Internal Ex-Post Evaluation for Technical Cooperation Project (SATREPS[1])

conducted by Indonesia Office: May, 2025

Country Name	**Project on Innovative Bio-Production in Indonesia : Integrated Bio-Refinery Strategy to Promote Biomass Utilization using Super-microbes for Fuels and chemicals Production**
Republic of Indonesia	

I. Project Outline

Background	Rich energy resources such as petroleum oil and gas, as well as abundant natural resources such as animal oil and fat and natural rubber, had helped the Indonesian economy grow remarkably. The Government of Indonesia set up a policy to establish a system to generate a steady supply of electricity, use diverse energy resources, and improve the electrification rate to sustain further economic growth. On the other hand, Indonesia relied on petroleum sources for most of its energy supply. According to the data in 2011, 46.7% of 1,176 BOE (barrel of oil equivalent) of energy consumption in Indonesia was from petroleum sources. When the energy supply had been dependent on only petroleum sources, it could have had a huge impact on the nation's finance and industrial activity due to the soaring oil prices and could have led to social instability for the people of the country. Indonesia was taking up the challenge of using a) diverse energy sources so that it would not have to rely on petroleum alone and b) making a shift to a low-carbon energy society to tackle the environmental issues that are on the rise in today's world.		
Objectives of the Project	Through establishing a pretreatment protocol for lignocellulose biomass, producing the lignocellulose-degrading enzymes, developing microbes with separation technology, producing bio-based polymer from separated chemicals, and promoting collaborative biorefinery efforts involving the private sector, the project aims to establish the integrated bio-refinery strategy to promote biomass utilization, thereby contributing to implementing integrated bio-refinery technology to produce bio-based products from potential biomass of the country. 1. Expected Overall Goal: Implementation of integrated bio-refinery technology to produce bio-based product(s) from potential biomass in Indonesia. 2. Project Purpose: To establish "Innovative Bio-production in Indonesia (iBiol): Integrated Bio-refinery Strategy to Promote Biomass Utilization using Super-microbes for Fuels and Chemicals Production."		
Activities of the Project	1. Project site: Indonesia (whole nation) *Research study was mainly carried out by the Indonesian Institute of Sciences (LIPI) in Cibinong City. 2. Main activities: (i) To establish the pretreatment protocol for lignocellulose biomass from oil palm and sugarcane industry (ii) To produce and evaluate the lignocellulose-degrading enzymes (iii) To develop microbes with separation technology to produce bio-fuels and bio-chemicals (iv) To produce bio-based polymer from separated chemicals (v) To conduct the feasibility study and to promote the integrated bio-refinery process 3. Inputs (to carry out above activities) Japanese Side * As of the terminal evaluation 1) Experts: 13 persons (researchers) 2) Equipment: Experimental equipment such as Gas Chromatography-Mass Spectrometry (GC-MS), Gel Permeation Chromatography, Fermenter Bioflo, Centrifuge, etc. Indonesian Side * As of the terminal evaluation 1) Staff allocated: 68 persons * 64 researchers from LIPI and four researchers from the University of Indonesia 2) Land and space: Provision of research and office spaces		
Project Period	(ex-ante) May 2013 – March 2018 (60 months)[2] (actual) 1 November 2013 – 31 October 2018 (60 months)	Project Cost (Japanese side only)	(ex-ante) 301 million yen, (actual) 348 million yen
Implementing Agency	Indonesian Institute of Sciences (LIPI) * LIPI was integrated into the National Research and Innovation Agency (BRIN) in September 2021.		
Cooperation Agency in Japan	Kobe University, Nagasaki University, University of Shizuoka, and Mie University		

II. Result of the Evaluation

<Special Perspectives Considered in the Ex-Post Evaluation >

・The continuation status of project effects at the time of the ex-post evaluation was evaluated based on the SATREPS ex-post evaluation framework, focusing on the utilization of the project's outputs and the continuation and development of related research rather than the comparison between the achievement of individual project purpose indicators and their target values.

