Botswana

FY2021 Ex-Post Evaluation Report of Technical Cooperation Project

"Information-based Optimization of Jatropha Biomass Energy Production in the Frost- and Drought-Prone Regions of Botswana"

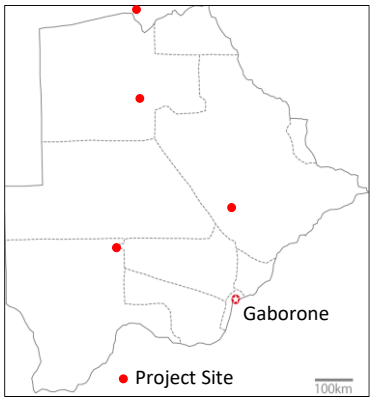
External Evaluator: Keishi Miyazaki, OPMAC Corporation

## 0. Summary

The project aimed to accumulate the technical knowledge and experience necessary to produce Jatropha biodiesel in Botswana on a commercial basis by conducting research in five areas: (i) the establishment of a Jatropha farming protocol suitable for the climate of Botswana, (ii) the establishment of bases for developing high yield and stress tolerant-Jatropha varieties, (iii) research on the characteristics of jatropha oil and development utilization methods, (iv) development of technologies to utilize non-oil Jatropha biomass, and (v) evaluation of the impact of Jatropha production and biomass from environmental, social and economic perspectives. This is in line with the Botswana's development policies and needs, as well as with Japan's assistance policy, and thus its relevance is high. In all five areas, research outputs were produced according to the plan and the project purpose was mostly achieved. Regarding the initiatives for social implementation which were set as the overall goals, three out of seven initiatives have been already completed or are on-going, while the remaining four have been not implemented yet. The project has made a certain contribution to improving the research capacity of the implementing agencies in Botswana, and there were generally no problems with the operation and maintenance of equipment. No negative impact on the natural environment was observed and there was no land acquisition or resettlement of people. Since this project has to some extent achieved the project purpose and overall goal, the effectiveness and impact of the project are fair. Both the project cost and project period were within the plan. Therefore, the efficiency of the project is high. No major problems have been observed in the policy background or in the institutional/ organizational, technical, or financial aspects. Therefore, the sustainability of the project effects is high.

In light of the above, this project is evaluated to be highly satisfactory.

## 1. Project Description




Project Locations

Jatropha cultivated on the pilot farm

## 1.1 Background

Botswana had seen tremendous economic growth since its independence in 1966. However, its economy had largely been driven by mineral resources such as diamonds, and domestic consumption, including oil, has been heavily dependent on imports. Meanwhile, Botswana's harsh weather conditions and low agricultural profitability had left much land unused. In such circumstances, the Government of Botswana decided to embark on the domestic production of biofuels with a view to increasing energy self-sufficiency, mitigating climate change and promoting the sustainable use of energy, and the government made clear its intention to actively explore and utilize renewable energy sources in *the Tenth National Development Plan* (2009-2016). Also, the Government of Botswana had been considering increasing the energy consumption from renewable energy sources to 30% of total energy consumption by 2030. In this connection, the production of biodiesel using Jatropha was seen as high potential. However, many challenges needed to be overcome to achieve the commercial production of Jatropha biodiesel such as developing varieties adapted to low rainfall and drought, establishing a Jatropha cultivation method and assessing its toxicity. Meanwhile, Botswana's research experience in the field of Jatropha research was extremely limited, and there was a need to conduct joint research with Japan, a world pioneer in this field.

