

Country Name	Multi-beneficial measure for the mitigation of climate change in Vietnam and Indochina countries by development of biomass energy
Socialist Republic of Viet Nam	

I. Project Outline

Background	<p>Concerned with energy security, the Government of Viet Nam adopted policies to promote the production and consumption of renewable energy, notably the development of biodiesel fuel (BDF) using Jatropha and other biomass resources. BDF was considered beneficial for climate change mitigation and prevention of air pollution, as it contains fewer contaminants, and the total carbon dioxide emission by BDF production and utilization is less than that of fossil fuel. Several national strategies and policies in favor of BDF promotion were in place; however, technology for the development of promising raw materials, production of high-quality BDF, and researches on the actual environmental and socio-economic impacts of BDF production were scarce in Viet Nam. As a consequence, development and investment in BDF and its commercialization were still slow.</p>												
Objectives of the Project	<p>The project aimed to come up with measures to mitigate climate change, environmental pollution, and poverty in Viet Nam and other Indochina countries by establishing cultivation, production and utilization of biomass energy cycle through (i) the development of oil materials for producing BDF, (ii) the development of a countermeasure technology for polluted soil and corresponding plantation techniques, (iii) the production of BDF from raw material oil with green technologies, (iv) the development of an environmental monitoring method for evaluating the impact of BDF utilization, and (v) the verification of the feasibility of the developed results in Viet Nam, thereby contributing to the promotion of the production and utilization of BDF.</p> <ol style="list-style-type: none"> Expected Overall Goal: Establish the economically and environmentally superior cultivation-production-utilization of biomass energy cycle and broad use of above system in the world. Project Purpose: Realize the effective measure for the mitigation of climate change, improvement of environmental pollution and overcome the poverty in Viet Nam and Indochina Countries by establishing cultivation, production and utilization of biomass energy cycle. 												
Activities of the Project	<ol style="list-style-type: none"> Project Site: Viet Nam Main activities: (i) Identification of species and cultivation techniques of the materials and production of BDF out of them; (ii) Dioxin pollution survey, drawing a soil pollution map, investigation of soil pollutants transfer to Jatropha; (iii) Design and construction of a pilot plant for BDF production and production of BDF and byproducts such as glycerine; (iv) Collection of monitoring data for air quality, identification of novel atmospheric pollutants in BDF exhaust gas, (v) Development and use of an evaluation method for BDF feasibility, preparation of policy recommendations. Inputs (to carry out above activities) <table style="width: 100%; border: none;"> <tr> <td style="width: 50%; border: none;">Japanese Side</td> <td style="width: 50%; border: none;">Vietnamese Side</td> </tr> <tr> <td style="border: none;">1) Experts: 23 persons</td> <td style="border: none;">1) Staff allocated: 19 persons</td> </tr> <tr> <td style="border: none;">2) Trainees received: 84 persons for short-term training, 4 persons for master course, and 15 persons for doctoral course</td> <td style="border: none;">2) Facilities: Project coordination Office in VNU and six laboratories/facilities</td> </tr> <tr> <td style="border: none;">3) Equipment: BDF production plant, ambient air quality monitoring system, laboratory equipment, etc.</td> <td style="border: none;">3) Operation cost</td> </tr> <tr> <td style="border: none;">4) Operation cost</td> <td style="border: none;"></td> </tr> </table> 			Japanese Side	Vietnamese Side	1) Experts: 23 persons	1) Staff allocated: 19 persons	2) Trainees received: 84 persons for short-term training, 4 persons for master course, and 15 persons for doctoral course	2) Facilities: Project coordination Office in VNU and six laboratories/facilities	3) Equipment: BDF production plant, ambient air quality monitoring system, laboratory equipment, etc.	3) Operation cost	4) Operation cost	
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Project Period	October 2011 – September 2016	Project Cost	(ex-ante) 372 million yen, (actual) 322 million yen										
Implementing Agency	<p>Vietnam National University Hanoi (VNU) Vietnam National University Ho Chi Minh City (VNU-HCM) The Institute for Improvement of Forest Genetic Resources and Product Development (IIFPD) of the Ministry of Agriculture and Rural Development (MARD) Institute of Environmental Technology (IET) of Vietnam Academy of Science and Technology (VAST) Institute of Tropical Biology (ITB) of VAST Department of Development of Forestry (DDF) of MARD Center for Environmental Monitoring (CEM) of the Ministry of Natural Resources and Environment (MONRE) Institute of Oil and Oil Plants (IOOP) of the Ministry of Industry and Trade (MOIT)</p>												
Cooperation Agency in Japan	<p>Osaka Prefecture University (OPU); Osaka City University (OCU); Ehime University; Japan International Research Center for Agricultural Science (JIRCAS)</p>												