1 Relevance/Coherence
[Relevance] <Consistency with the Development Policy of Indonesia at the Time of Ex-Ante Evaluation >

[1] SATREPS: Science and Technology Research Partnership for Sustainable Development

[2] The Ex-ante Evaluation Sheet reads, "May 2013 to March 2018 (5 years)." Although the number of months between May 2013 and March 2018 is 59, the Record of Discussions mentions "The duration ... will be five (5) years," and the implementing agency shares the same understanding. Therefore, the planned project period is considered to be 60 months (5 years).

The project was consistent with the development policy of Indonesia at the time of ex-ante evaluation. In January 2006, Presidential Decree No. 2006-5 on National Energy Policy was formulated, reading "with a target year of 2025, to reduce oil consumption by 20% from 2006 levels and increase use of natural gas and biofuels by 30% as alternatives to oil, 15% increase in renewable energy." Also, Presidential Decree No. 1 of 2006 on the Supply and Use of Biofuels as Alternative Energy states the expansion of biofuel use. Furthermore, in 2010, the National Development Goals for Biofuels were formulated. They aim to foster the biofuel industry and expand the area under biofuel cultivation to approximately 2.2 million hectares with the objectives of (1) creating 3.5 million jobs and (2) increasing farmers' income.

<Consistency with the Development Needs of Indonesia at the Time of Ex-Ante Evaluation >

The project was consistent with the development needs of Indonesia at the time of ex-ante evaluation. As stated in the "Background" above, the promotion of biomass utilization was needed to diversify energy sources and shift to a low-carbon energy society.

<Appropriateness of Project Design/Approach>

The project design/approach was highly appropriate. The project planned to deliver equitable benefits to the vulnerable. Indonesia, as an archipelago country, faces diverse challenges in accessing fuel and energy sources across different regions and islands. This disparity particularly affects remote and marginalized communities, where traditional energy sources are scarce or difficult to obtain. Under such circumstances, this project played a crucial role in addressing these challenges by focusing on regions with abundant biomass. The project introduced biorefinery technology, which is not only sustainable but also adaptable to the local resources available in these areas. By harnessing local biomass, such as agricultural and forestry waste, communities in remote areas would be able to achieve energy self-sufficiency. This approach would reduce their dependency on conventional fuel imports and promote the use of renewable resources. As a result, the project would directly benefit vulnerable communities by providing them with localized, affordable, and sustainable energy solutions, empowering them to develop energy independence. This, in turn, would foster regional development and economic resilience, particularly in areas where energy access has traditionally been a barrier to progress.

One of the most prominent approaches of the project was the establishment of effective communication with local stakeholders. This open and ongoing dialogue ensured that the needs and concerns of the community were understood and addressed throughout the project. It also facilitated smoother coordination, stronger partnerships, and greater local engagement, which were essential for the project's success and long-term sustainability.

<Evaluation Result>

In light of the above, the relevance of the project is ③[3].

[Coherence]

<Consistency with Japan's ODA Policy at the Time of Ex-Ante Evaluation>

The project was consistent with Japan's ODA policy to Indonesia at the time of ex-ante evaluation. In its "Country Assistance Policy for the Republic of Indonesia" (2013), Japan identified "assistance to improve the capacity of the Asian region and the international community to cope with challenges" as a priority area for its assistance to the Republic of Indonesia and was cooperating in the promotion of high-efficiency energy, energy conservation, and alternative energy, aiming to build institutions to curb greenhouse gas emissions and reduce negative impacts associated with climate change.

<Collaboration/Coordination with JICA's Other Interventions>

The collaboration/coordination between the project and another SATREPS project, "the Project for Development of Internationally Standardized Microbial Center to Promote Life Science Research and Biotechnology" (2011-2016) (hereinafter called "SATREPS 1") of JICA, was planned at the time of ex-ante evaluation and was implemented, positive effects expected were confirmed at the time of ex-post evaluation. SATREPS1 supported the development of the Indonesia Culture Center (InaCC) of LIPI, and this project requested and received microbe strains from InaCC. Then, this project implemented the screening of strains and selected six promising yeast strains as host strains for ethanol production. Among them, the project succeeded in acquiring one InaCC strain that is capable of high ethanol production from raw biomass.

