarp Fibre
NRO	Natural Resources Office
OECD-DAC	Organization for Economic Co-operation and Development – Development Assistance Committee
PDM	Project Design Matrix
PO	Plan of Operation
POME	Palm Oil Mill Effluent
RM	Malaysian Ringgit
SATREPS	Science and Technology Research Partnership for Sustainable Development
SDBEC	Project on Sustainable Development for Biodiversity and Ecosystems Conservation in Sabah (Malaysia)
SHS	Superheat Steam
UMS	Universiti Malaysia Sabah
UPM	Universiti Putra Malaysia
VASP	Vapor-phase Assisted Surface Polymerization

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1. Outline of the Terminal Evaluation

1.1 Background and the purposes of the terminal evaluation

The Kinabatangan and Segama river basin is the largest watershed in the state of Sabah, Malaysia. It embraces a number of protected areas and forest reserves, which function as important habitats for rare and endangered species. The palm oil industry is a key industry in Sabah. In fact, there are more than 300 oil palm plantations (1.4 million hectares) and 28 palm oil mills within the Kinabatangan and Segama river basin. Water pollution has become an issue caused by farm chemicals from the oil palm plantations and by treated water discharged from the outdated treatment system of the mills. These factors are considered to have a negative impact on the biodiversity.

Kyushu Institute of Technology (hereinafter referred to as "Kyutech") and Universiti Putra Malaysia (hereinafter referred to as "UPM") have jointly developed the technology for the production of bio-composite plastics from the palm biomass. For example, in Japan, rice straw and bamboo were used as biomass in a pilot basis, but it is difficult to secure the materials with uniform quality at feasible costs throughout the year. In Malaysia, large quantity of biomass (empty fruit bunch, mesocarp fibre, etc.) with stable quality has been produced throughout the year from the oil mills, and a new business/industry can be created by the effective utilisation of biomass. Presently, major part of the biomass is consumed as energy sources by inefficient facilities at the mills. Surplus biomass and energy can be generated with more advanced, efficient facilities. Excess biomass and energy can be traded and would generate additional profit. The improved energy efficiency and proper utilisation and recycling of palm oil mill effluent would result in the reduction of environmental burden.

The joint research team between UPM and Universiti Malaysia Sabah (hereinafter referred to as "UMS") in Malaysia and Kyutech, National Institute of Advanced Industrial Science and Technology (hereinafter referred to as "AIST") and Kyushu University in Japan proposed a project to provide evidence on the feasibility of technologies and viability of business model mentioned above (hereinafter referred to as "the Project") which was approved by the Government of Japan under the scheme of Science and Technology Research Partnership for Sustainable Development (hereinafter referred to as "SATREPS").

The Project started from November 2013 and will be completed in November 2017. In May 2017, 6 months before the termination of the cooperation period, the Project is required to undergo a terminal evaluation in accordance with the Minutes of Meetings signed for the Project in November 2012. Japan International Cooperation Agency (hereinafter referred to as "JICA") and Japan Science and Technology Agency (hereinafter referred to as "JST") dispatched the Japanese Evaluation Team to Malaysia for the purpose of conducting the terminal evaluation which was undertaken jointly with Malaysian authorities concerned.

The purposes of the terminal evaluation are:
(1) To verify the achievements of the Project referring to actual inputs, achievement of outputs and the project purpose;
(2) To evaluate the Project based on the five evaluation criteria (Relevance, Effectiveness, Efficiency, Impact and Sustainability); and,
(3) To make recommendations for the measures to be taken in the remaining cooperation period and in the future, and draw the lessons learned.

1.2 Members and the schedule of the evaluation

1.2.1 Members concerned to the evaluation

The terminal evaluation was jointly conducted by both Malaysian and Japanese sides. The members concerned are shown below.

(a) Malaysian side
- Prof. Dato' Ir. Dr. Abdul Wahab bin Mohammad, Professor, Department of Chemical and Process Engineering, Universiti Kebangsaan Malaysia (5/29, 6/7)
- Ms. Nur Farahin Fazira binti Mohd Munim, Assistant Director, HEI Excellence Planning Division, Higher Education Department, Ministry of Higher Education (6/8)

(b) Japanese side
- Mr. Kazunobu Suzuki, Leader, Director, Natural Environment Team 1, Forestry and Nature Conservation Group, Global Environment Department, JICA
- Ms. Reiko Iitsuka, Cooperation Planning, Technical Advisor, Natural Environment Team 1, Forestry and Nature Conservation Group, Global Environment Department, JICA

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- Prof. Dr. Atsushi Tsutsumi, SATREPS Planning and Evaluation, Research Supervisor, JST/ Project Professor, Institute of Industrial Sciences, The University of Tokyo
- Dr. Keisuke Kosaka, SATREPS Planning and Evaluation, JST
- Ms. Ai Ishitobi, Evaluation Analysis, TekizaiTekisyo LLC

1.2.2 Schedule of the evaluation mission

The evaluation has been conducted from May 28 to June 8, 2017. The detailed schedule of the evaluation is shown in Appendix 1.

1.3 Outline of the Project

The outline of the Project described in the Project Design Matrix (hereinafter referred to as "PDM") (version 2.0, Appendix 2) is as follows.

(1) Overall Goal

Green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through reduction of pollutants due to waste water in relevant areas in Sabah including Kinabatangan.

(2) Project Purpose

Innovative knowledge and viable technologies for business models are developed and shared positively among the potential users for the transformation of palm oil industry into sustainable green industry.

(3) Outputs

1) The effectiveness of zero-discharge is ensured through energy efficiency improvement resulting surplus biomass and excess energy at showcase facilities of zero-discharge established at an oil mill.
2) Viability of business model is verified through the proposed zero-discharge and creation of new industry from surplus biomass and excess energy.
3) The innovative research is pursued on the effective utilisation of palm biomass and energy for the reduction of environmental burden caused by palm oil processing.
4) Validity of business model and the research results are shared extensively and recognised within the Sabah Government and domestic/international investors and firms.

(4) Project Term

November 2013 to November 2017 (four years)

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2. Methodology

2.1 Framework for the evaluation

The evaluation was carried out in accordance with "the JICA Guidelines for Project Evaluation, Ver. 2 (May 2014)," which mainly follows "the Principles for Evaluation of Development Assistance, 1991" issued by the Organization for Economic Co-operation and Development – Development Assistance Committee (OECD-DAC).

The PDM was used as a basic reference for the evaluation. As instructed in the JICA Guidelines, an *Evaluation Grid* (Appendix 3) was prepared as a framework to collect data and information. The Grid lists evaluation questions, indicators, data to be collected, data sources, and methods for data collection. The table on the implementation status of each activity and each indicator listed in the PDM was also prepared based on a project report and key informant interviews, checked by Chief Advisor and other research members, and updated according to their inputs. This table was used in order to assess the achievements of the Outputs. To collect information for the Evaluation Grid, questionnaires were also prepared and forwarded in advance to project leaders from member universities and research institution, companies and government organizations. During the evaluation mission, the evaluation team conducted interviews with them and observed the use of equipment provided at laboratories at UPM and UMS and a showcase facility in Keningau.

2.2 Evaluation Criteria

The project was evaluated based on the five evaluation criteria proposed by OECD-DAC ("Relevance, Effectiveness, Efficiency, Impact, and Sustainability). The details of each criterion are as follows.

Five Evaluation Criteria

Relevance	Degree of compatibility between the development assistance and priority of policy of the target group, the recipient, and the donor.
Effectiveness	A measure of the extent to which an aid activity attains its objectives.
Efficiency	Efficiency measures the outputs - qualitative and quantitative – in relation to the inputs. It is an economic term which is used to assess the extent to which aid uses the least costly resources possible in order to achieve the desired results. This generally requires comparing alternative approaches to achieving the same outputs, to see whether the most efficient process has been adopted.
Impact	Impact measure effects of the project with an eye on the longer term effects including direct or indirect, positive or negative, intended or unintended.
Sustainability	Sustainability is concerned with measuring whether the benefits of an activity are likely to continue after donor funding has been withdrawn.

Sources: the JICA Guidelines for Project Evaluation, Ver. 2 (May 2014)

2.3 Points to be checked for the terminal evaluation

The following points are especially checked for this terminal evaluation.

1) Overall achievements and progress by the time of the terminal evaluation
2) Research achievements
3) Strategic and effective approach to reflect the project outputs into policy level discussion
4) Possibility of social application of the project outputs
5) Sustainability of activities

2.4 Data collection

The following data and information collection methods were employed for the evaluation.

1) Desk review
   Project-related documents were reviewed, which include the detailed design survey report, the mid-term review report, annual progress reports, the final report for the terminal evaluation, Malaysia's policy documents, data and presentations provided by the Project, and documents from similar projects by JICA.

2) Questionnaire surveys
   Before the evaluation started, questionnaires had been prepared and sent to Project Manager, Deputy Project Manager, Chief Advisor, Kyushu University and AIST, Japanese and Malaysian companies that are interested in technologies developed from the Project, and Malaysian governmental organizations.

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3) Key Informant Interviews
Semi-structured interviews were conducted with researchers, companies and the State Secretary of Sabah State Government.

4) Observation
The evaluation team observed the use of equipment provided at laboratories at UPM and UMS and a showcase facility and its operation in Keningau.

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3. Achievements of the Project and Implementation process

3.1 Results of Inputs

(1) Malaysian Side

1) Assignment of Counterpart Personnel
Project Director: Professor. Dato' Dr. Husaini Omar, Deputy Vice Chancellor (Research and Innovation), UPM
Deputy Project Director: Professor. Dr. Shahril Yusof, Deputy Vice Chancellor (Research and Innovation), UMS
Project Manager: Professor. Dr. Mohammed Ali Hassan
Deputy Project Manager: Professor. Dr. Charles Santhanaraju Vairappan, Director, Institute for Tropical Biology and Conservation (ITBC), UMS

Other counterparts: 4 project subleaders and approximately 35 researchers at UPM and UMS (excluding undergraduate students) have been involved in the Project. The details of the main counterparts are referred to in Appendix 4.

2) Office space for Project Coordinator
UMS has provided office space for Project Coordinator at UMS with office furniture and communication facilities including internet access.

3) Local Operational Costs
The Government of Malaysia provided RM 3 million for this Project, which is an unusually large amount as a research grant. UPM and UMS have spent RM 1.55 million[1] for the Project by August 2016. The remaining balance is approximately RM 1.5 million. Besides, UPM also provided necessary cost for the additional parts of a carbonization system at the showcase facility to overcome the Department of Environment (DOE) regulations on PM10 and CO.

(2) Japanese Side

1) Experts
By April 2017, a total of 16 experts visited Malaysia 115 times (2,205 days) in total as shown below.

Table 1 The assignment of experts

Experts	Number of experts	Times assigned	Total days in Malaysia
Short-term experts			
Chief Advisor	1	81	698
Environmental development	3	5	39
Biomass utilization	8	20	135
Microbiota analysis method	1	6	54
Biodiversity	1	1	5
Subtotal	14	113	931
Long-term experts			
Project coordinator	2	2	1,094
Total	16	115	2,025

Source: Information provided by JST and JICA

2) Provision of Equipment
Equipment for laboratory experiments and the showcase facility were procured. The total amount of procurement by June 2017 was RM 4.4 million (JPY 116 million). The details of the procured equipment are referred to in Appendix 5.

3) Counterpart Training in Japan
A total of 23 researchers participated in the training courses in Japan by June 2017. A list of participants and the

[1] Currency rate: RM1 = JPY26.14 as of May 26, 2017

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training themes are referred to in Appendix 6.

4) Local Operational Costs
The Japanese side has provided part of the necessary expenses for carrying out project activities. The total local operational cost disbursed from the commencement of the Project was RM 243.045 (JPY 6.35 million) by April 1, 2017. This includes fees for vehicles, airfares and other travel expenses.

For the Project, by 1 April 2017, JST has spent RM 5.19 million (JPY 135.6 million) and JICA has provided RM 13 million (JPY 344 million), which includes the cost for equipment and local operational costs listed above. JICA will further provide RM 1.4 million (JPY 36.7 million) by the end of the Project. The total amount Japanese side provided for the Project by 1 April 2017 is RM 18.19 million (JPY 479.6 million).

3.2 Achievements of Activities

Activities	Status as of May 2017
1-1 Select an oil mill for the showcase facilities 1-2 Conduct basic and detail designing of the zero-discharge facilities 1-3 Construct and set the facilities	Since an oil mill that was originally selected for a showcase facility had to be changed from Sandakan due to security concerns, the Keningau Palm Oil Mill (KPOM) was selected. Basic and detail designing of the facility was conducted. Based on the design, the facility was constructed and set in the KPOM. The showcase facility consists of a zero-discharge system, a carbonization system and a compost production system.
1-4 Prepare manuals for the establishment and operations of the showcase facilities and monitor its application	The manuals for the establishment and operations of the showcase facility were prepared and kept inside the facility. Its application was monitored by a site engineer.
1-5 Operate the facilities	The facility has been operated by UPM since February 2016.
1-6 Collect data	Data to check the operation has been collected every weekday by a site engineer. Samples of water quality is collected once a month and analysed at UMS. A part of data are analysed by an external company.
1-7 Analyze and verify data for effectiveness of zero-discharge	The data collected shows that Biochemical Oxygen Demand (BOD) of the discharge was reduced from 30,705 ppm to 8 ppm. The colour of Palm Oil Mill Effluent (POME) final discharge through the showcase facility is transparent, much clearer than the colour of typical waste water. Therefore the effectiveness of zero-discharge was verified in terms of BOD and colour.
1-8 Prepare model Operation and Maintenance (O&M) plan for future commercial plants	At the time of the terminal evaluation, the Project team and a company conducts an experiment which is likely to contribute to development of the model O&M plan for future commercial plants.
2-1 Examine the results of zero-discharge analysis from Output 1 among related firms/organisations.	The results of zero-discharge analysis from Output 1 were examined among related firms and organizations at KPOM with companies and organizations that are interested in the analysis. A number of companies visited the showcase facility at KPOM and 4 of them visited the facility two times so far. The results were also presented at the seminars and workshops as noted in Activity 4-1.
2-2 Carry out cost-benefit analysis for potential business models	Four potential business models were developed: 1) basic unit model, 2) basic unit + micro composite model, 3) basic unit + vegetable factory model and 4) basic unit + eco resort hotel model. Cost-benefit analysis for the models was carried out.
2-3 Validate profitability of business models with related firms and organizations.	Profitability of the models has been validated with a business consulting firm that developed the models and examined them with firms that are interested in the models. Discussion with firms on the business models has been ongoing and there is a possibility that validation will be done in several years after the Project ends.
2-4 Prepare and revise model business proposals and model investment plan.	Model business proposals and model investment plans based on the cost-benefit analysis (Activity 2-2) were prepared and revised based on the feedback from companies.