II. Result of the Evaluation

< Special Perspectives Considered in the Ex-Post Evaluation >

For this SATREPS project, a Project Design Matrix (logical framework) was not prepared. The Record of Discussion (R/D) (September 12, 2011) stated the Overall Goal as “Establish the economically and environmentally superior cultivation-production-utilization of biomass energy cycle and broad use of the above system in the world,” and the mid-term review report acknowledged the same Overall Goal. No indicator was set for this Overall Goal. On the other hand, the terminal evaluation report stated that the Overall Goal did not exist for this project while expecting the promotion of production and utilization of BDF as actions towards the social application of the research outputs/outcomes after project completion. Based on the analysis of this situation within the framework of the ex-post evaluation of STAREPS projects, this ex-post evaluation keeps the text of the Overall Goal stated in the R/D but assesses its achievement by whether the production and utilization of BDF are being promoted in Viet Nam and other Indochina countries using the

¹ SATREPS: Science and Technology Research Partnership for Sustainable Development

1 Relevance

<Consistency with the Development Policy of Viet Nam at the Time of Ex-Ante Evaluation>

This project was consistent with Viet Nam's development policies such as the "National Energy Strategy" (2007) and the "National Target Program to Respond to Climate Change (NTP-RCC)" (2008-2020), which all promoted the development of renewable energy as a climate change countermeasure. Also, the "Roadmap for Biofuel Development to 2015 and Vision to 2025" approved by the Decision No. 177/2007/QĐ-TTĐ promoted the biofuel development.

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

As mentioned in "Background" above, this project was consistent with the need to develop and invest in BDF and its commercialization.

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

This project was consistent with the "Country Assistance Program for Viet Nam" (2009), which held "Stable Supplies for Resource and Energy" (under "Promotion of Economic Growth and Strengthening of International Competitiveness"), "Natural Environment Conservation" (under "Environmental Conservation"), and "Rural Development and Improvements in Livelihood" (under "Improvements in Living and Social Conditions and Corrections of Disparities").

<Evaluation Result>

In light of the above, the relevance of the project is high.

2 Effectiveness/Impact

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

The project achieved the Project Purpose at the time of project completion. An optimal cultivation technique using tissue culture technology was developed to produce elite varieties of *Jatropha*, enabling the productivity of more than 5 t/ha. It was found that *Jatropha* grows well on the degraded lands in Quang Tri Province in the north-central region but is not suitable for the weather conditions of the northern region of Viet Nam. Therefore, the project explored other oil-plants that can grow well in the northern region, such as *Pongamia Pinnata* (Indicator 1). Regarding the production of BDF, the project successfully produced it at VNU using the co-solvent method. It proved a potential use of the technology for future scaled-up production of BDF (Indicator 2). In terms of promotion on the utilization of BDF, at the time of project completion, the project completed an assessment of socio-economic and environmental impacts of BDF (Indicator 3) and the first draft of a policy recommendation on BDF utilization, which went through consultations with state agencies and was submitted to the Ministry of Industry and Trade (MOIT) at the end of 2016 (Indicator 4).