In addition, this project had a meeting with the members of another SATREPS project, "the Project for Development of a Model System for Fluidized Bed Catalytic Gasification of Biomass Wastes and Following Liquid Fuel Production in Indonesia" (2014-2019) (hereafter called the "BPPT project"). The BPPT project aimed at developing a production process of ethanol and methanol from biomass waste (such as oil palm empty fruit bunch: OPEFB). The information was shared among researchers of this project, the BPPT project, and the Bandung Institute of Technology.

<Cooperation with other institutions/ Coordination with International Framework>

The cooperation/coordination with interventions from other institutions (see the collaborations mentioned in Indicator 4 of the Project Purpose in the table below) was planned during the project period, implemented as planned, and positive effects were confirmed at the time of ex-post evaluation. BRIN confirmed that such collaborative efforts have fostered a strong network of support and shared resources, contributing to the successful achievement of the project's objectives and demonstrating the value of effective cooperation and coordination with other stakeholders.

<Evaluation Result>

In light of the above, the coherence of the project is ③.

[Evaluation Result of Relevance/Coherence]

In the light above, the relevance/coherence of the project is ③.

2 Effectiveness/Impact

<Status of Achievement of the Project Purpose at the Time of Project Completion>

At the time of project completion, the Project Purpose was mostly achieved as planned. The project mostly achieved the planned outputs, such as developing efficient pretreatment protocols for biomass like OPEFB and sugarcane bagasse, identifying suitable lignocellulose-degrading enzymes, optimizing microbial strains for biofuel (ethanol) and biochemical (lactic acid) production, and synthesizing bio-based polymers like poly lactic acid (PLA), resulting in new technologies, registered patents, and collaborative biorefinery efforts between Japanese and Indonesian institutions. The number of ISI journal (a journal indexed in the Institute for Scientific Information

[3] ④ : very high, ③ : high, ② : moderately low, ① : low

database) publications was 19, exceeding the target of 15 (Indicator 1). A total of 5 patent applications were planned, and 3 were registered while 1 was awaiting registration (Indicator 2). The number of Ph.D. students reached 16, surpassing the target of 10 (Indicator 3). One cooperative relationship with companies was established against the target of 2 (Indicator 4).

<Continuation Status of Project Effects at the Time of Ex-Post Evaluation>

By the time of the ex-post evaluation, the project effects have been continued. Many of the project's outputs have been utilized. For example, technologies such as the pretreatment protocol for OPEFB, the production of enzymes (pectinase, xylanase, mannanase), the creation of oligosaccharides (mannan oligosaccharides (MOS), xylooligosaccharides (XOS), fructooligosaccharides (FOS), and xylitol), and PLA production have been applied by LIPI, BRIN, and some institutions and companies. Also, various research on integrated biorefinery topics is ongoing, including the one by BRIN, Padjadjaran University, and Mulawarman University through a SATREPS project, the Development of Integrated Bio-circular Economy from Food and Energy Estate Waste Fraction to Biofuel and Bio-chemicals (2023-2028) (hereafter called "SATREPS Biocircular Economy").

All of the microorganisms utilized in the project, along with information regarding their biorefinery capabilities, have been made publicly accessible. They are available in the InaCC catalog or are in the process of being included, ensuring that researchers and practitioners can easily access and utilize this valuable information for further studies and applications in biorefinery and related fields. This transparency promotes collaboration and knowledge sharing within the scientific community.

The major research instruments provided under this project have been utilized. They are not only employed by project members but also accessible to researchers across BRIN from various regions in Indonesia. According to BRIN, this broad utilization enhances the benefits of these facilities and equipment, extending their impact well beyond the initial outputs anticipated during the project planning phase. BRIN also mentioned that the collaborative use of these resources fosters greater research opportunities and contributes to advancing scientific knowledge and applications in the field.