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2-5 Study reduction on GHG emissions from the showcase facilities	The amount of biogas (methane) generated through anaerobic treatment of POME at the showcase facility has been measured. With the data collected, reduction on GHG emissions from the facility is planned to be studied before the Project ends.
3-1 Form a joint research team and research methods	Joint research teams with UPM, UMS, Kyutech, Kyushu University and AIST were formed according to research themes. Research methods were discussed and agreed on.
3-2 Conduct baseline survey on the biodiversity and ecology of aquatic system affected by palm oil mills. 3-3 Monitor regularly on water quality and analyze the monitoring results and prepare monitoring reports.	Baseline survey on the microbial diversity, biodiversity and ecology of aquatic system was conducted. Another baseline study on ecology of Bornean primates in various types of forests including palm oil plantation. The sampling was carried out monthly from March 2015 to February 2016. The monitoring results were analysed and reports were prepared. An article on the analysis was submitted to a peer-reviewed journal.
3-4 Investigate influences of palm oil mills to the biodiversity. 3-4-1 Correlation between water quality and microbial diversity 3-4-2 Chemical and microbiological properties of the final waste water	The project team investigated the impact of POME to the biodiversity (i.e., an aquatic system of the river) and to microbial diversity from 1) water of a river bordering oil palm and of ponds, and 2) soils of a range of types of forests in terms of microbial community structures and functions using molecular fingerprinting approaches. Chemical properties of the final waste water were also studied.
3-5 Conduct various basic research and consider for implementation regarding the effective utilisation of surplus biomass and waste water/ hot steam. 3-5-1 Research on the quality improvement of compost from palm biomass: identification of useful bacteria using a next generation DNA sequencer 3-5-2 R&D for pretreatment, saccharification and value-added material production technology from EFB and mesocarp fibre 3-5-3 Research on carbonisation and energy generation using Yamasen-oven system	The project team conducted the following basic researches. - The project team identified useful bacteria using a next generation DNA sequencer to improve the quality of compost from palm biomass. - The team also demonstrated that continuous addition of POME anaerobic sludge which contains indigenous microbes and nutrients, contributed to rapid composting of lignocellulosic EFB. - The project team researched and developed non-chemical pre-treatment (superheat steam (SHS) treatment and hot compressed water (HCW) treatment) and saccharification of, and value-added material (e.g. nano-composite, charcoal, acetoin) production technologies from empty fruit bunches (EFB) and mesocarp fiber (MF). - The project team researched on carbonisation and bio charcoal production for energy generation using Yamasen-oven system installed in UPM and KPOM.
3-6 Produce and provide samples of bio-plastic materials to private firms using nano-technology 3-6-1 R&D for nano-fibre production technology from EFB and mesocarp fibre, and providing samples for enterprises. R&D for cellulose-nano-fiber material production 3-6-2 Basic research on production technology of nano-composite with nano-space and higher intensity than commodity plastics using the nano-interface technology/ superheat steam treatment technology, and production of the master batch. Provision of Bio-composite of equal or better quality than base material with reduced price	- The Project team researched and developed nano-fibre production technology from EFB and MF, and cellulose-nano-fibre material production technology and provided samples for companies that were interested in the technologies. - The project team conducted basic research on production technology of nano-composite with nano-space and higher intensity than commodity plastics using the nano-interface technology/ SHS treatment technology, and produced the master batch. - The team also demonstrated that provision of bio-composite of equal or better quality than base material is possible with more than 20% reduced price.

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4-1 Organize workshops, seminars and trade fairs regarding the business model, model investment plan and research results.	A total of 17 workshops and seminars regarding the business models, model investment plans and research results were held from January 2014 to March 2017 in Japan and Malaysia.
4-2 Discuss regularly with SDBEC and other related projects for possible collaboration. 4-3 Cooperate with SDBEC for capacity development of local government and for utilization of developed technologies	Chief Advisor discussed with SDBEC for possible collaboration when necessity arises. Chief Advisor of SDBEC also attended JCC of the Project. The collaboration with SDBEC was summarized as an article and published in a journal with a high impact factor (*Biomass and Bioenegy*). As a result of the collaboration, major research members of the Project and SDBEC applied a joint proposal for another SATREPS project based on research achievements of both projects.
4-4 Implement publicity through mass media	Articles to introduce the Project were published in Malaysian newspapers (Daily Express, Borneo Times) three times in 2014. An article on the research result was published in a Japanese newspaper (Oita Godo Shimbun) in 2016.

3.3 Achievements of Outputs

The following part explains the achievement levels of each Output from the commencement of the cooperation.

(1) Output 1: The effectiveness of zero-discharge is ensured through energy efficiency improvement resulting surplus biomass and excess energy at showcase facilities of zero-discharge established at an oil mill.

Objectively Verifiable Indicator	Progress and achievements
1.1 The showcase facilities aiming zero-discharge are established at an oil mill. [Status: Achieved]	The showcase facility aiming zero-discharge was established at the KPOM in October 2015 and the operation started since February 2016. The operation continued for more than a year without a major problem. Regarding the carbonization system, however, the DOE emission regulations for CO and PM10 need to be overcome.
1.2 The operation records are maintained properly for the showcase facilities. [Status: Achieved]	The operation of the showcase facility has been monitored and operation records are maintained properly by a site engineer. The records show that the facility has been operated without a major problem.
1.3 The excess energy, biomass, hot steam and methane gas are available for effective utilisation. [Status: Achieved]	A palm oil mill produces crude palm oil and kernel as main products as well as POME and palm biomass such as EFB, MF and shell. The project team demonstrated that *methane gas* generated from POME treatment can be used to produce *more electricity* than a palm oil mill needs and that *excess hot steam* which are currently wasted can be also utilized to purify final discharged water. The team also showed that excess *biomass* are available for utilization as noted below in Indicator 1.4
1.4 Bio-composite, charcoal and compost are produced from the excess biomass. [Status: Achieved]	The team also showed that the excess biomass can be effectively utilized to produce various bio products such as bio-composite, bio-charcoal and composts.
1.5 Discharged water from the showcase facilities is fully recycled. [Status: Achieved]	The project team proposed a new treatment system for zero-discharge of POME and showed that the combination of inexpensive existing appropriate technologies can purify POME to meet river quality, making it sustainable to be recycled, although discharged water from the showcase facility is not fully recycled. The experiment by the team confirmed that BOD of discharged water (30,705 ppm) can be reduced to 8 ppm through the proposed system, which is much lower than the DOE regulation on POME treatment in Sabah state (BOD <20 ppm). The colour of recycled water of a showcase facility is also much clearer than discharged water from the current system. At the time of the evaluation, another experiment on POME treatment in collaboration with a Japanese company had been conducted. This experiment is expected to contribute to the reduction of the size of the current large aerobic tank and more efficient treatment of POME.

<Overall assessment of Output 1>
All the planned activities except for development of a model operation and maintenance plan for future commercial plants were completed. All indicators of Output 1 were achieved. Based on the results, achievement level of Output 1 at the time of the terminal evaluation is high and the results show that the idea of zero-discharge was proved through energy efficiency improvement resulting surplus biomass and excess energy at the showcase facility.

(2) Output 2: Viability of business model is verified through the proposed zero-discharge and creation of new industry from surplus biomass and excess energy.

Objectively Verifiable Indicator	Progress and achievements
2.1 Viable business model and model investment plans are proposed based on the cost-benefit analysis. [Status: Achieved]	Responding to a recommendation of the mid-term review, the project hired a consultant in charge of developing business models, carrying out cost-benefit analysis and proposing model investment plans based on the analysis with the fund from JST. By the consultant, four business models were proposed as noted in Activity 2-2. Model investment plans of the models were also developed. The business model and model investment plans were shared with Japanese and Malaysian companies through workshops and seminars.
2.2 New products made by the materials from surplus biomass will be produced on a trial basis. [Status: Achieved]	The project team demonstrated through activities of Output 1 that bio composite, sludge oil, nano fibre and bio charcoal can be produced from surplus biomass and they were produced on a trial basis.

<Overall assessment of Output 2>
While both indicators were achieved, some activities (validation of profitability of business models with related firms and organizations, and study of reduction on GHG emissions from the showcase facility) were not completed at the time of the terminal evaluation. Although discussions with related firms on business models have been ongoing, it is unknown when profitability can be validated with them since it depends on whether the firms will adopt a business model or not. Given the feedback on the business models from the palm oil industry, however, the models need to be revised to make it more appealing to the industry.

(3) Output 3: The innovative research is pursued on the effective utilisation of palm biomass and energy for the reduction of environmental burden caused by palm oil processing.

Objectively Verifiable Indicator	Progress and achievements
3.1 A baseline survey report is produced. [Status: Achieved]	The baseline survey report on the biodiversity and ecology of aquatic system affected by palm oil mills was produced by UMS and the result of the baseline survey was summarized as an article and submitted to a scientific journal.
3.2 Sampling sites are decided to investigate the effect of our zero-discharge (recycled water) on the biodiversity. [Status: Achieved]	14 sampling sites were decided [9 sites in Keningau and 5 sites in Kinabatangan] to investigate on the biodiversity. They include mangrove with palm growing environment, mangrove forest, riverine forest, oil palm plantation, river bordering oil palm, raw POME treating pond, treated POME cooling pond, and a showcase facility.
3-3 The effect of zero-discharge (recycled water) on the bio-diversity recovery is evaluated scientifically.	The findings demonstrated that POME final discharge contributed to the shift of bacterial community dynamics in, and chemical properties of receiving river water. Regarding the study on soils, the Project team showed that Borneo tropical soils is large reservoir for soil bacteria and future exploration is needed in fully understanding the diversity structure and their bacteria functional properties. The Project team also developed the method of monitoring the ecology of Bornean primates through monitoring microbial diversity (i.e. gut microbiome diversity). By enhancing the understanding of ecology of Bornean primates, this research can provide valuable information to support eco-tourism in Sabah. Though the effect of zero-discharge on the biodiversity "recovery" was not evaluated scientifically, this cannot be possible within several years (i.e., the project period). Through the research on biodiversity, the Project team produced unplanned positive outcomes so far. First of all, the team is highly likely to contribute to providing new

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[Status: Ongoing]	insights on biodiversity in Sabah, including ecological cycle of palm plantation which has been hardly investigated. These insights can be effectively utilized to promote palm industry while recovering the bio-diversity of Sabah. Secondly, the team presented a new approach to research biodiversity by studying microbial biodiversity. This approach makes it possible to assess the impact on biodiversity in a much shorter time compared with a traditional method to study biodiversity.
3-4 The effect of superheated steam is confirmed for the production of nano fibers to be used in nano bio -composites. [Status: Achieved]	The project team confirmed that SHS is effective in crashing palm biomass, removing surface impurities and hemicellulose, modifying the surface of nano-fibers and subsequently improving the characteristics of nano-fibers. The team demonstrated that the tensile, flexural and impact properties, as well as dimensional stability of the bio composites were remarkably enhanced by the presence of SHS treated OPMF
3-5 The control of nano-interface between palm biomass fibers and mother plastics by gas-phase polymerization is confirmed. [Status: Achieved]	The team showed that the Vapor-phase-Assisted Surface Polymerization (VASP) could highly modify the cellulose surface compared to conventional method in liquid process.
3-6 A master batch of nano bio-composite is provided. [Status: Achieved]	The team proved that production of a master batch of nano bio-composite is possible by VASP. This enables the Project to provide a sample of nano-bio composite for companies.
3-7 A nano bio-composite with nano-space (<100nm) and higher intensity (50% and up) than commodity plastics is provided (Melt Flow Index >5) [Status: Achieved]	The project team showed that a nano bio-composite (MFI>5) with nano-space (<100 mm) and higher intensity can be obtained by VASP and utilized as a master batch.
3-8 Supply of a bio-composite equal to or greater than the qualities of the mother plastics can be confirmed with price reduced by 20% [Status: Achieved]	The project team developed technology to produce lignocellulose/ prepare nano fibre composite in one pot with a twin screw extruder. With this technology, mechanical properties of a bio-composite was improved to the extent equal to or a greater than the qualities of the mother plastics. 20% price reduction of the bio-composite turned out to be possible based on a simulation by the project team. The team filed a patent based on this research result.
3-9 A production method for nano-cellulose fibers is proposed. [Status: Achieved]	Three production methods for nano-cellulose fibers were proposed: 1) physical process such as wet disk milling approach, and extruding approach, 2) chemical process such as ionic liquid treatment, and surface modification by gas-phase polymerization method or compatibilizer, and 3) a new defiberizing method, which combines physical defiberization with chemical treatment. The project team demonstrated that with this new method, tensile strength of nano-cellulose fibers was increased by about 80%.
3-10 The saccharification efficiency from palm biomass more than 80% is confirmed. [Status: Achieved]	The project team confirmed that by conducting hydrothermal and mechanochemical treatment as pre-treatment of enzymatic saccharification, the saccharification efficiency of all samples of palm biomass (EFB, MF, fruit fiber) can be more than 80%.
3-11 Bio-charcoal with Calorific Value of 20MJ/kg and compost at NPK of 5% are produced from palm biomass. [Status: Achieved]	The project team successfully produced bio-charcoal with calorific value of 20MJ/kg and compost at NPK of 5% from palm biomass using Yamasen-oven system. The carbonization system has been operated at the showcase facility, though the DOE emission regulations for CO and PM10 by a treatment system need to be overcome.

<Overall assessment of Output 3>

Activities were completed by the time of the terminal evaluation. All indicators except for the scientific evaluation on the impact of zero-discharge on the biodiversity recovery were achieved. As for the biodiversity recovery, since it takes decades of years to assess the impact, this indicator cannot be achieved within the project duration. Based on the evaluation, achievements of Output 3 show that knowledge and technologies for the effective utilisation of palm

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biomass and energy were developed to reduce environmental burden caused by palm oil processing.

(4) Output 4: Validity of business model and the research results are shared extensively and recognised within the Sabah Government and domestic/international investors and firms.

Objectively Verifiable Indicator	Progress and achievements
4-1 Workshops, seminars and trade fairs are organised regarding the business model and research results at least twice a year. [Status: Achieved]	As noted in Activity 4-1, a total of 17 workshops and seminars were organized from January 2014 to March 2017 in Japan and Malaysia, which means more than five times a year. At the workshops and seminars, the research results were shared. The business models were also shared at a seminar in Kuala Lumpur, Kota Kinabalu and Osaka in March 2017.
4-2 At least 100 organisations/ agencies in total participate in such events. [Status: Achieved]	A total of 1,015 people from much more than 100 organizations/agencies including the private sector, academia and governmental organizations participated in the above events and the business model and research results were shared and discussed.
4-3 The events are exposed to mass media [Status: Achieved]	One of the research results was publicized by a Japanese newspaper (Oita Godo Shimbun).