<Continuation Status of Project Effects at the time of Ex-post Evaluation>

The project effects have continued to the time of ex-post evaluation. Most of the equipment/experimental sites provided under this project have been continuously used for researches by respective implementing agencies. VNU, the main counterpart, established the Key Laboratory for Bioenergy Development (VNU Key-Lab) at the VNU Hoa Lac campus in 2016 for bioenergy development and with funding from VNU itself and other sources such as Ministry of Science and Technology (MOST). The professor who is the former Project Director of this project and currently the Director of the VNU Key-Lab and his team have succeeded in improving the co-solvent technology for BDF production by replacing acetone with non-volatile biodiesel. This is a significant improvement that can help to reduce the production cost. Moreover, further research focusing on byproducts of BDF production, such as plasticizers and heat stabilizers, shows that byproducts could bring added value to BDF, making it more competitive with other fossil fuels.

Other outputs of this project, such as the tissue culture technology to create *Jatropha* variety with higher productivity (by IOOP/MOIT), cultivation techniques of BDF source plants suitable for the northern region such as *Pongamia Pinnata* and *Vernicia Montana* (by Quang Ninh Center for Science and Forestry-Agriculture Production (CSFAP), IIFPD/MARD, and VNU Key-Lab), and the quick test for dioxin analysis (by VNU HCM and CEM/MONRE), are continuously studied and utilized for further projects.

<Status of Achievement for Expected Overall Goal at the time of Ex-post Evaluation>

The Expected Overall Goal has been achieved by the time of ex-post evaluation. First, in Viet Nam, some progress in promoting BDF production and utilization has been made based on this project's outcomes. For example, VNU Key-Lab has cooperated with some local governments such as Lao Cai Province to develop forestation programs with oil plants, such as those mentioned above, that are suitable for the weather conditions. Unfortunately, some activities have been suspended due to the fall of the market price of fossil fuel, which is almost the same as the price of biofuel, making it difficult to increase biofuel preference by consumers.²

Second, regarding other Indochina countries, VNU has transferred the BDF production technology to some private companies from Laos and Cambodia to disseminate the results of the project. These companies are preparing to establish a production line, although they are facing difficulty competing with fossil fuel due to its plummeting price.

<Other Impacts at the time of Ex-post Evaluation>

No negative impact was observed. Positive impacts pointed out by VNU include the following. (1) Researchers involved in the project improved their search capacity in respective fields by participating in short-term training courses, scientific seminars and workshops organized by the project, and particularly when working directly with Japanese experts in the lab and conducting field surveys. After the project was completed, their research capacity has continued to be improved by "learning by doing" through conducting scientific projects and research and development projects funded by the Vietnamese Government, participating in scientific conferences and seminars, and

² However, a plan in Quang Ninh Province to restore a coal mine site with planting suitable source plants has been reconsidered since 2017 due to a plummet of the petrol price. For the same reason, a cruise boat company at Ha Long Bay once bought high-quality BDF from VNU Key-Lab at a cheaper price than fossil fuel but has temporarily stopped using BDF.

joining oversea training. (2) Government agencies improved their scientific literacy/realized the importance of using the technology developed by this project by being shared documents and involved in related projects. (3) Farmers increased income in some project areas such as Huong Hoa District, Quang Tri Province, and Si Ma Kai District in Lao Cai Province, by cultivating and breeding BDF source plants in once-polluted land areas (the project found the level of dioxin residue in the soil to be lower than the allowed level in these areas).³ (4) The simultaneous air monitoring methods became an effective technology and continue to be used to assess air quality in Hanoi and HCMC. (5) VNU and OPU cooperated with Hanoi Department of Natural Resources and Environment (DONRE) to develop a proposal for the JICA Partnership Program scheme on sanitary and environmental improvement in cattle slaughterhouses in Hanoi, and JICA approved the proposal in March 2019. As a part of this project, fat from cattle slaughterhouses will be collected and used for BDF production using the pilot plant at the VNU Key-Lab.

<Evaluation Result>

Therefore, the effectiveness/impact of the project is high.