<Status of Achievement for the Expected Overall Goal at the Time of Ex-Post Evaluation>

At the time of ex-post evaluation, the Overall Goal has been achieved as planned. One Indonesian private company has been utilizing the project's integrated bio-refinery technology since 2019 to date (Indicator 1). Because of the COVID-19 pandemic, actions to establish the base for Indonesian private companies for bio-production with the project's technology could not proceed as planned after 2020. This disrupted many research and development initiatives. According to BRIN, however, despite such challenges faced in 2020, the groundwork laid in 2019 reflects a commitment to fostering collaboration and establishing a strong foundation for private sector involvement in bio-production in Indonesia.

It should be noted that as of the time of the ex-post evaluation, a fully integrated bio-refinery process, including large-scale biomass pretreatment, has not been fully established at a practical level. In 2018, a pilot project was conducted; however, it was limited to a company level and did not extend to broader social implementation. This indicates that while initial research activities were carried out, further efforts are needed to achieve a more comprehensive and effective bio-refinery process applicable at a larger scale.

<Other Impacts at the Time of Ex-Post Evaluation>

The project has significantly improved the research capacity of the researchers involved. Specifically, at least ten individuals pursued their doctoral degrees during the course of the project. This advancement in academic qualifications has enhanced their expertise and skills in the field, enabling them to conduct more sophisticated research and contribute effectively to ongoing and future projects. This capacity building not only benefits the individual researchers but also strengthens the overall research capability of the institutions they represent.

Regarding the scientific literacy of related governmental organizations/institutions, BRIN indicated that BRIN and Universities are familiar with using the word "Integrated Biorefinery." The Ministry of Energy and Mineral Resources and PT. Pertamina (a state-owned oil and natural gas corporation) are also concerned about using biomass for producing biofuels. Since 2013 until this year (2024), BRIN conducted the International Symposium of Innovative Bioproduction Indonesia on Biotechnology (ISIBio) regularly every year. BRIN invited speakers and participants from academics, regulators, private companies, etc.

As for the utilization of agricultural residues from plantations, which were previously considered waste, BRIN reported that they have now been utilized effectively. For example, biomass from these residues has been sold by farmers, providing them with a new source of income. This transformation not only helps in reducing waste but also enhances the economic well-being of the farmers, demonstrating the practical benefits of integrating agricultural waste into bio-production and biorefinery processes. It is difficult to consider this positive change as the impact of a single research project (this project), but this project has facilitated the effective utilization of residues, and future contributions are anticipated.

<Evaluation Result>

In light of the above, the effectiveness/impact of the project is ③.

Achievement of Project Purpose and Overall Goal

Aim	Indicators	Results	Source
(Project Purpose) To establish "Innovative Bio-production in Indonesia (iBiol): Integrated Bio-refinery Strategy to Promote Biomass Utilization using Super-microbes for Fuels and Chemicals Production."	Indicator 1 Number of Publications of ISI journals: 15	Status of the Achievement (Status of the Continuation): achieved beyond the plan (continued) (Project Completion) ・ Papers Published: 19 papers published; 2 papers submitted ・ Symposiums: International symposiums held in 2015, 2016, and 2017. 4 symposium proceedings published ・ Bulletins: 8 bulletins issued to promote project activities ・ Conference Presentations: 4 invited lectures, 26 oral presentations, 30 poster presentations (Ex-Post Evaluation) ・ Related research has been continued utilizing the research outputs of the project.	Joint Terminal Evaluation Report, BRIN
	Indicator 2 Number of Patent	Status of the Achievement (Status of the Continuation): mostly achieved as planned (continued)	Joint Terminal Evaluation