## 1.2 Project Outline

| | | |
|---|---|---|
| Overall Goal | | None |
| Project Purpose | | Technical knowledge and experience to produce Jatropha biodiesel in Botswana on commercial basis is accumulated. |
| Outputs | Output 1 | Jatropha farming protocol[1] suitable for the climate of Botswana is established. |

[1] This includes management of tree pruning, windbreaks, water, and fertilizer timing to overcome winter droughts and cold damage.

| | | |
|---|---|---|
| | Output 2 | Bases for developing high yield and stress tolerant-Jatropha varieties are established[2]. |
| | Output 3 | Characteristics of Jatropha oil production become clear. |
| | Output 4 | Technologies to utilize non-oil Jatropha biomass are developed. |
| | Output 5 | Impact of Jatropha production and biomass use is evaluated environmentally, socially and economically. |
| Total cost (Japanese Side) | | 288 million yen |
| Period of Cooperation | | April 2012 – April 2017 |
| Target Area | | Sebele (Gaborone), Kang, Serowe, Maun |
| Implementing Agency | | Department of Energy (DOE)/Ministry of Mineral Resources, Green Technology and Energy Security (MMGE), Department of Agricultural Research (DAR)/Ministry of Agriculture (MOA), University of Botswana |
| Other Relevant Agencies/ Organizations | | None |
| Consultant/ Organization in Japan | | Tottori University, University of the Ryukyus, Institute of Physical and Chemical Research (RIKEN) |
| Related Projects | | Technical Cooperation, "Sustainable Production of Biodiesel from Jatropha in Mozambique" (July 2011 – June 2016) |

1.3 Outline of the Terminal Evaluation

1.3.1 Achievement Status of Project Purpose at the Terminal Evaluation

It was judged that the project purpose was partially achieved. Four academic papers on Jatropha biodiesel had been published, three were under review in academic journals and four were being drafted. Drafts for technical knowledge and experience, the so called "technical protocol" on Jatropha cultivation methods, the development of transgenic Jatropha, the utilization of non-oil Jatropha, etc. were complete. On the other hand, only one researcher was able to obtain a master's/PhD degree during the project implementation period.

1.3.2 Achievement Status of Overall Goal at the Terminal Evaluation

(Including other impacts.)

[2] As it has aimed for the establishment of a methodology for efficient variety development, it is not envisaged that the project will lead to the development of new varieties.

An overall goal was not set in this project.

1.3.3 Recommendations from the Terminal Evaluation

The following recommendations were proposed:

(1) Development of a road map for social implementation of the project
(2) Contribution to the National Energy Policy
(3) Preparation of rules and regulations for genetic engineering
(4) Continuous utilization of facility/equipment provided through project implementation.

## 2. Outline of the Evaluation Study

2.1 External Evaluator

Keishi Miyazaki, OPMAC Corporation

2.2 Duration of Evaluation Study

This ex-post evaluation study was conducted with the following schedule.

Duration of the Study: July 2021 - January 2023

Duration of the Field Study: November 1 – November 14, 2021

2.3 Constraints during the Evaluation Study

This project is categorized as Science and Technology Research Partnership for Sustainable Development (SATREPS)[3]. Usually, the ex-post evaluations of SATREPS projects are undertaken by the internal evaluation. However, the ex-post evaluation of this target project was made by an external evaluator since the JICA Evaluation Department considered that useful insights could be gained through interviews with stakeholders in Japan, etc. It should be noted that this ex-post evaluation applied the previous evaluation criteria (five evaluation criteria) due to the timing of the introduction of the new evaluation criteria.

## 3. Results of the Evaluation (Overall Rating: A[4])

3.1 Relevance (Rating: ③[5])

[3] SATREPS are implemented by the Japan Science and Technology Agency (JST), the Japan Agency for Medical Research and Development (AMED) and JICA, with support from the Ministry of Foreign Affairs and the Ministry of Education, Culture, Sports, Science and Technology, to promote science and technology cooperation and science and technology diplomacy with developing countries through the collaboration of Japan's excellent science and technology and ODA. The aim of SATREPS is to acquire new knowledge and technologies and create innovations that will lead to solutions to global issues such as the environment, carbon neutrality, bioresources, disaster prevention and infectious diseases, as well as to improve the independent research and development capacity of developing countries and to build a sustainable system of activities that will contribute to solving these issues.