Achievement of Project Purpose and Overall Goal

Aim	Indicators	Results
<p>(Project Purpose) Realize the effective measure for the mitigation of climate change, improvement of environmental pollution and overcome the poverty in Viet Nam and Indochina Countries by establishing cultivation, production and utilization of biomass energy cycle.</p>	<p>Indicator 1: Optimal cultivation technique of BDF-source plant species in degraded lands and former coal mines is established.</p>	<p>Status of the Achievement: partially achieved (continued) (Project Completion) - The optimal cultivation technique of <i>Jatropha Curcas</i> was established for the southern region (annual yield: 5.4 t/ha). However, the species was confirmed not suitable in the northern region. - The results from other BDF-source plant species suggested that the appropriate species for each region would be planting both <i>Vernicia Montana</i> and <i>Hibiscus</i>, or <i>Pongamia Pinnata</i> in the north, extracting raw material oil from existing rubber tree seeds in the middle, and planting <i>Jatropha Curcas</i> in the south of Viet Nam, respectively. (Ex-post Evaluation) - IOOP/MOIT continues to use the tissue culture technology for researches on diversification of oil plant varieties. It maintains the 6-ha experimental <i>Jatropha</i> site with more than 60 varieties, including three elite varieties with high productivity of more than 5 t/ha/year. - Quang Ninh CSFAP continues to use the weather monitoring methods to maintain the 3-ha pilot site of <i>Pongamia Pinnata</i> and other oil-bearing varieties. The result confirmed that <i>Pongamia Pinnata</i> could adapt well to the soil of abandoned open mining sites in Quang Ninh Province in the northeast. - IIFPD/MARD continues to use the tissue culture technology to develop the 3-ha <i>Pongamia Pinnata</i> experimental site in Ba Vi, Hanoi. It plans to expand the experiment to choose the best variety.</p>
	<p>Indicator 2: A production method of high-quality BDF by the co-solvent method is cooperatively developed.</p>	<p>Status of the Achievement: achieved (continued) (Project Completion) - A BDF pilot plant system produced high-quality BDF and valuable byproducts by the co-solvent method from various kinds of raw material oil. - One of the research papers produced was the world's first report of BDF production by the co-solvent method.⁴ (Ex-post Evaluation) - VNU Key-Lab promoted bioenergy production. It continued to use the transferred production technology and further improved it: (1) the volatile acetone was replaced with the non-volatile biodiesel, which made the process more environmental-friendly and efficient (40% cheaper than other production technology); (2) the integrated technology for the production of biodiesel and high value-added plasticizers and heat stabilizers from inedible oils and fats have been developed; (3) one-pot method for the simultaneous production of biodiesel and heat stabilizers from waste oils and fats, using the heterogeneous catalysts has been developed.</p>
	<p>Indicator 3: Results of assessment of socio-economic and environmental impacts in the case where produced BDF is utilized in Viet Nam.</p>	<p>Status of the Achievement: achieved (continued) (Project Completion) - Assessment of socio-economic and environmental impacts of BDF was completed. - One of the research papers produced was the world's first report of emissions of new pollutants (low molecular weight-methyl esters (LMW-ME)) from BDF combustion.⁵ (Ex-post Evaluation) - CEM/MONRE continues to use bioassay (investigation of the effects of chemical substances using living organisms) and other methods to monitor industrial dioxin contamination in soil. - VAST provided funding to IET to assess the creativeness and preciseness of data obtained from the air monitoring station installed at VAST by this project. - Faculty of Environmental Sciences/VNU-HCMC continues to use the transferred air quality and weather monitoring methods in researches and education.</p>
	<p>Indicator 4: A plan of utilization of high-quality</p>	<p>Status of the Achievement: partially achieved by project completion, and achieved soon after project completion (continuation status is not verifiable)</p>

³ For example, the project's recommendation on multi-benefits afforestation, i.e., taking the oil and making watershed forests to prevent floods and erosion, helped Si Ma Kai farmers get additional income from selling *Vernicia Montana* seeds, as part of the payment they receive from the Government for afforestation.

⁴ Y. Maeda, L.T. Thanh, K. Imamura, K. Izutani, K. Okitsu, L.V. Boi, P. N. Lan, N.C.Tuan, Y.E. Yoo, N. Takenaka, "New Technology for The Production of Biodiesel Fuel" *Green Chem.* Vol. 13, pp. 1124-1128, (2011).