<Overall assessment of Output 4>
All activities were completed and all indicators were achieved by the time of the terminal evaluation. The business model was shared once in each city (Kuala Lumpur, Kota Kinabalu and Osaka). In order to attract investors and ensure support from policy makers to make the favourable environment for investors, business models need to be further examined with the Sabah Government, domestic/international investors and firms. Validity of the business models and the research results need to be exposed to Malaysian mass media as well.

3.4 Prospects of achieving the Project Purpose

Project Purpose: Innovative knowledge and viable technologies for business models are developed and shared positively among the potential users for the transformation of palm oil industry into sustainable green industry.

Objectively Verifiable Indicators	Achievements by June 2017	Status
1. At least 5 firms or investors start considering actual investments based on the business model and model investment plan.	According to the result of the questionnaire surveys, 3 firms started considering investments based on the business model and model investment plan.	Ongoing
2. At least 2 firms express their willingness to apply the technologies and research results that are generated from Output 3.	According to the result of the questionnaire surveys, 11 firms expressed their willingness to apply the technologies and research results that are generated from Output 3.	Achieved
3. At least 50 research articles are prepared on the related subjects/ topics and published.	99 research articles were prepared on the related subjects/topics and published.	Achieved
4. At least 10 PhD and 10 master's degrees are awarded to Malaysian students who studied the related subjects/ topics.	12 PhD and 10 master's degrees were awarded to Malaysian students who studied the related subjects/ topics by the time of the terminal evaluation. By the end of the Project, 7 PhD and 3 master's degrees will be further awarded to Malaysian students.	Achieved

The business models developed from the Project have been positively recognized by three large Japanese companies and 11 Malaysian and Japanese companies expressed their willingness to apply the technologies and research results that were developed from Output 3. Although Indicator 1 was not achieved at the time of the terminal evaluation, the evaluation team finds that this indicator is rather ambitious. In terms of the output related to researches, outputs have been produced more than planned. The number of research articles published by the Project team was twice as many as the original target. Some of them were published by scientific journals with high impact factors (e.g. *Bioresource Technology*, *Biomass and Bioenegy*). The Project also achieved development of human resources more than planned. Through this Project, a total of 32 Malaysian students received PhD and master's degrees. Some of those students obtained positions as a lecturer nationally or internationally.

Based on the results of Indicator 1 and 2, the project purpose ("Innovative knowledge and viable technologies for

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business models are developed and shared positively among the potential users for the transformation of palm oil industry into sustainable green industry.") is likely to be achieved by the end of this project if promotion of technologies and knowledge generated from the Project is shared with potential users and policy makers.

3.5 Prospects of achieving the Overall Goal

Narrative Summary	Green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through reduction of pollutants due to waste water in relevant areas in Sabah including Kinabatangan.
Objectively Verifiable Indicators	1. The technologies proposed by or derived from the project are adapted in at least 2 palm oil companies in their palm oil mills by themselves.
	2. The technologies proposed by or derived from the project are adopted in at least 10 palm oil mills by the initiative of investors.
	3. Policy discussions based on the results from the project are started by relevant authorities in Sabah, Malaysia.

While the time for the terminal evaluation is limited, the results of the questionnaire and interview surveys indicate that although several companies are interested in the business models and technologies proposed by or derived from the Project as noted above, it is highly likely that the first actual investment may take longer than originally expected with insufficient resources for marketing, and hence the current indicators are somewhat ambitious to be achieved within 3 years. Validated profitability of a business model by the first investment is likely to attract further investments; it is expected that this will not happen within 3 years. Given the gap between the Project Purpose and the Overall Goal, the prospect of achieving the Overall Goal seems difficult.

Moreover, the current narrative summary of the Overall Goal limits the scope of the Project outcomes by focusing only on knowledge and technologies related to reduction of pollutants due to waste water, although the Project developed various technologies for the effective utilization of biomass including biocomposites. This also needs to be addressed in order to appropriately capture the scope of the Project.

3.6 Implementation Process

(1) Monitoring

The overall project implementation has been monitored according to the PDM. In order to monitor the project progress and discuss any relevant issues amongst stakeholders, Joint Coordination Committee (JCC) was held three times in October 2014, November 2015 and May 2017 and discussed the PDM and the progress of activities. The fourth JCC is held at the end of the evaluation to share the results of the evaluation as well as the progress of activities.

In addition, Chief Advisor was dispatched to Malaysia frequently (81 times) and for a long period of time (698 days), has monitored the overall implementation and whenever issues that could adversely affect the project progress arouse, quickly responded to them. This enabled the Project to catch up with the schedule in spite of a number of difficulties. Through informal meetings among project leaders, progress of responsible researches was also monitored.

(2) Progress/Schedule

The Project team had to give up the establishment of the showcase facility in Sandakan due to security concerns, identify another palm oil mill which allows the Project to establish the facility, and finally set it up in Keningau. This unplanned process largely delayed the implementation of Output 1 and 2. During this period, the Project team focused on researches for Output 3 and provision of training, and was able to catch up the delay by the time of the terminal evaluation with untiring efforts by the Project team. Although there are some issues to be solved (i.e. the DOE regulations on CO and PM10 and water leakage of the carbonization system), the Project almost recovered the schedule.

(3) Communication

Communication between Malaysian Project Manager and Japanese Chief Advisor is very good, due to the long relationship they have built for the past 20 years. Communication between other Malaysian and Japanese researchers and also among Japanese researchers has no major issue observed. Communication between Chief Advisor and Project Coordinators has been also good.

(4) Ownership and participation

Each Malaysian university (i.e. UPM, UMS) has taken a lead in conducting researches on their responsible research component, in collaboration with other member universities. They also voluntarily assisted the implementation, such

as sharing necessary costs (e.g. the additional parts of the carbonization system) and negotiating with the police for the Project vehicle to park on their property during the work in Keningau. Moreover, in terms of social application of the Project outcomes, UPM by itself searched for and identified Malaysian firms that are interested in technologies generated from the Project through the Technology Transfer Office and personal relationships of Project Manager. Sabah State Government largely assisted the Project in selecting the project site. Sabah State Government and UMS also actively shared the knowledge generated from the Project with other governmental organizations such as the Sabah Biodiversity Council and the Sabah Bio-technology Advisory, and planned to contribute to the implementation of the Sabah Biodiversity Strategy. Therefore counterparts' ownership of the Project is very high. Especially Project Manager and Deputy Project Manager took leading roles in implementing these activities above, participation of responsible persons in the Project is also very high.

4. Evaluation by Five Criteria[2]

4.1 Relevance

The relevance of the Project is assessed as relatively high.

(a) Consistency with the federal and state governmental policies of Malaysia

The Project is aligned well with Malaysian federal and state policies. One of the key focus areas of the *11th Malaysia Plan* (2016-2020) is "Adopting the sustainable consumption and production concept". One of the strategies is increasing investment in waste as resources such as biomass for power generation. The project is also in line with Entry Point Project 5 (*Developing Biogas Facilities at Palm Oil Mills*) under one of 12 National Key Economic Area of the National Economic Transformation Programme and the Project contributed to and can further enhance the field. The Project is also aligned well with Sabah's development plan, "Halatuju Pembanguan Dan Kemajuan Negeri Sabah (Direction of Sabah State Development and Advancement), which stipulates that certain areas should be reserved for conservation of natural resources to support healthy ecosystems in addition to the policies on environment and biodiversity conservation such as the Sabah Biodiversity Strategy. The *Sabah's Strategic Long Term Action Plan (2016-2035)* specifies that the development in Sabah state should include economic, social and environmental aspects. In addition, both the federal and Sabah state governments support an effective utilization of biomass and made the *National Biomass Strategy 2020: New Wealth Creation for Malaysia's Biomass Industry* and *Sabah Biomass Industry Development Plan* respectively.

(b) Consistency with Japanese assistance policy

One of the priority areas of the *Country Assistance Policy for Malaysia* set in April 2012 and the *Rolling Plan for Malaysia* as of April 2016 is "Supporting a balanced development towards Malaysia becoming a high-income nation" and states that "Japan supports Malaysia in areas which contribute to improvement of national welfare, such as narrowing national economic disparities, measures against an ageing society, environment management, welfare service for persons with disabilities and disaster prevention." Since the Project aims to contribute to improvement of environmental management, it is also aligned well with the Japanese assistance policy.

(c) Appropriateness of the project design

As noted above, there is dissociation between the Overall Goal and the Project Purpose, and the indicators of the Overall Goal and the Project Purpose are rather ambitious given the limited resources for social application.

4.2 Effectiveness

The effectiveness of the Project is relatively high.

As stated in "*3.4 Prospects of achieving the Project Purpose*", the Project Purpose is likely to be achieved by the end of the Project if technologies and knowledge generated from the Project are further outreached to potential users and policy makers. In addition, the Project contributed to development of human resources by providing higher education for Malaysian students, and to advancement of researches in the fields of biotechnology and biodiversity.

In terms of the Mid-Term Review recommendations, the implementation status is as follows.

(1) Urgent assignment of an assistant in charge of monitoring of pilot plant for the zero-discharge experiment including allocation of UPM researchers and students

A site engineer in charge of monitoring of the showcase facilities was hired and has been posted. He monitors the facility every day and sends a weekly monitoring report to the Project. UPM researchers and students also come to the facility once a month to collect the data and analyze them at UMS.

[2] Judged on a scale from "High," "Relatively High," "Moderate (there were some issues)," "Relatively Low," to "Low."

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(2) Assignment of a professional personnel in charge of the cost benefit analysis and development of model business investment plans for the zero-discharge business model
A professional personnel was assigned and developed the investment plans (including the cost benefit analysis) for the zero-discharge business models. The investment plans were shared at the seminars in Japan and Malaysia.

(3) Holding informal meetings among research members including Malaysian and Japanese sides
Informal meetings among research members including Malaysian and Japanese sides have been held when it is necessary. No major issue in communication among research members was observed at the time of terminal evaluation.

(4) Making the future management plan on the pilot plant at the KPOM
At the time of the terminal evaluation, the Project examined three options on the future management of the pilot plant (the showcase facility). One is to bring it back to UPM and the budget for the transportation (RM 100,000) was already secured. The second option is to maintain it in the KPOM as the showcase facility. This option will be discussed with the owner at the end of the next year (August 2018). The third option is to allow a company that is interested in the facility to use it. Since the project duration for Malaysian side ends in August 2018, UPM will document a future management plan by then.

(5) Revision of PDM
PDM was revised according to the recommendation of the Mid-Term Review and approved by the 3rd JCC in April 2017.

Therefore most of recommendations were followed up by the time of the terminal evaluation.

4.3 Efficiency
The efficiency of the Project is assessed as relatively high.

(a) Dispatch of Japanese experts
A total of 16 Japanese experts with various areas of expertise visited Malaysia 115 times (2,205 days in total) by April 2017 and expedited the research collaboration. According to the results of the questionnaire survey, both Malaysian and Japanese researchers were satisfied with the timing, quantity and quality of the dispatch of Japanese experts.

(b) Provision of equipment
As listed in Appendix 5, equipment for laboratory experiments and the showcase facility were provided for the Project. Most of them were utilized well to conduct planned activities, although the carbonization system needs to solve some issues for commercialization.

(c) Local operational costs
As stated in *3.1 Results of Inputs*, both Malaysian and Japanese sides provided operational costs to implement the Project. Malaysian government provided RM 3 million (JPY 78 million), which is an unusually large amount as a research grant and therefore the amount of operational costs have been sufficient.

(d) Counterpart training in Japan
Counterpart training in Japan effectively contributed to enhancing the knowledge and skills of Malaysian researchers. A total of 23 Malaysian researchers participated in the training and all of them (except for those who already graduated) still continued the research at UPM and UMS at the time of the evaluation, and utilized the knowledge and technology obtained through the training for their daily work. Training participants acquired knowledge and technologies that cannot be obtained in Malaysia and they were indispensable to produce expected research outputs. Besides, since some of the training participants are lecturers, the knowledge acquired through the training has been shared at lectures and seminars at Malaysian universities.

(e) Assignment of counterparts
A total of 41 Malaysian researchers participated in the Project and have been well assigned to produce expected research outputs as well as develop human resources. Therefore the assignment of counterparts was sufficient.

Contributing factors that have led to efficiently converting inputs to outputs can be summarized as follows:
- Physical presence of Chief Advisor at the counterpart university (UPM) to expedite the implementation process
- The trust built through the long relationship between Chief Advisor and Project Manager at UPM, and between

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JICA and Deputy Project Manager at UMS through the past projects with UMS, including SDBEC.

Inhibiting factors are summarized as follows:
- Security concerns which largely delayed the construction of and the experiments at the showcase facility
- Drastic change of the currency exchange rate, which led to large decrease in the project budget, and then affected the budget for the procurement of business consultants

Although the quality, quantity and timing of most inputs were sufficient, a part of equipment (i.e. the carbonization system) has some issues, which needs to be overcome. Delay in the construction of the showcase facility hindered the planned activities on development of zero-discharge technology.

4.4 Impact
Impacts of the Project can be judged as relatively high since the prospects of achieving the Overall Goal is moderate while some positive impacts of the Project were observed at the time of the terminal evaluation.

(a) Prospects of achieving the Overall Goal
As already discussed in *3.5 Prospects of achieving the Overall Goal*, the current Goal is difficult to be achieved within 3 years due to rather ambitious indicators with insufficient resources for marketing. The narrative summary needs to be revised to incorporate all the technologies developed from the Project.

(b) Impacts of the Project
Positive impacts observed by the evaluation team are as follows.
- Contribution to the insights of biodiversity in Sabah including the ecological cycle of palm plantations, which has been hardly investigated
- Development of a novel approach to research biodiversity by studying microbial biodiversity
- Development of Malaysian human resources, which will lead to advance science and technologies in the relevant field in Malaysia and other countries
- Development of innovative technologies. Consequently, 2 patents are registered in Japan and 3 patents are filed in other countries including Malaysia.
- Development of Japanese human resources in Japan and in Malaysia through the strengthened partnership among member universities and a research institute.
- Enhanced recognition of zero-discharge technologies given the number of workshop participants gradually increased
- Enhanced political will in the Sabah State Government towards the promotion of zero-discharge technologies in Sabah

No negative impacts by the Project were observed.

4.5 Sustainability
The sustainability of the Project is high.

■ **Policy and Institutional Aspects**
Sustainability of the Project from policy and institutional aspects is high.
The policy environment for the Project remains unchanged since the Project started. The collaborative research is likely to be carried out among member universities and research institution due to existing agreements among them.