[4] A: Highly satisfactory, B: Satisfactory, C: Partially satisfactory, D: Unsatisfactory

[5] ③: High, ②: Fair, ①: Low

3.1.1 Consistency with the Development Plan of Botswana

At the time of the ex-ante evaluation, *the Tenth National Development Plan* (2009-2016) focused on key areas such as building a knowledge society, breaking away from dependence on mining and promoting industrial diversification, improving public services, promoting private sector growth, information communication and research, human resource development, public safety and security measures, infrastructure development and conservation, and investment in the service sector. The Plan included the active development and utilization of renewable energy sources from the perspective of improving energy self-sufficiency, mitigating climate change and promoting the sustainable use of energy. In addition, *the National Energy Policy* which was being developed at that time was considering the inclusion of a target to increase energy consumption from renewable energy sources to 30% of total energy consumption by 2030, and in this connection, the production of biodiesel from Jatropha was seen as a promising option.

At the time of the ex-post evaluation, *the Eleventh National Development Plan* (2017-2023), formulated on the basis of *VISION 2036*, which sets out long-term development strategy until 2036, identified priority areas such as the promotion of industrial diversification, human resources development, social development, sustainable use of natural resources and the implementation of an efficient management and evaluation system. This included the development of renewable energy, including the use of Jatropha. In addition, *the National Energy Policy of Botswana* (2020-2040) sets targets to reduce carbon dioxide emissions by 15% by 2030 and 36% by 2036 compared to 2010, in which the potential of Jatropha as a biofuel resource is mentioned.

3.1.2 Consistency with the Development Needs of Botswana

At the time of the ex-ante evaluation, Botswana's harsh weather conditions and low agricultural profitability left a lot of land unused, and the production of biodiesel from Jatropha on unused land was seen as promising[6]. However, for the commercial production of Jatropha biodiesel a number of challenges had to be overcome. These included developing varieties adapted to low rainfall and drought, establishing cultivation systems and assessing toxicity. In 2010, DOE/MMGE, with the help of Japanese Jatropha researchers, identified the challenges for Jatropha biodiesel production and decided that the selection and breeding of varieties suitable for Botswana's dry and cold environment and the establishment of cultivation methods should be a top priority. On the other hand, DAR/MOA and University of Botswana had researchers with knowledge in the relevant fields and some research facilities, but very little research experience in this field, and in

[6] Jatropha is inedible and therefore has the advantage that biodiesel can be extracted purely as energy, without competing with food and available bioethanol feedstocks such as maize.

order to make the commercial production of Jatropha biodiesel possible in the future, joint research with Japan, a world leader in the field of Jatropha research, was required.

At the time of the ex-post evaluation, it was confirmed that though the project, the project has made some achievements in the development of transgenic Jatropha seeds and cultivation methods that are stress tolerant in the climatic conditions of Botswana. However, there are still some issues to be resolved before promotion of full-scale cultivation of Jatropha, including continued research on cultivation methods, genome breeding research, and the establishment of domestic laws in related fields. Based on the above, DOE/MMGE changed its policy to the development of biodiesel through the use of non-Jatropha biomass[7], as it recognized that full-scale cultivation of Jatropha under Botswana's climatic conditions would leave some issues to be resolved. In response, DOE/MMGE, DAR/MOA and University of Botswana signed a Memorandum of Understanding to implement the "Biofuels Production Project[8]" (April 2018 - March 2023), utilizing various biomasses available in Botswana. This research project aims to continue and advance the development of biodiesel based on the research results of the SATREPS project, while extending the scope of the research to the development of biodiesel from waste biomass, including resource crops, tallow and waste cooking found in Botswana, rather than being limited to the development of Jatropha biodiesel. The research project is financed by the Government of Botswana, with a budget of approximately 14.2 million Pula (approximately 142 million yen[9]) over four years, which will be used for research and travel expenses (e.g., travel expenses to collect materials for biodiesel) for DAR/MOA and University of Botswana. Meanwhile, Japanese researchers, DAR/MOA, and University of Botswana continue to focus on the usefulness and potential of Jatropha as a biofuel resource, and DAR/MOA has expressed its willingness to continue research on the development of cultivation methods and variety improvement adapted to Botswana's climate conditions.