⁵ Phan Quang Thang, Yasuaki Maeda, Nguyen Quang Trung, and Norimichi Takenaka, Detailed Chemical Kinetics for Thermal Decomposition of Low Molecular Weight-Methyl Esters Generated by Using Biodiesel Fuel, *Environ. Progress & Sustainable Energy*, 2016, March, 1-8.

	BDF is proposed to the Government of Viet Nam as a potential policy.	(Project Completion) - The recommendations to the Vietnamese government agencies were summarized by the end of the project period. Based on discussions with state agencies, VNU completed a proposal on bioenergy policies and submitted it to the Science and Technology Department of MOIT at the end of 2016. (Ex-post Evaluation) - No information is available about how MOIT handled the above-mentioned proposal to MOIT.
(Expected Overall Goal) Establish the economically and environmentally superior cultivation-production-utilization of biomass energy cycle and broad use of above system in the world.	Contribution to the promotion of the production and utilization of BDF.	(Ex-post Evaluation) achieved <u>In Viet Nam</u> - To implement the plan of oil plant diversification scenario and to implement the MARD Circular No. 23/2017/BNNPTNT on Alternative Afforestation, the VNU Key-Lab has been cooperating with Lao Cai Provincial Department of Agriculture and Rural Development (DARD) to develop 40 ha of elite Vernicia Montana at Si Ma Kai District, Lao Cai Province. From this nursery, seeds will be collected for the improvement of 900 ha of existing forests. <u>In Other Indochina countries</u> - The improved co-solvent method was transferred to a Cambodian company to produce BDF from Jatropha seed oil. - VNU Key-Lab has signed a Memorandum of Understanding to transfer the technology to a company in Laos for the production of biodiesel from Vernicia Montana seed oil.

Source: Terminal Evaluation Report; Final Report; Questionnaire with the implementing agencies

3 Efficiency

Both the project cost and the project period were within the plan (ratio against the plan: 87% and 100%, respectively). The Outputs of the project were produced as planned. Therefore, the efficiency of the project is high.

4 Sustainability

<Policy Aspect>

The Vietnamese Government has continuously promoted the use of biofuel such as ethanol mixed petrol (E5, E50, E100) or biodiesel (B5, B100) through various policies such as the “Development Strategy of Renewable Energy of Vietnam by 2030 with a vision to 2050,” the “Roadmap for Biofuel Development to 2015 and Vision to 2025,” the “Roadmap for Application of Ratios for Blending Biofuels with Fossil Fuel,” and the “Vietnam’s Renewable Energy Development Strategy up to 2030 with an Outlook to 2050.” MOIT has issued ministerial decisions and circulars to focus on the implementation of these plans. Also, the three regional sustainable development programs including the promotion of biofuel production, namely, the “Science and Technology Program for Sustainable Development in the North-west Region,” the “Science and Technology Program for the Central Highlands Region,” and the “Science and Technology Program for Sustainable Development in the South-western Region,” have been implemented up to 2025. VNU Key-Lab has received funding from these programs to continue research on the improvement of the BDF production technology.

<Institutional/Organizational Aspect>

The questionnaire survey confirmed that the implementing agencies, which are key institutes of the respective organizations, have a solid and working organizational arrangement to continue their research and development activities.⁶ Many of the counterpart personnel were promoted to directors. It was also found that each institute clearly defines the operation and maintenance responsibility for the equipment provided by this project. Further, VNU Key-Lab has been cooperating with some private companies to develop a plantation of oil plants and collect waste animal fats for BDF production.

<Technical Aspect>

Much ex-counterpart personnel remains in the same implementing agencies. The questionnaire survey confirmed that researchers at each implementing agency have sufficient research capacity to continue their research by being involved in projects and attending various training/scholar exchanges organized by international organizations. They retain skills to operate and maintain the equipment provided by the project.

<Financial Aspect>

Each research institute has secured the budget to continue its research and development activities. Only fragmentary data were available on the Government's relevant policy implementation budget. However, based on the information described above, it can be inferred that the government authority has spent a certain budget for the continuation of project effects.