■ **Financial/Organizational Aspects**
The financial and organizational sustainability is high.
The operating revenue of UMS for the past 3 years (2013-2015) has increased as shown in the table below. While the total operating revenue of UPM decreased in 2015, both universities largely increased other income, which indicate that they increased financial independence, not solely relying on government grants. Both UPM and UMS also have received external funds from large companies to continue related researches. Therefore financial sustainability of the Project effects is high.

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Table 2 The operating revenues of UMS and UPM (Unit: million RM)

	UMS			UPM		
	2013	2014	2015	2013	2014	2015
Government grants	332.48	348.92	363.95	745.22	772.4	627.37
Various fees	29.35	30.92	33.54	102.8	107.04	106.25
Other income	0.94	4.2	6.1	159.44	150.42	175.57
Total	362.77	384.03	403.56	1007.46	1029.86	909.19

Source: UMS annual report 2015, UPM annual report 2014

In terms of human capacity, sustainability is high. While Chief Advisor and Project Manager will be retired in a couple of years, their Malaysian successors have been groomed and developed personal connections with other senior researchers across the border through the Project.

■ **Technical Aspects**

Technical sustainability is high.

Knowledge and technologies transferred through the Project can be shared through articles published and manuals. In terms of operation and maintenance of the equipment provided under the Project, students or a science officer were assigned to take charge of the maintenance of equipment. A supervisor of students (lecturers) assigns new students for maintenance each year and monitors the status of the maintenance. Manuals were well kept and operation and maintenance instructions were widely shared. Local contractors are available to fix them if they are broken. Since the equipment provided by previous JICA projects has been well maintained, the equipment provided by this Project can be assumed to be maintained appropriately.

5. Conclusion

Based upon the findings of the evaluation, the evaluation team confirmed that the Project has been carried out satisfactory after the mid-term review even though some activities were delayed. The Project Purpose is likely to be achieved by the end of the Project if the promotion of technologies and knowledge generated from the Project is shared with potential users and policy makers.

Results of the terminal evaluation by the five (5) evaluation criteria are summarized below.

Criteria	Evaluation	Summary
Relevance	Relatively High	The Project coincides with policies of Malaysia and Japan. As for the appropriateness of the project design, there is dissociation between the Overall Goal and the Project Purpose, and the indicators of the Overall Goal and the Project Purpose are rather ambitious given the limited resources for social application.
Effectiveness	Relatively High	The Project Purpose is likely to be achieved by the end of the Project if technologies and knowledge generated from the Project are further outreached to potential users and policy makers. The recommendations from the Mid-Term Review have been followed up except for making the future management plan on the showcase facility at the KPOM, which will be prepared before August 2018.
Efficiency	Relatively High	The quality, quantity and timing of most inputs were sufficient. Yet, a part of equipment has some issues, which needs to be overcome for commercialization. Delay in the construction of the showcase facility hindered the planned activities on development of zero-discharge technology.
Impact	Relatively High	The current Goal is difficult to be achieved within 3 years due to rather ambitious indicators with insufficient resources for marketing. The narrative summary needs to be revised to incorporate all the technologies developed from the Project. The impacts from the Project are seen in the development of human resources, the advancement of researches, and the increased awareness of the state government and the public toward the zero-discharge technologies. No negative impacts were observed.
Sustainability	High	All aspects for the sustainability are "high". Researches will continue to be carried out with internal funds of member institutions as well as external financial resources.

* Ranking according to the five-grade evaluation: High, Relatively high, Moderate, Relatively low and Low.

The evaluation team confirmed that the technologies for zero-discharge are developed and the researches in the relevant areas are advanced. Additionally, the evaluation team confirmed that the Project has greatly contributed to development of human resources in Malaysia as well as in Japan particularly through training courses in Japan.
It should be noted that this is attributed to the good relationship among Kyutech, Kyushu University, AIST, UPM, and UMS as well as supports from the Malaysian government and the Sabah State Government.

6. Recommendations

Based on the results of the evaluation above, the joint terminal evaluation team makes the following recommendations to the Project team:

(1) Revision of the Overall Goal and its indicators in the PDM

The evaluation team proposes to revise the Overall Goal and the indicators for it in the present PDM (Version 2) as follows.

<Overall Goal>

Present	Green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through reduction of pollutants due to waste water in relevant areas in Sabah including Kinabatangan.
Proposed	Green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through zero-discharge technologies in relevant areas in Sabah including Kinabatangan

<Objectively Verifiable Indicators>

Present	1. The technologies proposed by or derived from the Project are adapted in at least 2 palm oil companies in their palm oil mills by themselves. 2. The technologies proposed by or derived from the Project are adopted in at least 10 palm oil mills by the initiative of investors. 3. Policy discussions based on the results from the Project are started by relevant authorities in Sabah, Malaysia.
Proposed	1. The technologies proposed by or derived from the Project are adapted in at least 2 palm oil companies in their palm oil mills by themselves. 2. Cost-benefit analysis of business models utilizing technologies based on the Project is carried out by the initiative of investors for potential commercialization. 3. At least one business model is adopted in at least 1 palm oil mill by the initiative of investors. 4. Policy discussions based on the results from the Project are started by relevant authorities in Sabah, Malaysia.

<Important Assumption for the Overall Goal>

Present	Oil palm plantations do not expand or degrade drastically during and after the Project.
Proposed	• Oil palm plantations do not expand or degrade drastically during and after the Project. • There are no major negative changes in the policy/economic environments surrounding the palm oil industry in Sabah and Malaysia. • The security in Sabah remains stable.

(2) Revision of the current proposed business models and business plans

Before 20th November 2017, in order to make the business models more appealing to the palm oil industry, relevant industries and investors, it is recommended that the Project team should revise the current business models having inputs from experts in the fields of business and of engineering both in Japan and Malaysia as well as technical inputs from JST.

(3) Incorporation of research results into the policy dialogue

It is noted that some activities of the Project have been adopted by National Biomass Strategy 2020.

Considering the importance of the government's involvement, it is significant to continue to incorporate research results and technologies into the policy dialogue.

The evaluation team recommends that the Project team continue to share the research results and the developed

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technologies at the Sabah Biodiversity Council, Sabah Biotechnology Advisory Committee, the Biomass Committee, Bioeconomy Corporation, Green Technology Development Corporation and other related governmental committees to influence development policies in Malaysia. Furthermore, inputs from the research results need to contribute to the implementation of the Sabah Biodiversity Strategy.

(4) Reaching out to potential investors through organizing seminars, available platforms, and/or mass media.

While seminars for the business models were held in Malaysia and Japan, the evaluation team found that it would be significant for the Project team to carry on sharing the knowledge and technologies developed by the Project with the targeted audience.

Therefore, firstly it is suggested that the Project team continue to strengthen dialogue with the firms/companies in the palm oil industry and potential investors which have interests in outputs from the Project to make their business plans realized.

Secondly, the evaluation team recommends that the Project team should continue to have discussions to make the business models more acceptable for the private sector before the Project finishes.

Thirdly, the evaluation team suggests that the Project team disseminate the Project's outputs including the business model/plans to reach out to potential investors/tour operators based in surrounding Kinabatangan through available platforms, such as UMS EcoCampus Management Centre and mass media.

(5) Meeting the CO and PM10 regulations of the carbonization system at the showcase facility

It is very crucial to meet the CO and PM10 regulations of the system at the showcase facility for commercialization. Thus, before the JICA's project duration ends, the Project team needs to solve the issues of CO and PM10.

(6) Finalizing the management plan for the showcase facility

The evaluation team suggests that a final management plan for the showcase facility should be prepared by UPM before the end of the Project duration for the Malaysian side (August 2018) to ensure the sustainability of activities at the showcase facility.

7. Lessons learned

The Project has learned the following lessons.

(1) During the implementation of a project, gaps between the reality and the PDM tend to be recognized. To avoid them, a project team should hold a meeting regularly to monitor progress of the project and revise a PDM according to the progress and issues.

(2) At the stage of designing a PDM, inputs from business experts should be included if a project purpose aims to link with the private sector for the purpose of practical application of technologies and knowledge.

Appendix 1. Schedule of the Terminal Evaluation

Date		Activities
5/28	Sun	Arrive in KL
5/29	Mon	AM 10:00 Interview with UPM researchers PM 2:30 Interview with Sime Darby
5/30	Tue	AM 9:00 Interview with training participants in Japan PM 2:30 Interview with FELDA Palm Industry.
5/31	Wed	Interview with Chief Advisor
		Leave KL and arrive in KK
6/1	Thu	AM9:00 Interview with Dr. Charles (UMS) PM10:30 Interview with Mr. Kelvin (UMS)
		PM: Leave KK and arrive in Keningau
6/2	Fri	Visit to Keningau POM Interview with Datuk Yap / Mill Manager
		PM: Leave Keningau and arrive in KK
6/3	Sat	Documentation
6/4	Sun	Documentation
6/5	Mon	9:00- Meeting with the Sabah State Secretary 10:30 - Meeting with DIDR, DOE, MOTCE 16:55: Leave KK and Arrive in KL
6/6	Tue	9:30-13:00 Discussion and drafting Minutes 14:00- Meeting with UMS and JICA Malaysia Office
6/7	Wed	9:30-16:30 Discussion and drafting Minutes @UPM
6/8	Thu	14:30: JCC and Signature of Minutes @UPM
6/9	Fri	Leave KL and arrive in Tokyo

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Appendix 2. PDM (Version 2.0)

Project Design Matrix (PDM)

Project Title: Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation
Project Duration: 21 Nov. 2013 to 20 Nov. 2017 (four years)
Project Sites: UPM(Serdang, Selangor), UMS(Kota Kinabalu, Sabah), Keningau Palm Oil Mill(Keningau, Sabah)
Target Group: Staff members, researchers and students of UPM and UMS; Federal and Sabah Government agencies; and Stakeholders in the palm oil industry in Malaysia

Version Number: Version 2.0
Date: 4th May, 2017

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal (to be achieved within 3 – 5 years after the completion of the Project): Green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through reduction of pollutants due to waste water in relevant areas in Sabah including Kinabatangan.	1. The technologies proposed by or derived from the project are adapted in at least 2 palm oil companies in their palm oil mills by themselves. 2. The technologies proposed by or derived from the project are adopted in at least 10 palm oil mills by the initiative of investors. 3. Policy discussions based on the results from the project are started by relevant authorities in Sabah, Malaysia.	• Questionnaire survey to the firms in palm oil industry • Minutes of discussions	
Project Purpose: Innovative knowledge and viable technologies for business models are developed and shared positively among the potential users for the transformation of palm oil industry into sustainable green industry.	1. At least 5 firms or investors start considering actual investments based on the business model and model investment plan. 2. At least 2 firms express their willingness to apply the technologies and research results that are generated from Output 3. 3. At least 50 research articles are prepared on the related subjects/ topics and published. 4. At least 10 PhD and 10 master's degrees are awarded to Malaysian students who studied the related subjects/ topics.	• Interview survey to the firms and investors • Questionnaire survey to the firms • Research article • Interview survey with the degree providers	Oil palm plantations do not expand or degrade drastically during and after the Project.
Output: Output 1: The effectiveness of *zero-discharge is ensured through energy efficiency improvement resulting surplus biomass and excess energy at showcase facilities of zero-discharge established at an oil mill.	1-1 The showcase facilities aiming zero-discharge are established at an oil mill. 1-2 The operation records are maintained properly for the showcase facilities. 1-3 The excess energy, biomass, hot steam and methane gas are available for effective utilisation. 1-4 Bio-composite, charcoal and compost are produced from the excess biomass. 1-5 Discharged water from the showcase facilities is fully recycled.	• Physical visit to the showcase facilities • Visual inspection of operation records and interview survey to the operators at the facilities • The report that indicates the effectiveness of zero-discharge and physical visit • Manual(s) for the establishment/operation of the showcase facilities and for monitoring its application • Model O & M plan	• There are no major negative changes in the policy/ economic environments surrounding the palm oil industry in Sabah and Malaysia. • Close collaboration continues with other related projects as SDBEC.
Output 2: Viability of business model is verified through the proposed zero-discharge and creation of new industry from surplus biomass and excess energy.	2-1 Viable business model and model investment plans are proposed based on the cost-benefit analysis. 2-2 New products made by the materials from surplus biomass will be produced on a trial basis.	• Documents with the business model and model investment plan • Interview survey to the firms and investors • Report indicating the trial	

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Output 3: The innovative research is pursued on the effective utilisation of palm biomass and energy for the reduction of environmental burden caused by palm oil processing.	3-1 A baseline survey report is produced. 3-2 Sampling sites are decided to investigate the effect of our zero-discharge (recycled water) on the biodiversity. 3-3 The effect of zero-discharge (recycled water) on the bio-diversity recovery is evaluated scientifically. 3-4 The effect of superheated steam is confirmed for the production of nano fibers to be used in nano bio-composites. 3-5 The control of nano-interface between palm biomass fibers and mother plastics by gas-phase polymerization is confirmed. 3-6 A master batch of nano bio-composite is provided. 3-7 A nano bio-composite with nano-space (<100nm) and higher intensity (50% and up) than commodity plastics is provided(Melt Flow Index >5). 3-8 Supply of a bio-composite equal to or greater than the qualities of the mother plastics can be confirmed with price reduced by 20% 3-9 A production method for nano-cellulose fibers is proposed. 3-10 The saccharification efficiency from palm biomass more than 80% is confirmed. 3-11 Bio-charcoal with Calorific Value of 20MJ/kg and compost at NPK of 5% are produced from palm biomass.	• Baseline survey report • Pollution monitoring reports • Papers and patents	
Output 4: Validity of business model and the research results are shared extensively and recognised within the Sabah Government and domestic/international investors and firms.	4-1 Workshops, seminars and trade fairs are organised regarding the business model and research results at least twice a year. 4-2 At least 100 organisations/ agencies in total participate in such events. 4-3 The events are exposed to mass media.	• Project reports • Records of mass media	

*zero-discharge: all by-products from mills will be transformed into useful biomass, energy and recycled water which are valuable or tradable as a result of improved energy efficiency and resource utilisation in the process of palm oil production.