### 3.1.3 Consistency with Japan's ODA Policy

At the time of the ex-ante evaluation, *Japan's ODA policy for Botswana* identified "Support for infrastructure development for economic growth" and "Promotion for development in impoverished areas" as priority areas for cooperation, and stated that cooperation would be provided to help the country break away from its resource-dependent economic and industrial structure and achieve sustainable economic growth. In addition, at

[7] Biomass is the concept that expresses the quantity (mass) of biological resources (bio) and is defined as "renewable, organic resources of biological origin, excluding fossil resources". Biomass can be classified according to its status: (1) waste biomass (e.g., livestock waste, food waste, sewage sludge, manure sludge), (2) unused biomass (e.g., rice straw, wheat straw, rice husks, forest residues), (3) resource crops (e.g., sugar cane, corn and other starch resources, rapeseed oil resources, willow, poplar, etc.) (Source: website of Kyushu Regional Agricultural Administration Office, https://www.maff.go.jp/kyusyu/kikaku/baiomasu/teigitou.html).
[8] The Biofuels Production Project is implemented under the budget of Botswana government.
[9] Exchange rate used: BWP 1 = JPY 10.

the Fourth Tokyo International Conference on African Development (TICAD IV) in May 2008 and on other occasions, Japan expressed its intention to strengthen cooperation with African countries in their efforts to combat climate change, and this project was positioned as a concrete measure to support such efforts.

Furthermore, this project, which aimed to support the realization of a stable and sustainable energy supply in the Southern African region, was positioned as a "Regional Resource and Energy Supply System Development Program" in *JICA's country operation programs*.

3.1.4 Appropriateness of the Project Plan and Approach

The Project Design Matrix (PDM) at the time of the ex-ante evaluation set four indicators (Indicator 5.1 to Indicator 5.4) in Outcome 5. However, in the PDM used during the terminal evaluation, Indicator 5.3, "Impacts on land use, industry, employment, etc., are determined when the commercial use of Jatropha is assumed" was deleted, so it was not a subject of the evaluation judgement. However, the reason why Indicator 5.3 was deleted could not be confirmed.

In addition, Indicator 2 of the project purpose, "At least 6 researchers obtain a master/ PhD degree related to Jatropha", was not generated as a result of the activities of Outcomes 1-5 and therefore it is considered that Indicator 2 was not necessarily appropriate as an indicator to measure the achievement status of the project purpose. Rather, it would have been logistically appropriate to add the provision of scholarships to young Botswana researchers (master's and PhD students) engaged in Jatropha research, to give research guidance to them as project activities and use them as outcome indicators. However, it is considered that the appropriateness of the project plan and approach was not a problem, since the problems with the above two indicators cannot be said to be factors that prevented the project from being effective.

This project was highly relevant to Botswana's development plan and development needs, as well as Japan's ODA policy. Therefore, its relevance is high.