	applications: 5	(Project Completion) 1) Synthesis of Poly Lactic Acid (PLA) using Tin catalyst with mineral clay as support (registered) 2) Composite Material Method of PLA and Cellulose Microfibril (MFC) (registered) 3) Preparation method to making protoplast from Streptomyces albus as host cell for protein and secondary metabolites production (registered) 4) Yeast cell to increase ethanol production from lignocellulosic biomass (to be registered) (Ex-Post Evaluation) ・ Related research has been continued utilizing the research outputs of the project.	Report, BRIN
	Indicator 3 Number of Ph.D students: 10	Status of the Achievement (Status of the Continuation): achieved beyond the plan (continued) (Project Completion) Total Ph.D. students under the project: 16 students ・ Ph.D. students at Kobe University: 8 students in total; 6 studying and 2 to be entering a doctoral course ・ Ph.D. students overseas (other than Kobe University): 3 students ・ Ph.D. students at Indonesian universities: 5 students (Ex-Post Evaluation) ・ Related research has been continued utilizing the research outputs of the project. Ph.D. candidates are increasing.	Joint Terminal Evaluation Report, BRIN
	Indicator 4 Number of the collaboration with companies: 2	Status of the Achievement (Status of the Continuation): partially achieved (continued) (Project Completion) The project established one (1) cooperative relationship by concluding MOU among LIPI, Kobe University, and Indonesian and Japanese private companies. ・ Title of collaboration business and place: Cooperation on the Development and Implementation of Integrated Biorefinery Technology in Indonesia ・ Name of Company in Indonesia: Center for Innovation, LIPI, the Research Center for Biotechnology, LIPI, and P.T. Agricinal Indonesia ・ Name of Company in Japan: Kobe University and Bio-Energy Corporation ・ Final Product: 1) Development and implementation of technology for the production of biofuel from biomass in Indonesia; 2) Establishment and operationalization of pilot scale production of Biodiesel from Palm Acid Oil and /or Crude Palm Oil (CPO) through enzymatic process in Indonesia (Ex-Post Evaluation) ・ See the Overall Goal below.	Joint Terminal Evaluation Report, BRIN
(Expected Overall Goal) Implementation of integrated bio-refinery technology to produce bio-based product(s) from potential biomass in Indonesia.	Indicator At least one of Indonesian private companies for bio-production with our integrated bio-refinery technology.	Status of the Achievement: achieved as planned (Ex-Post Evaluation) Private company: one ・ PT. Agricinal Indonesia (2019-present) State-owned enterprises (SOEs) / Institutions under SOEs: two (only in 2019) ・ Petrosida Gresik (2019) ・ Indonesian Coffee and Cocoa Research Institute (2019)	BRIN

3 Efficiency

The project cost slightly exceeded the plan (the ratio against the plan: 116%) due to the combined factors, and the project period was as planned (the ratio against the plan: 100%).

	Project Cost (Japanese side only, yen)	Project Period (months)
Plan (ex-ante)	301 million yen	60 months
Actual	348 million yen	60 months
Ratio (%)	116%	100%

Outputs were produced as planned.

In the light above, the efficiency of the project is ③.

4 Sustainability

<Policy Aspect>

At the time of the ex-post evaluation, there is established support from the government policy and systems to utilize the research outputs and outcomes from the SATREPS project. Specifically, the theme of integrated biorefinery research has been prioritized as a key area of research in Indonesia: integrated biorefinery has been adopted as a national program, reflecting government commitment to applying research in policy-making. These efforts collectively ensure that research facilities and equipment installed by the SATREPS project are effectively utilized, supporting ongoing development and innovation. Also, national policy such as the Zero Emission by 2060 policy from the Ministry of Energy and Mineral Resources supports initiatives aligned with the integrated biorefinery approach. Such recognition by

the government underscores the importance of biorefinery technologies in enhancing the country's agricultural and industrial sectors, facilitating the application of research findings to real-world challenges and opportunities in sustainable development.