別添資料 1

Activities:	Input (Japanese side):	Input (Malaysian side):	Precondition
Outputs 1 1-1 Select an oil mill for the showcase facilities 1-2 Conduct basic and detail designing of the zero-discharge facilities 1-3 Construct and set the facilities 1-4 Prepare manuals for the establishment and operations of the showcase facilities and monitor its application 1-5 Operate the facilities 1-6 Collect data 1-7 Analyze and verify data for effectiveness of zero-discharge 1-8 Prepare model Operation and Maintenance (O&M) plan for future commercial plants	**Dispatch of Japanese experts** : -Long-term expert ➢ Project Coordinator -Short-term experts ➢ Chief Advisor ➢ Chemical Engineering ➢ Applied Microbiology ➢ Organic Chemistry ➢ Ecology ➢ Other specific fields **Equipments and facilities :** -Showcase facilities for zero-discharge and the installation -A project vehicle -Laboratory equipment for UPM and UMS **Local project expenses** **Training in Japan**	**Provision of counterpart personnel (C/P)(UPM/UMS)** **Operators and operation cost for the showcase facilities (UPM/UMS)** **Office space and other necessary office facilities and equipments (UPM/UMS)** **Site for showcase facilities for zero-discharge (Sabah State Government)** **Joint Coordination Committee (UPM)** **Biodiversity evaluation (UMS)**	• C/P organisations/ agencies make efforts to secure and provide adequate budgets for joint research and other project activities. • C/P organisations/ agencies dispatch adequate and proper researchers to the Project on time. • There are firms that are willing to cooperation with the Project, especially for the setting of showcase facilities.
Output 2 2-1 Examine the results of zero-discharge analysis from Output 1 among related firms/organisations. 2-2 Carry out cost-benefit analysis for potential business models 2-3 Validate profitability of business models with related firms and organizations. 2-4 Prepare and revise model business proposals and model investment plan. 2-5 Study reduction on GHG emissions from the showcase facilities			

Output 3 3-1 Form a joint research team and research methods 3-2 Conduct baseline survey on the biodiversity and ecology of aquatic system affected by palm oil mills. 3-3 Monitor regularly on water quality and analyze the monitoring results and prepare monitoring reports. 3-4 Investigate influences of palm oil mills to the biodiversity. 3-4-1 Correlation between water quality and microbial diversity 3-4-2 Chemical and microbiological properties of the final waste water 3-5 Conduct various basic research and consider for implementation regarding the effective utilisation of surplus biomass and waste water/ hot steam. 3-5-1 Research on the quality improvement of compost from palm biomass: identification of useful bacteria using a next generation DNA sequencer 3-5-2 R&D for pretreatment, saccharification and value-added material production technology from EFB and mesocarp fibre 3-5-3 Research on carbonisation and energy generation using Yamasen-oven system 3-6 Produce and provide samples of bio-plastic materials to private firms using nano-technology 3-6-1 R&D for nano-fibre production technology from EFB and mesocarp fibre, and providing samples for enterprises. R&D for cellulose-nano-fiber material production 3-6-2 Basic research on production technology of nano-composite with nano-space and higher intensity than commodity plastics using the nano-interface technology/ superheat steam treatment technology, and production of the master batch. Provision of Bio-composite of equal or better quality than base material with reduced price			
Output 4 4-1 Organize workshops, seminars and trade fairs regarding the business model, model investment plan and research results. 4-2 Discuss regularly with SDBEC and other related projects for possible collaboration. 4-3 Cooperate with SDBEC for capacity development of local government and for utilization of developed technologies 4-4 Implement publicity through mass media			

別添資料 1

Evaluation Grid of "the Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation"

Achievement and Implementation Process (ver.0)

May 18, 2017

Items to be checked: Main points	Items to be checked: Specific Questions	Objectively Verifiable Indicators (Criteria /Method for assessment)	Necessary information /data	Information Sources	Method for data collection
Achievement/Performance					
- Prospect of achieving Outputs	1 The effectiveness of zero-discharge is ensured through energy efficiency improvement resulting surplus biomass and excess energy at showcase facilities of zero-discharge established at an oil mill.	1-1 The showcase facilities aiming zero-discharge are established at an oil mill. 1-2 The operation records are maintained properly for the showcase facilities. 1-3 The excess energy, biomass, hot steam and methane gas are available for effective utilisation. 1-4 Bio-composite, charcoal and compost are produced from the excess biomass. 1-5 Discharged water from the showcase facilities is fully recycled.	- Operational records - Project reports, articles - Opinions	- Experts - UPM,UMS - KPOM	- Document review - Questionnaire - Interview - Observation
	2 Viability of business model is verified through the proposed zero-discharge and creation of new industry from surplus biomass and excess energy.	2-1 Viable business model and model investment plans are proposed based on the cost-benefit analysis. 2-2 New products made by the materials from surplus biomass will be produced on a trial basis.	- The business model and model investment plan - Project reports, articles - Opinions		
	3 The innovative research is pursued on the effective utilisation of palm biomass and energy for the reduction of environmental burden caused by palm oil processing.	3-1 A baseline survey report is produced. 3-2 Sampling sites are decided to investigate the effect of our zero-discharge (recycled water) on the biodiversity. 3-3 The effect of zero-discharge (recycled water) on the bio-diversity recovery is evaluated scientifically. 3-4 The effect of superheated steam is confirmed for the production of nano fibres to be used in nano bio-composites. 3-5 The control of nano-interface between palm biomass fibres and mother plastics by gas-phase polymerization is confirmed. 3-6 A master batch of nano bio-composite is provided. 3-7 A nano bio-composite with nano-space (<100nm) and higher intensity (50% and up) than commodity plastics is provided(Melt Flow Index >5). 3-8 Supply of a bio-composite equal to or greater than the qualities of the mother plastics can be confirmed with price reduced by 20% 3-9 A production method for nano-cellulose fibres is proposed. 3-10 The saccharification efficiency from palm biomass more than 80% is confirmed. 3-11 Bio-charcoal with Calorific Value of 20MJ/kg and compost at NPK of 5% are produced from palm	- Baseline survey report - Pollution monitoring reports - Project reports, articles Opinions		
	4 Validity of business model and the research results are shared extensively and recognised within the Sabah Government and domestic/international investors and firms.	4-1 Workshops, seminars and trade fairs are organised regarding the business model and research results at least twice a year. 4-2 At least 100 organisations/ agencies in total participate in such events. 4-3 The events are exposed to mass media.	Project reports Records of mass media		
Implementation Process					

Evaluation Grid of "the Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation"

Achievement and Implementation Process (ver.0)

May 18, 2017

Items to be checked		Objectively Verifiable Indicators (Criteria /Method for assessment)	Necessary information /data	Information Sources	Method for data collection
Main points	Specific Questions				
- Progress/Schedule	- Whether the activities have been carried out as planned - What were the reasons for delay and what measures have been taken to catch up for delay?	- Compare the original plan with the actual implementation - Check the reasons and measures for the delay	- Project reports - Opinions	- Experts - UPM,UMS	- Document review - Questionnaire - Interview
- Monitoring	- How the project progress is monitored - Whether the monitoring system of the project is appropriate and effective. - Whether the results of monitoring have been reflected to the project management.	- Check the means and frequency of the project monitoring	- Project reports - Opinions		
- Communication among related parties and personnel	- Whether communication 1) between Malaysian and Japanese researchers and 2) among Japanese researchers have been established well to manage the	- Check the degree of communication, and its means and frequency if necessary	- Opinions - Project reports		
- Participation of Malaysian side	- Degree of participation in management by the responsible persons - Attitude of C/Ps	- The extent to which a project manager and a chief advisor have participated in project management - Whether C/Ps are collaborative and self-motivated towards the project activities	- Meeting records - Opinions - Project reports		

Evaluation Grid of "the Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation"

Five Evaluation Criteria (ver.0)

May 18, 2017

Items to be checked		Objectively Verifiable Indicators (Criteria /Method for assessment)	Necessary information /data	Information Sources	Method for data collection
Main points	Specific Questions				
Relevance					
- Consistency with development and nature conservation policies and plans in Malaysia	- Whether the project is still in line with national policies/plans related to development and nature (esp. biodiversity) conservation	- Whether the project is in line with a. development policies (e.g. 11th Malaysia Plan) b. nature/biodiversity conservation policies (e.g. National Biomass Strategy 2020)	- Policy papers	- Malaysian central/local government	- Document review - (Interview)
- Consistency with Japanese policy	- Whether nature conservation is prioritized in Japanese assistance policy - Whether the project is in line with JICA's thematic guideline on nature conservation	- Whether the project is still in line with a. the Japanese Country Assistance Policy for Malaysia/ Rolling Plan for Malaysia b. JICA's thematic guideline on nature conservation	- Country Assistance Policy - Guideline on nature	- MOFA - JICA	- Document review
- Meeting with the needs of target groups/beneficiaries	- Whether the project purpose still meets the needs of C/Ps	- Whether the mandate and needs of C/Ps remain unchanged - Whether there is no institutional change which have affected the relevance	- Annual reports of C/Ps - Project reports - Opinions	- UPM,UMS	- Document review - Questionnaire - (Interview)
Effectiveness					
- Probability of achieving the Project Purpose	- Whether innovative knowledge and viable technologies for business models are developed and shared positively among the potential users for the transformation of palm oil industry into sustainable green industry.	1. At least 5 firms or investors start considering actual investments based on the business model and model investment plan. 2. At least 2 firms express their willingness to apply the technologies and research results that are generated from Output 3. 3. At least 50 research articles are prepared on the related subjects/ topics and published. 4. At least 10 PhD and 10 master's degrees are awarded to Malaysian students who studied the related subjects/ topics	- Opinions - Articles - Project reports	- Experts - UPM,UMS - Companies	- Document review - Interview - Questionnaire
- Contribution of the Outputs to the Project Purpose	- Whether all Outputs which are required to achieve the Project Purpose are listed in the PDM	- The logic of PDM (Project purpose/Outputs) - Whether any other outputs which are not specified in the PDM are necessary to achieve the Project Purpose	- Opinions - PDM - Project reports	- Experts - UPM,UMS	- Document review - Interview - Questionnaire
- Follow-up of the recommendations made at the mid-term review	- Whether an assistant in charge of monitoring of the pilot plant was urgently assigned for the zero-discharge - Whether a professional personnel in charge of the cost benefit analysis and development of model business investment plans for the zero-discharge business model was assigned - Whether informal meetings among research members including Malaysian and Japanese sides were held	- The assignment of human resources in charge of monitoring of the pilot plant - The implementation status of the cost benefit analysis and development of model business investment plans - The implementation status of informal meetings	- Opinions - Project reports - Latest PDM	- Experts - UPM, UMS	- Document review - Interview - Questionnaire

Evaluation Grid of "the Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation"

Five Evaluation Criteria (ver.0)

May 18, 2017

Items to be checked		Objectively Verifiable Indicators (Criteria /Method for assessment)	Necessary information /data	Information Sources	Method for data collection
Main points	Specific Questions				
	- Whether the future management plan on the pilot plant at the Keningau Palm Oil Mill was - Whether PDM was revised	- The implementation status of developing the future management plan - The same as left mentioned			
- Promoting / hampering factors	- Whether the important assumption affected the project achievement - Whether there are/were any factors affecting the achievement of the Project Purpose	- Whether palm oil plantations do not expand or degrade drastically during and after the Project. - The same as left mentioned	- Opinions - Project reports	- Experts - UPM,UMS - KPOM	- Interview - Document review
Efficiency					
- Generation of Outputs	- Whether all activities have been sufficient to generate the Outputs as planned	- The logic of PDM (Output/activities) - The progress of activities and status of Outputs (→Implementation Process)	- Project reports - PDM	- Experts - UPM,UMS - Governmental organizations - KPOM	- Document review - Questionnaire - Interview
- Conversion of the input to the outputs	- Whether the timing, quantity and quality of inputs was appropriate to generate the Outputs	- Check if the inputs were appropriate in terms of (a) Dispatch of Japanese experts (b) Provision of machinery and equipment (c) Local Operational costs (d) C/P training in Japan (e) Budget disbursement of C/P (f) Assignment of C/P personnel (g) Other inputs by C/P	- Summary of inputs - Opinions - Project reports		
- Promoting / hampering factors	- Whether the important assumptions affected the project achievement - Whether other external factors influenced converting inputs to outputs	- Whether there are no major negative changes in the policy/ economic environments surrounding the palm oil industry in Sabah and Malaysia. - Whether close collaboration continues with other related projects as SDBEC. - The same as left mentioned	- Opinions - Project reports		
Impact					
- Probability of achieving the Overall Goal	- Whether green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through reduction of pollutants due to waste water in relevant areas in Sabah including Kinabatangan.	1. The technologies proposed by or derived from the project are adapted in at least 2 palm oil companies in their palm oil mills by themselves. 2. The technologies proposed by or derived from the project are adopted in at least 10 palm oil mills by the initiative of investors. 3. Policy discussions based on the results from the project are started by relevant authorities in Sabah, Malaysia.	- Opinions - Project reports	- Experts - UPM,UMS - Companies - Governmental organizations	- Document review - Questionnaire - Interview

別添資料 1

Evaluation Grid of "the Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation"

Five Evaluation Criteria (ver.0)

May 18, 2017

Items to be checked		Objectively Verifiable Indicators (Criteria /Method for assessment)	Necessary information /data	Information Sources	Method for data collection
Main points	Specific Questions				
- Ongoing/possible collaborations with other donors and projects	- Whether there are any ongoing/possible collaborations with multi/bi-lateral development partners and other projects by JICA If any, whether there are any impacts of the	- The collaboration with other JICA projects and other donors and any impacts of the collaboration	- Opinions - Project reports	- Experts - UPM,UMS	- Document review - Questionnaire - Interview
- Other expected and unexpected impacts	- Whether there are other impacts (positive/negative) generated by the project implementation	- Impacts on government policies/ programmes, organizations, groups, the environment and any other impacts	- Project reports - Opinions	- Experts - UPM,UMS - Governmental organizations	- Document review - Questionnaire - Interview
Sustainability					
- Institutional/political aspects	- Whether the government will keep putting the priorities on nature conservation - Whether there is a need to have a MOU or any framework to continue the research activities	- The government policy or plan - MOU or any other framework	- Policy or plan paper - Opinions - Project reports	- Governmental organizations - Experts - UPM,UMS	- Document review - Questionnaire - Interview
- Financial aspects	- Whether C/Ps will have sufficient budget to continue the activities after the project duration	- The budget for the last three years and a coming year if possible - External financing from donors and private sectors	- C/Ps' Annual reports - Opinions	- UPM, UMS	- Document review - Questionnaire - Interview
- Organizational aspects	- Whether C/Ps will have sufficient capacity of pursuing relevant research activities to keep project effects after the project completion	- Ownership of C/Ps - Allocation of researchers - Retention of researchers	- C/P list - Opinions - Project reports	- UPM, UMS	- Document review - Questionnaire - Interview
- Technical aspects	- Whether the skills/techniques of C/Ps which the project enhanced are and will be shared amongst and further enhanced by C/Ps - Whether the machinery and equipment provided by the Project is likely to be maintained appropriately	- Results of training in Japan - Number of training and participants - Training opportunities and update of expertise/ knowledge - Current practice of maintenance of the machines provided for this project and past ones - Plan of maintenance - Availability of operation and maintenance manuals	- Opinions - Plan - Project reports - Manuals	- Experts - UPM,UMS	- Interview - Questionnaire - Document review - Observation

Appendix 4. List of main counterparts

No	Name	Title	Organization
1	Prof. Dr. Mohd Ali Hassan	Professor	UPM
2	Prof. Dr. Charles Santhanaraju Vairappan	Director	UMS
3	Dr. Hidayah Ariffin	Senior Lecturer	UPM
4	Dr. Mohd Rafein Zakaria	Lecturer	UPM
5	Dr. Norhayati Ramli	Lecturer	UPM
6	Dr. Mohd Zulkhairi Mohd Yusoff	Lecturer	UPM
7	Mr. Gerald Jetony	Senior Geologist	NRO, Sabah State Gov.