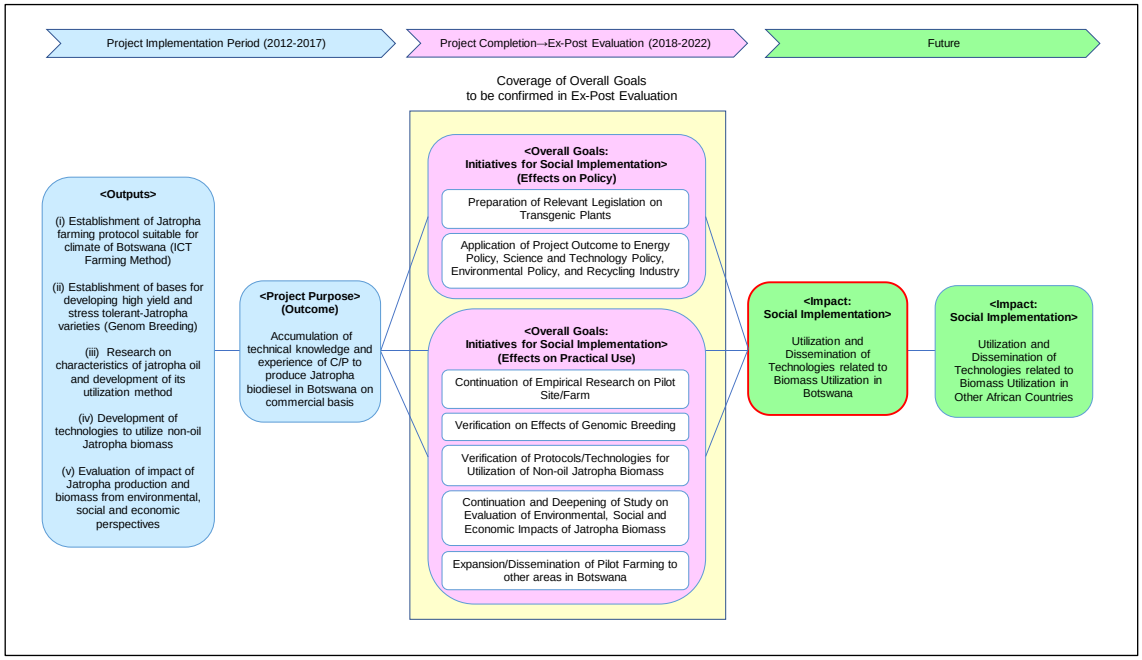
3.2 Effectiveness and Impact[10] (Rating: ②)

This project was a technical cooperation project conducted within the framework of SATREPS, which ultimately aimed to promote the social implementation of science and technology that responds to the issues and needs of the partner country, rather than merely providing support for basic or applied research. The social implementation aimed at by the project is the "Utilization and dissemination of technologies related to biomass utilization in

[10] The Sub-rating for Effectiveness is to be put with Consideration of Impact.

Botswana." [11] Several steps are necessary from the implementation of SATREPS to the realization of social implementation. For this reason, the "initiatives for social implementation" to be realized by 3-4 years after project completion were identified. These "initiatives for social implementation" were positioned as the overall goals of the project, and the achievement of the overall goals was analyzed from the viewpoint of whether or not various requirements were in place and whether progress was being made toward the realization of social implementation at the time of the ex-post evaluation.

The "initiatives for social implementation" are (i) Preparation of Relevant Legislation on Transgenic Plants, and (ii) Application of Project Outcome to Energy Policy, Science and Technology Policy, Environmental Policy, and the Recycling Industry as "Effect on Policy". They also include (iii) Continuation of Empirical Research on Pilot Sites/Farms, (iv) Verification of Effects of Genomic Breeding, (v) Verification of Protocols/Technologies for the Utilization of Non-oil Jatropha Biomass, (vi) Continuation and Deepening of Study on the Evaluation of Environmental, Social and Economic Impacts of Jatropha Biomass, and (vii) Expansion/Dissemination of Pilot Farming to other areas in Botswana as "Effect on Practical Use". The analytical framework used in this ex-post evaluation and the coverage of the overall goals to be confirmed in this ex-post evaluation is shown in Figure 1.




Source: Prepared by the Evaluator.

Figure 1 Evaluation Framework and Coverage of Overfall Goals

[11] It was assumed that initially the social implementation of this project was defined as "Commercial production and dissemination of Jatropha biodiesel." However, it was redefined in the ex-post evaluation as "Utilization and dissemination of technologies related to biomass utilization in Botswana" after the definition was confirmed with the researchers in Japan and Botswana.

3.2.1 Effectiveness

3.2.1.1 Project Outputs

(1) Output 1

Output 1 “Jatropha farming protocol suitable for the climate of Botswana is established” was achieved. In the four pilot farms in Sebele, Kang, Serowe and Maun, 76 indigenous accessions of Jatropha in Botswana and Jatropha in Ghanaian were planted, irrigation facilities and weather monitoring equipment were installed, and research on Jatropha cultivation was conducted. Based on the identification of the cold season through the analysis of weather data for the past five years, it was confirmed that irrigation twice a week from August to November while monitoring soil moisture would promote tree growth and flower bud differentiation, allowing seed harvesting before the winter (the frost season). In addition, for several superior accessions, it was possible to harvest more than 80 seeds per tree. Based on the above cultivation studies, a cultivation manual, “Jatropha Cultivation in Botswana”, was prepared.