<Institutional/Organizational Aspect>

There is an organizational arrangement in place to utilize outputs from the SATREPS project. The Deputy for the Utilization of Research and Innovation of BRIN is responsible for managing and overseeing the implementation of research. LIPI's Center of Excellence for Integrated Biorefinery, which was active from 2016 to 2020, has continued its efforts and evolved into the Research Collaboration Centers (RCCs). This transition signifies ongoing collaboration between various research institutions and government authorities to implement policies and programs based on the research outputs. The establishment of RCCs facilitates enhanced partnerships, knowledge sharing, and the generation of benefits derived from the integrated biorefinery research initiatives.

Also, there is an established organizational arrangement for the operation and maintenance of the research facilities and equipment installed by the SATREPS project. The Directorate of Research and Innovation Infrastructure (DIRI), BRIN, is responsible for overseeing these activities. This directorate ensures that the facilities are properly maintained and operational, facilitating ongoing research efforts and maximizing the utilization of the installed equipment for various scientific and technological advancements.

Information on whether staffing for relevant departments and centers is sufficient was not obtained. However, given the positive continuation of activities described in the Effectiveness/Impact section, no significant issues are apparent.

<Technical Aspect>

At the time of the ex-post evaluation, research organizations and institutions demonstrated the technical capacity to utilize SATREPS project outputs, including improved research skills among researchers and enhanced scientific literacy among government authorities. These advancements support future initiatives, such as the ongoing SATREPS Biocircular Economy. Researchers have sustained their capacity through collaboration with external experts, securing research funding for biorefinery topics, and increasing the number of Ph.D. candidates in the field. Collaboration with Kobe University and other networks continues to provide knowledge exchange and skill development.

<Financial Aspect>

At the time of the ex-post evaluation, research organizations successfully secure financial resources to sustain and expand the SATREPS project outcomes. Key initiatives include the following: the In House Program Join Collaboration Research (Rumah Program) by BRIN, which provides structured management and funding for ongoing research; the establishment of RCCs focused on biomass, bioproducts, microorganisms, genetic engineering, and clean technology to attract funding; the prioritization of enzyme production as a national agenda; and investment in Good Manufacturing Practices (GMP) bioprocessing to enhance the quality and scalability of bioproducts. Additionally, financial support was obtained from sources such as the Palm Oil Plantation Fund Management Agency (Badan Pengelola Dana Perkebunan Kelapa Sawit: BPDPKS) for palm oil sector research, the Indonesia Endowment Fund for Education (Lembaga Pengelola Dana Pendidikan: LPDP) for educational and research initiatives, and the Directorate of Research and Innovation Infrastructure (DIRI) for the operation and maintenance of research facilities and equipment.

Government authorities have also secured financial resources to utilize the research outcomes, particularly for policy and program implementation. Notable funding sources include "the Zero Emission by 2060" policy mentioned above. Furthermore, new government programs in structural biology and biorefinery have been established to promote research and innovation, ensuring that financial resources are available to drive sustainable practices and achieve national goals.

<Environmental and Social Aspect>

No issue on environmental and social aspects has been observed, and it has not been necessary to take any countermeasures.

<Evaluation Result>

In light of the above, no problem has been observed in terms of the policy, institutional/organizational, technical, financial, and environmental and social aspects of the implementing agency. Therefore, the sustainability of the project effects is ④.

5 Summary of the Evaluation

The project mostly achieved the establishment of the integrated biorefinery strategy to promote biomass utilization (Project Purpose) and to the implementation of the strategy (Overall Goal) as planned.

Considering all of the above points, this project is evaluated to be highly satisfactory.

IV. Recommendations & Lessons Learned

Lessons Learned for JICA:

This project had good collaboration with other SATREPS projects, which can be replicated as a good practice. The effects include the utilization of the research outputs of other SATREPS projects (i.e., good yeast strains in case of this project) and exchange of information among other Indonesian research institutions involved the other SATREPS projects (i.e., information on the development of a production process of ethanol and methanol from biomass waste in case of this project). JICA is expected to refer to this case when considering collaboration with other projects during the planning of SATREPS projects.