Appendix 5. List of Equipment Provided

Item	Price (RM)	Location
Thermogravimetry analyser / Mass spectroscopy	213,000	UPM
PCR thermal cycler	40,000	UPM
Flow cyctometer	326,480	UPM
DGGE	114,268	UPM
Grinding machine (hammer mill)	136,740	UPM
Grinding machine (wet disc mill)	15,000	UPM
Total organic carbon and nitrogen analyser	320,000	UMS
Fluorescence spectrophotometer	126,000	UMS
4WD vehicle	113,603	UMS
Showcase facility (construction work)	2,550,190	KPOM
Showcase facility (equipment)	395,509	KPOM
Smoke Treatment System	75,412	KPOM
Total	4,426,202	

Appendix 6 : A list of counterpart training participants

Name	Organization	Receiving organization	Theme	From	To	Total number of days
Charles Santhanaraju	UMS	・JST ・JICA	Super heated steam treatment	2014/1/27	2014/4/19	14
		UMS	Biodiversity			
Norhayati Binti Ramli	UPM	Kyushu University	Genetic analysis	2014/2/24	2014/5/23	89
Mohd Zulkahairi Mohd Yusoff	UPM	UPM	Analysis of microbiota	2014/4/9	2014/4/16	8
		Kyushu Institute of Technology		27/7/2015	13/8/2015	18
Hidayah Ariffin	UPM	Kyushu Institute of Technology	bio nano fiber	30/11/2014	18/12/2014	19
				11/12/2016	24/12/2016	14
Izzudin Ibrahim	UPM	Kyushu Institute of Technology	bio charcoal	3/8/2015	17/9/2015	46
Mohd Nor Faiz Norrrahim	UPM	Kyushu Institute of Technology	biomass and biocomposite	17/8/2015	29/9/2015	44
Tengku Arisyah Tengku Yasim Anuar	UPM	Kyushu Institute of Technology	biomass and biocomposite	17/8/2015	29/9/2015	44
Tim Hoe Song	UMS	Kyushu University	Analysis of microbial community structure	17/8/2015	5/11/2015	81
Kishneth Palanivlco	UMS	Kyushu University	Analysis of microbial community structure	17/8/2015	5/11/2015	81
Ahmad Muhaimin Roslan	UPM	AIST	biorefinery technolgy development	1/9/2015	31/10/2015	61
Siti Jamilah Hanim binti Mohd Yusof	UPM	AIST	biorefinery technolgy development	1/9/2015	31/10/2015	61

Jaya Seelan	UMS	Kyushu University	Training for analysis of microbial community structure changes impacted by oil palm sediments	18/4/2016	7/7/2016	81
Kishneth Palaniveloo	UMS	Kyushu University	Training for analysis of microbial community structure changes impacted by oil palm sediments	18/4/2016	7/7/2016	81
Lailiza Ahmad	UPM	AIST	Production of xylooligosaccharides from mesocarp fiber using hydrothermal pretreatment	20160418	20161014	180
Khairiatul Nabilah Jansar	UPM	AIST	Development of robust pretreatment for oil palm biomass - Enhancement of glucose production from combined oil palm biomass using robust pretreatment of hot compressed water	2016/7/19	2016/9/16	60
Tengku Arisyah Tengku Yasim Anuar	UPM	Kyushu Institute of Technology	Optimization, production and characterization of nanocomposite	2016/8/15	2017/3/10	208
Mohd Nor Faiz Norrrahim	UPM	Kyushu Institute of Technology	Characterization of nanofiber	2016/8/15	2017/1/20	159
Siti Suliza	UPM	Kyushu Institute of Technology	Analysis of samples using the next-generation DNA Sequencer	2016/8/15	2016/10/13	60

K.S

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Diana Mohd No	UPM	Kyushu Institute of Technology	Analysis of microbial community structure using MiSeq and bioinformatics tools"	2016/8/15	2016/9/16	33
Siti Suhailah Sharuddin	UPM	Kyushu Institute of Technology	Analysis of microbial community structure using MiSeq and bioinformatics tools	2016/8/15	2016/9/16	33
Hoe Seng, Tin	UMS	Kyushu University	Training for analysis of microbial community structure changes impacted by oil palm sediments	9/2/2017	8/5/2017	51
Dr. Mohd Rafein Zakaria	UPM	Kyushu Institute of Technology	Identification of toxic materials from POME	16/4/2017	29/4/2017	14
Ms. Liana Noor Megashah	UPM	Kyushu Institute of Technology	Characterization of nanofiber	7/5/2017	28/5/2017	22

K.S

AWM

Project Design Matrix (PDM)

Project Title: Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation
Project Duration: 21 Nov. 2013 to 20 Nov. 2017 (four years)
Project Sites: UPM(Serdang, Selangor), UMS(Kota Kinabalu, Sabah), Keningau Palm Oil Mill(Keningau, Sabah)
Target Group: Staff members, researchers and students of UPM and UMS; Federal and Sabah Government agencies; and Stakeholders in the palm oil industry in Malaysia

Version Number: Version 3.0
Date: 8th June, 2017

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal (to be achieved within 3 – 5 years after the completion of the Project): Green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through zero-discharge technologies in relevant areas in Sabah including Kinabatangan。	1.The technologies proposed by or derived from the Project are adapted in at least 2 palm oil companies in their palm oil mills by themselves. 2.Cost-benefit analysis of business models utilizing technologies based on the Project is carried out by the initiative of investors for potential commercialization. 3.At least one business model is adopted in at least 1 palm oil mill by the initiative of investors. 4.Policy discussions based on the results from the Project are started by relevant authorities in Sabah, Malaysia.	• Questionnaire survey to the firms in palm oil industry • Minutes of discussions	
Project Purpose: Innovative knowledge and viable technologies for business models are developed and shared positively among the potential users for the transformation of palm oil industry into sustainable green industry.	1. At least 5 firms or investors start considering actual investments based on the business model and model investment plan. 2. At least 2 firms express their willingness to apply the technologies and research results that are generated from Output 3. 3. At least 50 research articles are prepared on the related subjects/ topics and published. 4. At least 10 PhD and 10 master's degrees are awarded to Malaysian students who studied the related subjects/ topics.	• Interview survey to the firms and investors • Questionnaire survey to the firms • Research article • Interview survey with the degree providers	• Oil palm plantations do not expand or degrade drastically during and after the Project. • There are no major negative changes in the policy/ economic environments surrounding the palm oil industry in Sabah and Malaysia. • The security in Sabah remains stable.
Output: Output 1: The effectiveness of *zero-discharge is ensured through energy efficiency improvement resulting surplus biomass and excess energy at showcase facilities of zero-discharge established at an oil mill.	1-1 The showcase facilities aiming zero-discharge are established at an oil mill. 1-2 The operation records are maintained properly for the showcase facilities. 1-3 The excess energy, biomass, hot steam and methane gas are available for effective utilisation. 1-4 Bio-composite, charcoal and compost are produced from the excess biomass. 1-5 Discharged water from the showcase facilities is fully recycled.	• Physical visit to the showcase facilities • Visual inspection of operation records and interview survey to the operators at the facilities • The report that indicates the effectiveness of zero-discharge and physical visit • Manual(s) for the establishment/operation of the showcase facilities and for monitoring its application • Model O & M plan	• There are no major negative changes in the policy/ economic environments surrounding the palm oil industry in Sabah and Malaysia. • Close collaboration continues with other related projects as SDBEC.

別添資料 2

Output 2: Viability of business model is verified through the proposed zero-discharge and creation of new industry from surplus biomass and excess energy.	2-1 Viable business model and model investment plans are proposed based on the cost-benefit analysis. 2-2 New products made by the materials from surplus biomass will be produced on a trial basis.	• Documents with the business model and model investment plan • Interview survey to the firms and investors • Report indicating the trial

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Output 3: The innovative research is pursued on the effective utilisation of palm biomass and energy for the reduction of environmental burden caused by palm oil processing.	3-1 A baseline survey report is produced. 3-2 Sampling sites are decided to investigate the effect of our zero-discharge (recycled water) on the biodiversity. 3-3 The effect of zero-discharge (recycled water) on the bio-diversity recovery is evaluated scientifically. 3-4 The effect of superheated steam is confirmed for the production of nano fibers to be used in nano bio-composites. 3-5 The control of nano-interface between palm biomass fibers and mother plastics by gas-phase polymerization is confirmed. 3-6 A master batch of nano bio-composite is provided. 3-7 A nano bio-composite with nano-space (<100nm) and higher intensity (50% and up) than commodity plastics is provided(Melt Flow Index >5). 3-8 Supply of a bio-composite equal to or greater than the qualities of the mother plastics can be confirmed with price reduced by 20% 3-9 A production method for nano-cellulose fibers is proposed. 3-10 The saccharification efficiency from palm biomass more than 80% is confirmed. 3-11 Bio-charcoal with Calorific Value of 20MJ/kg and compost at NPK of 5% are produced from palm biomass.	• Baseline survey report • Pollution monitoring reports • Papers and patents	
Output 4: Validity of business model and the research results are shared extensively and recognised within the Sabah Government and domestic/international investors and firms.	4-1 Workshops, seminars and trade fairs are organised regarding the business model and research results at least twice a year. 4-2 At least 100 organisations/ agencies in total participate in such events. 4-3 The events are exposed to mass media.	• Project reports • Records of mass media	

*zero-discharge: all by-products from mills will be transformed into useful biomass, energy and recycled water which are valuable or tradable as a result of improved energy efficiency and resource utilisation in the process of palm oil production.

Activities: Outputs 1 1-1 Select an oil mill for the showcase facilities 1-2 Conduct basic and detail designing of the zero-discharge facilities 1-3 Construct and set the facilities 1-4 Prepare manuals for the establishment and operations of the showcase facilities and monitor its application 1-5 Operate the facilities 1-6 Collect data 1-7 Analyze and verify data for effectiveness of zero-discharge 1-8 Prepare model Operation and Maintenance (O&M) plan for future commercial plants	**Input (Japanese side):**	**Input (Malaysian side):**	**Precondition**
Output 2 2-1 Examine the results of zero-discharge analysis from Output 1 among related firms/organisations. 2-2 Carry out cost-benefit analysis for potential business models 2-3 Validate profitability of business models with related firms and organizations. 2-4 Prepare and revise model business proposals and model investment plan. 2-5 Study reduction on GHG emissions from the showcase facilities	**Dispatch of Japanese experts** : -Long-term expert ➢ Project Coordinator -Short-term experts ➢ Chief Advisor ➢ Chemical Engineering ➢ Applied Microbiology ➢ Organic Chemistry ➢ Ecology ➢ Other specific fields **Equipments and facilities** : -Showcase facilities for zero-discharge and the installation -A project vehicle -Laboratory equipment for UPM and UMS **Local project expenses** **Training in Japan**	**Provision of counterpart personnel (C/P)(UPM/UMS)** **Operators and operation cost for the showcase facilities (UPM/UMS)** **Office space and other necessary office facilities and equipments (UPM/UMS)** **Site for showcase facilities for zero-discharge (Sabah State Government)** **Joint Coordination Committee (UPM)** **Biodiversity evaluation (UMS)**	• C/P organisations/ agencies make efforts to secure and provide adequate budgets for joint research and other project activities. • C/P organisations/ agencies dispatch adequate and proper researchers to the Project on time. • There are firms that are willing to cooperation with the Project, especially for the setting of showcase facilities.

Output 3 3-1 Form a joint research team and research methods 3-2 Conduct baseline survey on the biodiversity and ecology of aquatic system affected by palm oil mills. 3-3 Monitor regularly on water quality and analyze the monitoring results and prepare monitoring reports. 3-4 Investigate influences of palm oil mills to the biodiversity. 3-4-1 Correlation between water quality and microbial diversity 3-4-2 Chemical and microbiological properties of the final waste water 3-5 Conduct various basic research and consider for implementation regarding the effective utilisation of surplus biomass and waste water/ hot steam. 3-5-1 Research on the quality improvement of compost from palm biomass: identification of useful bacteria using a next generation DNA sequencer 3-5-2 R&D for pretreatment, saccharification and value-added material production technology from EFB and mesocarp fibre 3-5-3 Research on carbonisation and energy generation using Yamasen-oven system 3-6 Produce and provide samples of bio-plastic materials to private firms using nano-technology 3-6-1 R&D for nano-fibre production technology from EFB and mesocarp fibre, and providing samples for enterprises. R&D for cellulose-nano-fiber material production 3-6-2 Basic research on production technology of nano-composite with nano-space and higher intensity than commodity plastics using the nano-interface technology/ superheat steam treatment technology, and production of the master batch. Provision of Bio-composite of equal or better quality than base material with reduced price			
Output 4 4-1 Organize workshops, seminars and trade fairs regarding the business model, model investment plan and research results. 4-2 Discuss regularly with SDBEC and other related projects for possible collaboration. 4-3 Cooperate with SDBEC for capacity development of local government and for utilization of developed technologies 4-4 Implement publicity through mass media			

Appendix 1. Schedule of the Terminal Evaluation

Date		Activities
5/28	Sun	Arrive in KL
5/29	Mon	AM 10:00 Interview with UPM researchers PM 2:30 Interview with Sime Darby
5/30	Tue	AM 9:00 Interview with training participants in Japan PM 2:30 Interview with FELDA Palm Industry.
5/31	Wed	Interview with Chief Advisor Leave KL and arrive in KK
6/1	Thu	AM9:00 Interview with Dr. Charles (UMS) PM10:30 Interview with Mr. Kelvin (UMS) PM: Leave KK and arrive in Keningau
6/2	Fri	Visit to Keningau POM Interview with Datuk Yap / Mill Manager PM: Leave Keningau and arrive in KK
6/3	Sat	Documentation
6/4	Sun	Documentation
6/5	Mon	9:00- Meeting with the Sabah State Secretary 10:30 - Meeting with DIDR, DOE, MOTCE 16:55: Leave KK and Arrive in KL
6/6	Tue	9:30-13:00 Discussion and drafting Minutes 14:00- Meeting with UMS and JICA Malaysia Office
6/7	Wed	9:30-16:30 Discussion and drafting Minutes @UPM
6/8	Thu	14:30: JCC and Signature of Minutes @UPM
6/9	Fri	Leave KL and arrive in Tokyo