(2) Output 2

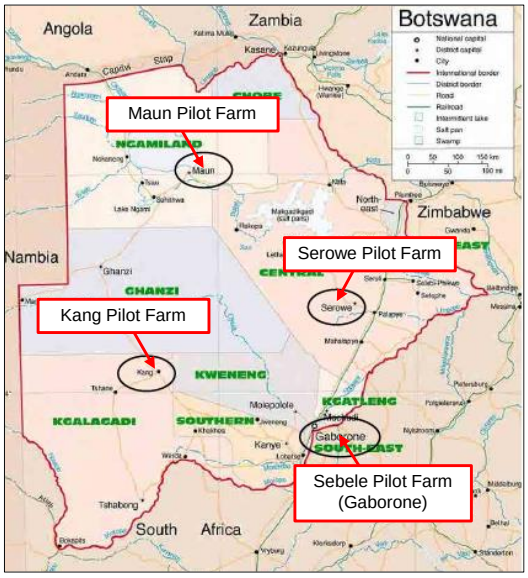
Output 2 “Bases for developing high yield and stress tolerant-Jatropha varieties are established” was achieved. The biomass productivity and seed productivity of all 76 accessions of Jatropha in Botswana planted in the Sebele pilot farm were assessed, and the accessions with high performance for each character were selected. Environmental stress tolerance was also evaluated based on biomass and seed productivity. In addition, genome analysis and databasing were conducted on five representative accessions of Jatropha in Botswana, and they were found to have high single nucleotide polymorphism (SNP). Based on this information, SNP markers were developed and the genotypes of all accessions of Jatropha in Botswana were analyzed, and successfully classified as a molecular phylogenetic tree. Following this, using a new transformation method developed at Tottori University, consisting of reduced pressure treatment and filter paper culture, three transgenic Jatropha varieties linked to high yield and stress tolerance were developed. Using this transgenic Jatropha, an environmental stress tolerance assessment was conducted at Tottori University, and it was confirmed that tolerance to low temperature stress had been improved. However, it was noted that it would take time for Outcome 2 to be disseminated to the Botswana side, as transgenic laws and regulations are not yet in place within Botswana and it was difficult to import the transgenic Jatropha varieties developed at Tottori University into Botswana. The transgenic Jatropha has been kept at Tottori University.

(3) Output 3

Output 3 “Characteristics of Jatropha oil production become clear” was achieved. As for the available 61 accessions of Jatropha harvested in Botswana, the oil content and oil composition of the seeds were analyzed, calorimetric data for typical accessions were obtained, and a database was constructed. 37 accessions that were harvested in the 2015 season out of the 76 accessions of Jatropha were analyzed for toxic compounds of Jatropha seeds, crude oil, and biodiesel. Basic fuel properties related to fuel specifications, such as the calorific value and viscosity of crude oil and biodiesel made from Jatropha seeds were measured, and combustion characteristics were determined using small generator and engine performance test equipment. Also, simulations of the electrification of non-electrified villages with small generators using biodiesel made from Jatropha were conducted, as well as the driving test of a vehicle using biodiesel. In addition, the yield efficiency of Jatropha biodiesel was calculated.

(4) Output 4

Output 4 “Technologies to utilize non-oil Jatropha biomass are developed” was achieved. The weight and composition of non-seed biomass (non-oil biomass) after oil squeezing, the shells of fruits, branches generated at harvest, etc. were analyzed to identify the characteristics of co-products (soil conditioners, raw fertilizer feedstock, solid fuel, catalysts). The results of the laboratory experiment on the application of Jatropha char to soil confirmed that soil treated with Jatropha char is likely to improve water holding capacity by more than 1.0% and water use efficiency by more than 0.5% compared to soil without Jatropha char. As a method of utilizing the non-oil biomass of Jatropha, technology has been developed to produce soil conditioners, solid fuels, solid fertilizers, etc. using biochar, and their effectiveness has been confirmed.