Funding for the implementing agency

Institute	Routine budget including operation and maintenance of equipment	Major research grants in the related fields
VNU Key-Lab	250 million VND/year from VNU (Hanoi)	2,650 million VND from MOIT (2016-2017), 949.7 million VND from VNU (2017-2018), 5,970 million VND from MOST (2019-2020)
VNU-HCM	100 million VND/year to Faculty of Environment from VNU-HCM; 6 billion VND from their own research activities	900 million VND from the Department of Science and Technology of Ho Chi Minh City (2017-2018), 1,100 million VND from Newton-UK (2019-2021)
IET/VAST	100 million VND/year to the Environmental Toxic Division from IET	300 million VND from VAST (2017-2019), 150 million VND from VAST (2018-2020)
CEM/MONRE	10 billion VND/year from MONRE	3,000 million VND from National Academy of Sciences-USA (2018-2020), 1,500 million VND from MONRE (2018-2021)

Source: Questionnaire with the implementing agencies

⁶ For example, VNU Key-Lab has six staff members: full-time researchers and the other ten staffs from the Department of Chemistry/VNU working as part-time researchers.

<Evaluation Result>

Therefore, the sustainability of the effects through the project is high.

5 Summary of the Evaluation

The project achieved the Project Purpose to come up with measures to mitigate climate change, environmental pollution, and poverty by establishing cultivation, production and utilization of biomass energy cycle. The project's effects have continued, i.e., VNU Key-Lab and other implementing agencies have continued and further expanded the research, and the Expected Overall Goal of contributing to the promotion of the production and utilization of BDF has been achieved. Regarding sustainability, no problem has been found in any of the policy, institutional/organizational, technical, and financial aspects. Considering all of the above points, this project is evaluated to be highly satisfactory.

III. Recommendations & Lessons Learned

Recommendations for Implementing Agency:

As a line agency of the project, VNU is recommended to review all achievements and experiences of BDF production piloted in this project and subsequent research and development activities in order to provide policy advisory service to the Government (MARD and MOIT) on the roadmap for the development of BDF production in Viet Nam.

Lessons Learned for JICA:

(1) The project's design focused on Jatropha as the main feedstock of BDF production. However, during implementation, it was found that the climate of the northern region of Viet Nam was not suitable for the cultivation of Jatropha. Therefore, additional activities were conducted to explore other plant species. A positive lesson learned from those activities is that a flexible change in project activities in response to research findings could enhance the effectiveness and impact of the project. At the same time, the project could have handled this change in a better way from a project management perspective. Despite this change, the project outputs and indicators were not revised, making the assessment of the achievement rather difficult. Although, SATREPS Project is a Technical Cooperation (TC) Project, Japanese and Vietnamese researchers involved in the project were not familiar with the principles and procedures of a TC. JICA should have provided some information/briefing on project design, R/D signing, and revision to both research institutes in Viet Nam and Japan who were implementing agencies of the project.

(2) With the strong leadership of the professor who was the Project Director of this project/Director of the Faculty of Chemistry of VNU, the project was able to secure a considerable amount of counterpart fund to construct the building of BDF research at the campus of Faculty of Chemistry and cover for some ad-hoc expenses such as domestic transportation of equipment, custom procedures of imported equipment, rental of a workshop to install the BDF pilot plant, etc. With sufficient counterpart funds, the project was able to cover the necessary expense that could not be paid by ODA provided by JICA. It helped to increase the efficiency of the project and also links to the sustainability of the project. Also, it is important that the timing of R/D signing aligns with the schedule of the approval procedures and budget planning at the Vietnamese side to ensure a decision on allocation of counterpart budget for the project is made timely.

(3) After project completion, JICA should consider to utilize its ongoing advocacy supports to help the project's outputs be reflected in related policies of the central government. In case of this project, JICA could have addressed MARD that is responsible for building up a plan for raw material plantation development to supply the biofuel production industry or the program of MOIT who is in charge of promotion of biofuel use.



Visit to biofuel production pilot plant in VNU for ex-post evaluation



Analytical equipment provided by the SATREPS project at VNU