Project Design Matrix (PDM)

Project Title: Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation
Project Duration: 21 Nov. 2013 to 20 Nov. 2017 (four years)
Project Sites: UPM(Serdang, Selangor), UMS(Kota Kinabalu, Sabah), Keningau Palm Oil Mill(Keningau, Sabah)
Target Group: Staff members, researchers and students of UPM and UMS; Federal and Sabah Government agencies; and Stakeholders in the palm oil industry in Malaysia

Version Number: Version 3.0
Date: 8th June, 2017

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Overall Goal (to be achieved within 3 – 5 years after the completion of the Project): Green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through zero-discharge technologies in relevant areas in Sabah including Kinabatangan。	1.The technologies proposed by or derived from the Project are adapted in at least 2 palm oil companies in their palm oil mills by themselves. 2.Cost-benefit analysis of business models utilizing technologies based on the Project is carried out by the initiative of investors for potential commercialization. 3.At least one business model is adopted in at least 1 palm oil mill by the initiative of investors. 4.Policy discussions based on the results from the Project are started by relevant authorities in Sabah, Malaysia.	• Questionnaire survey to the firms in palm oil industry • Minutes of discussions	
Project Purpose: Innovative knowledge and viable technologies for business models are developed and shared positively among the potential users for the transformation of palm oil industry into sustainable green industry.	1. At least 5 firms or investors start considering actual investments based on the business model and model investment plan. 2. At least 2 firms express their willingness to apply the technologies and research results that are generated from Output 3. 3. At least 50 research articles are prepared on the related subjects/ topics and published. 4. At least 10 PhD and 10 master's degrees are awarded to Malaysian students who studied the related subjects/ topics.	• Interview survey to the firms and investors • Questionnaire survey to the firms • Research article • Interview survey with the degree providers	• Oil palm plantations do not expand or degrade drastically during and after the Project. • There are no major negative changes in the policy/ economic environments surrounding the palm oil industry in Sabah and Malaysia. • The security in Sabah remains stable.
Output: Output 1: The effectiveness of *zero-discharge is ensured through energy efficiency improvement resulting surplus biomass and excess energy at showcase facilities of zero-discharge established at an oil mill.	1-1 The showcase facilities aiming zero-discharge are established at an oil mill. 1-2 The operation records are maintained properly for the showcase facilities. 1-3 The excess energy, biomass, hot steam and methane gas are available for effective utilisation. 1-4 Bio-composite, charcoal and compost are produced from the excess biomass. 1-5 Discharged water from the showcase facilities is fully recycled.	• Physical visit to the showcase facilities • Visual inspection of operation records and interview survey to the operators at the facilities • The report that indicates the effectiveness of zero-discharge and physical visit • Manual(s) for the establishment/operation of the showcase facilities and for monitoring its application • Model O & M plan	• There are no major negative changes in the policy/ economic environments surrounding the palm oil industry in Sabah and Malaysia. • Close collaboration continues with other related projects as SDBEC.

Output 2: Viability of business model is verified through the proposed zero-discharge and creation of new industry from surplus biomass and excess energy.	2-1 Viable business model and model investment plans are proposed based on the cost-benefit analysis. 2-2 New products made by the materials from surplus biomass will be produced on a trial basis.	• Documents with the business model and model investment plan • Interview survey to the firms and investors • Report indicating the trial	

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Output 3: The innovative research is pursued on the effective utilisation of palm biomass and energy for the reduction of environmental burden caused by palm oil processing.	3-1 A baseline survey report is produced. 3-2 Sampling sites are decided to investigate the effect of our zero-discharge (recycled water) on the biodiversity. 3-3 The effect of zero-discharge (recycled water) on the bio-diversity recovery is evaluated scientifically. 3-4 The effect of superheated steam is confirmed for the production of nano fibers to be used in nano bio-composites. 3-5 The control of nano-interface between palm biomass fibers and mother plastics by gas-phase polymerization is confirmed. 3-6 A master batch of nano bio-composite is provided. 3-7 A nano bio-composite with nano-space (<100nm) and higher intensity (50% and up) than commodity plastics is provided(Melt Flow Index >5). 3-8 Supply of a bio-composite equal to or greater than the qualities of the mother plastics can be confirmed with price reduced by 20% 3-9 A production method for nano-cellulose fibers is proposed. 3-10 The saccharification efficiency from palm biomass more than 80% is confirmed. 3-11 Bio-charcoal with Calorific Value of 20MJ/kg and compost at NPK of 5% are produced from palm biomass.	• Baseline survey report • Pollution monitoring reports • Papers and patents	
Output 4: Validity of business model and the research results are shared extensively and recognised within the Sabah Government and domestic/international investors and firms.	4-1 Workshops, seminars and trade fairs are organised regarding the business model and research results at least twice a year. 4-2 At least 100 organisations/ agencies in total participate in such events. 4-3 The events are exposed to mass media.	• Project reports • Records of mass media	

*zero-discharge: all by-products from mills will be transformed into useful biomass, energy and recycled water which are valuable or tradable as a result of improved energy efficiency and resource utilisation in the process of palm oil production.

Activities:	**Input (Japanese side):**	**Input (Malaysian side):**	**Precondition**
Outputs 1 1-1 Select an oil mill for the showcase facilities 1-2 Conduct basic and detail designing of the zero-discharge facilities 1-3 Construct and set the facilities 1-4 Prepare manuals for the establishment and operations of the showcase facilities and monitor its application 1-5 Operate the facilities 1-6 Collect data 1-7 Analyze and verify data for effectiveness of zero-discharge 1-8 Prepare model Operation and Maintenance (O&M) plan for future commercial plants	**Dispatch of Japanese experts** : -Long-term expert ➢ Project Coordinator -Short-term experts ➢ Chief Advisor ➢ Chemical Engineering ➢ Applied Microbiology ➢ Organic Chemistry ➢ Ecology ➢ Other specific fields **Equipments and facilities** : -Showcase facilities for zero-discharge and the installation -A project vehicle -Laboratory equipment for UPM and UMS **Local project expenses** **Training in Japan**	**Provision of counterpart personnel (C/P)(UPM/UMS)** **Operators and operation cost for the showcase facilities (UPM/UMS)** **Office space and other necessary office facilities and equipments (UPM/UMS)** **Site for showcase facilities for zero-discharge (Sabah State Government)** **Joint Coordination Committee (UPM)** **Biodiversity evaluation (UMS)**	• C/P organisations/ agencies make efforts to secure and provide adequate budgets for joint research and other project activities. • C/P organisations/ agencies dispatch adequate and proper researchers to the Project on time. • There are firms that are willing to cooperation with the Project, especially for the setting of showcase facilities.
Output 2 2-1 Examine the results of zero-discharge analysis from Output 1 among related firms/organisations. 2-2 Carry out cost-benefit analysis for potential business models 2-3 Validate profitability of business models with related firms and organizations. 2-4 Prepare and revise model business proposals and model investment plan. 2-5 Study reduction on GHG emissions from the showcase facilities			

Output 3 3-1 Form a joint research team and research methods 3-2 Conduct baseline survey on the biodiversity and ecology of aquatic system affected by palm oil mills. 3-3 Monitor regularly on water quality and analyze the monitoring results and prepare monitoring reports. 3-4 Investigate influences of palm oil mills to the biodiversity. 3-4-1 Correlation between water quality and microbial diversity 3-4-2 Chemical and microbiological properties of the final waste water 3-5 Conduct various basic research and consider for implementation regarding the effective utilisation of surplus biomass and waste water/ hot steam. 3-5-1 Research on the quality improvement of compost from palm biomass: identification of useful bacteria using a next generation DNA sequencer 3-5-2 R&D for pretreatment, saccharification and value-added material production technology from EFB and mesocarp fibre 3-5-3 Research on carbonisation and energy generation using Yamasen-oven system 3-6 Produce and provide samples of bio-plastic materials to private firms using nano-technology 3-6-1 R&D for nano-fibre production technology from EFB and mesocarp fibre, and providing samples for enterprises. R&D for cellulose-nano-fiber material production 3-6-2 Basic research on production technology of nano-composite with nano-space and higher intensity than commodity plastics using the nano-interface technology/ superheat steam treatment technology, and production of the master batch. Provision of Bio-composite of equal or better quality than base material with reduced price			
Output 4 4-1 Organize workshops, seminars and trade fairs regarding the business model, model investment plan and research results. 4-2 Discuss regularly with SDBEC and other related projects for possible collaboration. 4-3 Cooperate with SDBEC for capacity development of local government and for utilization of developed technologies 4-4 Implement publicity through mass media			

Evaluation Grid of "the Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation"

Achievement and Implementation Process (ver.0)

May 18, 2017

Items to be checkec Main points	Specific Questions	Objectively Verifiable Indicators (Criteria /Method for assessment)	Necessary information /data	Information Sources	Method for data collection
Achievement/Performance					
- Prospect of achieving Outputs	1 The effectiveness of zero-discharge is ensured through energy efficiency improvement resulting surplus biomass and excess energy at showcase facilities of zero-discharge established at an oil mill.	1-1 The showcase facilities aiming zero-discharge are established at an oil mill. 1-2 The operation records are maintained properly for the showcase facilities. 1-3 The excess energy, biomass, hot steam and methane gas are available for effective utilisation. 1-4 Bio-composite, charcoal and compost are produced from the excess biomass. 1-5 Discharged water from the showcase facilities is fully recycled.	- Operational records - Project reports, articles - Opinions	- Experts - UPM,UMS - KPOM	- Document review - Questionnaire - Interview - Observation
	2 Viability of business model is verified through the proposed zero-discharge and creation of new industry from surplus biomass and excess energy.	2-1 Viable business model and model investment plans are proposed based on the cost-benefit analysis. 2-2 New products made by the materials from surplus biomass will be produced on a trial basis.	- The business model and model investment plan - Project reports, articles - Opinions		
	3 The innovative research is pursued on the effective utilisation of palm biomass and energy for the reduction of environmental burden caused by palm oil processing.	3-1 A baseline survey report is produced. 3-2 Sampling sites are decided to investigate the effect of our zero-discharge (recycled water) on the biodiversity. 3-3 The effect of zero-discharge (recycled water) on the bio-diversity recovery is evaluated scientifically. 3-4 The effect of superheated steam is confirmed for the production of nano fibres to be used in nano bio-composites. 3-5 The control of nano-interface between palm biomass fibres and mother plastics by gas-phase polymerization is confirmed. 3-6 A master batch of nano bio-composite is provided. 3-7 A nano bio-composite with nano-space (<100nm) and higher intensity (50% and up) than commodity plastics is provided(Melt Flow Index >5). 3-8 Supply of a bio-composite equal to or greater than the qualities of the mother plastics can be confirmed with price reduced by 20% 3-9 A production method for nano-cellulose fibres is proposed. 3-10 The saccharification efficiency from palm biomass more than 80% is confirmed. 3-11 Bio-charcoal with Calorific Value of 20MJ/kg and compost at NPK of 5% are produced from palm biomass.	- Baseline survey report - Pollution monitoring reports - Project reports, articles Opinions		
	4 Validity of business model and the research results are shared extensively and recognised within the Sabah Government and domestic/international investors and firms.	4-1 Workshops, seminars and trade fairs are organised regarding the business model and research results at least twice a year. 4-2 At least 100 organisations/ agencies in total participate in such events. 4-3 The events are exposed to mass media.	Project reports Records of mass media		

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Achievement and Implementation Process (ver.0)

May 18, 2017

Items to be checkec		Objectively Verifiable Indicators (Criteria /Method for assessment)	Necessary information /data	Information Sources	Method for data collection
Main points	Specific Questions				
Implementation Process					
- Progress/Schedule	- Whether the activities have been carried out as plannec - What were the reasons for delay and what measures have been taken to catch up for delay?	- Compare the original plan with the actual implementation - Check the reasons and measures for the delay	- Project reports - Opinions	- Experts - UPM,UMS	- Document review - Questionnaire - Interview
- Monitoring	- How the project progress is monitored - Whether the monitoring system of the project is appropriate and effective. - Whether the results of monitoring have been reflected to the project management	- Check the means and frequency of the project monitoring	- Project reports - Opinions		
- Communication among related parties and personnel	- Whether communication 1) between Malaysian and Japanese researchers and 2) among Japanese researchers have been established well to manage the	- Check the degree of communication, and its means and frequency if necessary	- Opinions - Project reports		
- Participation of Malaysian side	- Degree of participation in management by the responsible persons - Attitude of C/Ps	- The extent to which a project manager and a chief advisor have participated in project management - Whether C/Ps are collaborative and self-motivated towards the project activities	- Meeting records - Opinions - Project reports		

Evaluation Grid of "the Project on Promotion of Green Economy with Palm Oil Industry for Biodiversity Conservation'

Five Evaluation Criteria (ver.0)

May 18, 2017

Items to be checked		Objectively Verifiable Indicators (Criteria /Method for assessment)	Necessary information /data	Information Sources	Method for data collection
Main points	Specific Questions				
Relevance					
- Consistency with development and nature conservation policies and plans in Malaysia	- Whether the project is still in line with national policies/plans related to development and nature (esp. biodiversity) conservation	- Whether the project is in line with a. development policies (e.g. 11th Malaysia Plan) b. nature/biodiversity conservation policies (e.g. National Biomass Strategy 2020)	- Policy papers	- Malaysian central/local government	- Document review - (Interview)
- Consistency with Japanese policy	- Whether nature conservation is prioritized in Japanese assistance policy - Whether the project is in line with JICA's thematic guideline on nature conservation	- Whether the project is still in line with a. the Japanese Country Assistance Policy for Malaysia/ Rolling Plan for Malaysia b. JICA's thematic guideline on nature conservation	- Country Assistance Policy - Guideline on nature	- MOFA - JICA	- Document review
- Meeting with the needs of target groups/beneficiaries	- Whether the project purpose still meets the needs of C/Ps	- Whether the mandate and needs of C/Ps remain unchanged - Whether there is no institutional change which have affected the relevance	- Annual reports of C/Ps - Project reports - Opinions	- UPM,UMS	- Document review - Questionnaire - (Interview)
Effectiveness					
- Probability of achieving the Project Purpose	- Whether innovative knowledge and viable technologies for business models are developed and shared positively among the potential users for the transformation of palm oil industry into sustainable green industry.	1. At least 5 firms or investors start considering actual investments based on the business model and model investment plan. 2. At least 2 firms express their willingness to apply the technologies and research results that are generated from Output 3. 3. At least 50 research articles are prepared on the related subjects/ topics and published. 4. At least 10 PhD and 10 master's degrees are awarded to Malaysian students who studied the related subjects/ topics.	- Opinions - Articles - Project reports	- Experts - UPM,UMS - Companies	- Document review - Interview - Questionnaire
- Contribution of the Outputs to the Project Purpose	- Whether all Outputs which are required to achieve the Project Purpose are listed in the PDM	- The logic of PDM (Project purpose/Outputs) - Whether any other outputs which are not specified in the PDM are necessary to achieve the Project Purpose	- Opinions - PDM - Project reports	- Experts - UPM,UMS	- Document review - Interview - Questionnaire
- Follow-up of the recommendations made at the mid-term review	- Whether an assistant in charge of monitoring of the pilot plant was urgently assigned for the zero-discharge - Whether a professional personnel in charge of the cost benefit analysis and development of model business investment plans for the zero-discharge business model was assigned - Whether informal meetings among research members including Malaysian and Japanese sides were held	- The assignment of human resources in charge of monitoring of the pilot plant - The implementation status of the cost benefit analysis and development of model business investment plans - The implementation status of informal meetings	- OpinionsProject re - -	- Experts - UPM, UMS	- Document review - Interview - Questionnaire

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May 18, 2017

Items to be checked		Objectively Verifiable Indicators (Criteria /Method for assessment)	Necessary information /data	Information Sources	Method for data collection
Main points	Specific Questions				
	- Whether the future management plan on the pilot plant at the Keningau Palm Oil Mill was - Whether PDM was revised	- The implementation status of developing the future management plan - The same as left mentioned			
- Promoting / hampering factors	- Whether the important assumption affected the project achievement - Whether there are/were any factors affecting the achievement of the Project Purpose	- Whether palm oil plantations do not expand or degrade drastically during and after the Project. - The same as left mentioned	- Opinions - Project reports	- Experts - UPM,UMS - KPOM	- Interview - Document review
Efficiency					
- Generation of Outputs	- Whether all activities have been sufficient to generate the Outputs as planned	- The logic of PDM (Output/activities) - The progress of activities and status of Outputs (→ Implementation Process)	- Project reports - PDM	- Experts - UPM,UMS - Governmental organizations - KPOM	- Document review - Questionnaire - Interview
- Conversion of the input to the outputs	- Whether the timing, quantity and quality of inputs was appropriate to generate the Outputs	- Check if the inputs were appropriate in terms of (a) Dispatch of Japanese experts (b) Provision of machinery and equipment (c) Local Operational costs (d) C/P training in Japan (e) Budget disbursement of C/P (f) Assignment of C/P personnel (g) Other inputs by C/P	- Summary of inputs - Opinions - Project reports		
- Promoting / hampering factors	- Whether the important assumptions affected the project achievement - Whether other external factors influenced converting inputs to outputs	- Whether there are no major negative changes in the policy/ economic environments surrounding the palm oil industry in Sabah and Malaysia - Whether close collaboration continues with other related projects as SDBEC. - The same as left mentioned	- Opinions - Project reports		
Impact					
- Probability of achieving the Overall Goal	- Whether green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through reduction of pollutants due to waste water in relevant areas in Sabah including Kinabatangan.	1. The technologies proposed by or derived from the project are adapted in at least 2 palm oil companies in their palm oil mills by themselves. 2. The technologies proposed by or derived from the project are adopted in at least 10 palm oil mills by the initiative of investors. 3. Policy discussions based on the results from the project are started by relevant authorities in Sabah, Malaysia.	- Opinions - Project reports	- Experts - UPM,UMS - Companies - Governmental organizations	- Document review - Questionnaire - Interview

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Five Evaluation Criteria (ver.0)

May 18, 2017

Items to be checked		Objectively Verifiable Indicators (Criteria /Method for assessment)	Necessary information /data	Information Sources	Method for data collection
Main points	Specific Questions				
- Ongoing/possible collaborations with other donors and projects	- Whether there are any ongoing/possible collaborations with multi/bi-lateral development partners and other projects by JICA - If any, whether there are any impacts of the collaboration	- The collaboration with other JICA projects and other donors and any impacts of the collaboration	- Opinions - Project reports	- Experts - UPM,UMS	- Document review - Questionnaire - Interview
- Other expected and unexpected impacts	- Whether there are other impacts (positive/negative) generated by the project implementation	- Impacts on government policies/ programmes, organizations, groups, the environment and any other impacts	- Project reports - Opinions	- Experts - UPM,UMS - Governmental organizations	- Document review - Questionnaire - Interview
Sustainability					
- Institutional/political aspects	- Whether the government will keep putting the priorities on nature conservation - Whether there is a need to have a MOU or any framework to continue the research activities	- The government policy or plan - MOU or any other framework	- Policy or plan paper - Opinions - Project reports	- Governmental organizations - Experts - UPM,UMS	- Document review - Questionnaire - Interview
- Financial aspects	- Whether C/Ps will have sufficient budget to continue the activities after the project duration	- The budget for the last three years and a coming year if possible - External financing from donors and private sectors	- C/Ps' Annual reports - Opinions	- UPM, UMS	- Document review - Questionnaire - Interview
- Organizational aspects	- Whether C/Ps will have sufficient capacity of pursuing relevant research activities to keep project effects after the project completion	- Ownership of C/Ps - Allocation of researchers - Retention of researchers	- C/P list - Opinions - Project reports	- UPM, UMS	- Document review - Questionnaire - Interview
- Technical aspects	- Whether the skills/techniques of C/Ps which the project enhanced are and will be shared amongst and further enhanced by C/Ps - Whether the machinery and equipment provided by the Project is likely to be maintained appropriately	- Results of training in Japan - Number of training and participants - Training opportunities and update of expertise/ knowledge - Current practice of maintenance of the machines provided for this project and past ones - Plan of maintenance - Availability of operation and maintenance manuals	- Opinions - Plan - Project reports - Manuals	- Experts - UPM,UMS	- Interview - Questionnaire - Document review - Observation

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- Follow-up of the recommendations made at the mid-term review	- Whether an assistant in charge of monitoring of the pilot plant was urgently assigned for the zero-discharge - Whether a professional personnel in charge of the cost benefit analysis and development of model business investment plans for the zero-discharge business model was assigned - Whether informal meetings among research members including Malaysian and Japanese sides were held	- The assignment of human resources in charge of monitoring of the pilot plant - The implementation status of the cost benefit analysis and development of model business investment plans - The implementation status of informal meetings	- OpinionsProject re - -	- Experts - UPM, UMS	- Document review - Interview - Questionnaire

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Efficiency					
- Generation of Outputs	- Whether all activities have been sufficient to generate the Outputs as planned	- The logic of PDM (Output/activities) - The progress of activities and status of Outputs (→ Implementation Process)	- Project reports - PDM	- Experts - UPM,UMS - Governmental organizations - KPOM	- Document review - Questionnaire - Interview
- Conversion of the input to the outputs	- Whether the timing, quantity and quality of inputs was appropriate to generate the Outputs	- Check if the inputs were appropriate in terms of (a) Dispatch of Japanese experts (b) Provision of machinery and equipment (c) Local Operational costs (d) C/P training in Japan (e) Budget disbursement of C/P (f) Assignment of C/P personnel (g) Other inputs by C/P	- Summary of inputs - Opinions - Project reports		
- Promoting / hampering factors	- Whether the important assumptions affected the project achievement - Whether other external factors influenced converting inputs to outputs	- Whether there are no major negative changes in the policy/ economic environments surrounding the palm oil industry in Sabah and Malaysia - Whether close collaboration continues with other related projects as SDBEC. - The same as left mentioned	- Opinions - Project reports		
Impact					
- Probability of achieving the Overall Goal	- Whether green economy is promoted in the palm oil industry of Malaysia, which will contribute to biodiversity recovery through reduction of pollutants due to waste water in relevant areas in Sabah including Kinabatangan.	1. The technologies proposed by or derived from the project are adapted in at least 2 palm oil companies in their palm oil mills by themselves. 2. The technologies proposed by or derived from the project are adopted in at least 10 palm oil mills by the initiative of investors. 3. Policy discussions based on the results from the project are started by relevant authorities in Sabah, Malaysia.	- Opinions - Project reports	- Experts - UPM,UMS - Companies - Governmental organizations	- Document review - Questionnaire - Interview

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- Other expected and unexpected impacts	- Whether there are other impacts (positive/negative) generated by the project implementation	- Impacts on government policies/ programmes, organizations, groups, the environment and any other impacts	- Project reports - Opinions	- Experts - UPM,UMS - Governmental organizations	- Document review - Questionnaire - Interview
Sustainability					
- Institutional/political aspects	- Whether the government will keep putting the priorities on nature conservation - Whether there is a need to have a MOU or any framework to continue the research activities	- The government policy or plan - MOU or any other framework	- Policy or plan paper - Opinions - Project reports	- Governmental organizations - Experts - UPM,UMS	- Document review - Questionnaire - Interview
- Financial aspects	- Whether C/Ps will have sufficient budget to continue the activities after the project duration	- The budget for the last three years and a coming year if possible - External financing from donors and private sectors	- C/Ps' Annual reports - Opinions	- UPM, UMS	- Document review - Questionnaire - Interview
- Organizational aspects	- Whether C/Ps will have sufficient capacity of pursuing relevant research activities to keep project effects after the project completion	- Ownership of C/Ps - Allocation of researchers - Retention of researchers	- C/P list - Opinions - Project reports	- UPM, UMS	- Document review - Questionnaire - Interview
- Technical aspects	- Whether the skills/techniques of C/Ps which the project enhanced are and will be shared amongst and further enhanced by C/Ps - Whether the machinery and equipment provided by the Project is likely to be maintained appropriately	- Results of training in Japan - Number of training and participants - Training opportunities and update of expertise/ knowledge - Current practice of maintenance of the machines provided for this project and past ones - Plan of maintenance - Availability of operation and maintenance manuals	- Opinions - Plan - Project reports - Manuals	- Experts - UPM,UMS	- Interview - Questionnaire - Document review - Observation

Appendix 4. List of main counterparts

No	Name	Title	Organization
1	Prof. Dr. Mohd Ali Hassan	Professor	UPM
2	Prof. Dr. Charles Santhanaraju Vairappan	Director	UMS
3	Dr. Hidayah Ariffin	Senior Lecturer	UPM
4	Dr. Mohd Rafein Zakaria	Lecturer	UPM
5	Dr. Norhayati Ramli	Lecturer	UPM
6	Dr. Mohd Zulkhairi Mohd Yusoff	Lecturer	UPM
7	Mr. Gerald Jetony	Senior Geologist	NRO, Sabah State Gov.

Appendix 5. List of Equipment Provided

Item	Price (RM)	Location
Thermogravimetry analyser / Mass spectroscopy	213,000	UPM
PCR thermal cycler	40,000	UPM
Flow cyctometer	326,480	UPM
DGGE	114,268	UPM
Grinding machine (hammer mill)	136,740	UPM
Grinding machine (wet disc mill)	15,000	UPM
Total organic carbon and nitrogen analyser	320,000	UMS
Fluorescence spectrophotometer	126,000	UMS
4WD vehicle	113,603	UMS
Showcase facility (construction work)	2,550,190	KPOM
Showcase facility (equipment)	395,509	KPOM
Smoke Treatment System	75,412	KPOM
Total	4,426,202	

Appendix 6 : A list of counterpart training participants

Name	Organization	Receiving organization	Theme	From	To	Total number of days
Charles Santhanaraju	UMS	・JST ・JICA	Super heated steam treatment	2014/1/27	2014/4/19	14
		UMS	Biodiversity			
Norhayati Binti Ramli	UPM	Kyushu University	Genetic analysis	2014/2/24	2014/5/23	89
Mohd Zulkahairi Mohd Yusoff	UPM	UPM	Analysis of microbiota	2014/4/9	2014/4/16	8
		Kyushu Institute of Technology		7/27/2015	8/13/2015	18
Hidayah Ariffin	UPM	Kyushu Institute of Technology	bio nano fiber	11/30/2014	12/18/2014	19
				12/11/2016	12/24/2016	14
Izzudin Ibrahim	UPM	Kyushu Institute of Technology	bio charcoal	8/3/2015	9/17/2015	46
Mohd Nor Faiz Norrrahim	UPM	Kyushu Institute of Technology	biomass and biocomposite	8/17/2015	9/29/2015	44
Tengku Arisyah Tengku Yasim Anuar	UPM	Kyushu Institute of Technology	biomass and biocomposite	8/17/2015	9/29/2015	44
Tim Hoe Song	UMS	Kyushu University	Analysis of microbial community structure	8/17/2015	11/5/2015	81
Kishneth Palanivlco	UMS	Kyushu University	Analysis of microbial community structure	8/17/2015	11/5/2015	81
Ahmad Muhaimin Roslan	UPM	AIST	biorefinery technolgy development	9/1/2015	10/31/2015	61
Siti Jamilah Hanim binti Mohd Yusof	UPM	AIST	biorefinery technolgy development	9/1/2015	10/31/2015	61

Jaya Seelan	UMS	Kyushu University	Training for analysis of microbial community structure changes impacted by oil palm sediments	4/18/2016	7/7/2016	81
Kishneth Palaniveloo	UMS	Kyushu University	Training for analysis of microbial community structure changes impacted by oil palm sediments	4/18/2016	7/7/2016	81
Lailiza Ahmad	UPM	AIST	Production of xylooligosaccharides from mesocarp fiber using hydrothermal pretreatment	20160418	20161014	180
Khairiatul Nabilah Jansar	UPM	AIST	Development of robust pretreatment for oil palm biomass - Enhancement of glucose production from combined oil palm biomass using robust pretreatment of hot compressed water	2016/7/19	2016/9/16	60
Tengku Arisyah Tengku Yasim Anuar	UPM	Kyushu Institute of Technology	Optimization, production and characterization of nanocomposite	2016/8/15	2017/3/10	208
Mohd Nor Faiz Norrrahim	UPM	Kyushu Institute of Technology	Characterization of nanofiber	2016/8/15	2017/1/20	159
Siti Suliza	UPM	Kyushu Institute of Technology	Analysis of samples using the next-generation DNA Sequencer	2016/8/15	2016/10/13	60

Diana Mohd Nc	UPM	Kyushu Institute of Technology	Analysis of microbial community structure using MiSeq and bioinformatics tools”	2016/8/15	2016/9/16	33
Siti Suhailah Sharuddin	UPM	Kyushu Institute of Technology	Analysis of microbial community structure using MiSeq and bioinformatics tools	2016/8/15	2016/9/16	33
Hoe Seng, Tin	UMS	Kyushu University	Training for analysis of microbial community structure changes impacted by oil palm sediments	2/9/2017	5/8/2017	51
Dr. Mohd Rafein Zakaria	UPM	Kyushu Institute of Technology	Identification of toxic materials from POME	4/16/2017	4/29/2017	14
Ms. Liana Noor	UPM	Kyushu Institute of Technology	Characterization of nanofiber	5/7/2017	5/28/2017	22


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