Source: Documents provided by JICA.

Figure 2 Map of Project Sites

(5) Output 5

Output 5 “Impact of Jatropha production and biomass use is evaluated environmentally, socially and economically” was achieved. A preliminary life cycle assessment of Jatropha production was conducted to estimate greenhouse gas emissions and reductions at various

stages of the Jatropha biodiesel project: the stages of cultivation, oil extraction, refining, distribution, and utilization. The results showed that in the Jatropha energy production and consumption process, reductions exceeded emissions by 63.4%. Secondly, an estimate of the reduction in petroleum fuel (diesel fuel) from Jatropha biodiesel production, a calculation of the reduction in wood fuel (firewood) from wood alternative fuel production, and an estimate of the number of households that could be supplied with a year's supply of firewood from wood alternative fuel were conducted. Following this, a cost-benefit analysis of the Jatropha biodiesel project was conducted by calculating the expenditure and revenue of the cultivation activities at the pilot farms and by constructing a scenario for generating profits using the model. In addition, a literature review of previously introduced Jatropha biodiesel projects in Sub-Saharan Africa was conducted, which supported the validity of the results of the above analysis.

3.2.1.2 Achievement of Project Purpose

The project purpose "Technical knowledge and experience to produce Jatropha biodiesel in Botswana on a commercial basis is accumulated" is judged as being mostly achieved. Table 1 shows the achievement status of each indicator.

Table 1 Achievement Status of Project Purpose

| Project Purpose | Indicator | Actual Status |
|---|---|---|
| Project Purpose: Technical knowledge and experience to produce Jatropha biodiesel in Botswana on a commercial basis is accumulated | Indicator 1: At least 5 academic papers are published. | Mostly achieved.<br>• Based on a literature review of projects previously introduced in Sub-Saharan Africa, an analysis of the requirements for, and issues connected to, the introduction of Jatropha biodiesel projects in Botswana from the perspectives of economic sustainability, energy policy, and socio-economic impacts was conducted. Four academic papers were submitted to international journals.<br>• In addition to the above, 28 original papers (26 in international journals and 2 in domestic journals) and 13 publications were also presented. In addition, the results of the research were compiled as manuals, databases, etc. |
| | Indicator 2 At least 6 researchers obtain master's/PhD degrees related to Jatropha. | Not achieved.<br>• Seven researchers received scholarships from the Botswana Government. Six started Jatropha research as graduate students at University of Botswana and one at the University of Botswana of Agriculture and Natural Resources (BUAN). However, the provision of the scholarships was significantly delayed due to delays in budget preparation by the Botswana Government. As a result, only one student was able to obtain a master's degree by project completion. |
| | Indicator 3 Technology protocols based on the Outputs of the Project are presented to the Botswana Government | Achieved.<br>• Technical knowledge and protocols related to Jatropha cultivation methods, the development of transgenic Jatropha, and the utilization of non-oil biomass were compiled into a Technological Package and submitted to the Botswana Government. |

Source: Documents provided by JICA.

Indicator 1 “At least 5 academic papers are published” was mostly achieved, Indicator 2 “At least 6 researchers obtain master’s/PhD degrees related to Jatropha” was not achieved, and Indicator 3 “Technology protocols based on the Outputs of the Project are presented to the Botswana Government” was achieved. The reason why Indicator 2 was not achieved was that the start of research for seven doctoral and master's degree graduate students was delayed due to a delay in their receiving scholarships from the Botswana Government, and as a result, only one graduate student was able to obtain a doctoral or master's degree by the time of project completion. However, it is questionable whether Indicator 2 was appropriate as an indicator of project purpose, since it was to be generated not as a result of joint research by universities and research institutions on the Japan-Botswana side conducted as activities for Outcomes 1-5, but through the research activity of Botswana graduate students based on technical knowledge and experience gained through the project. It would, rather, have been logistically appropriate to add the provision of scholarships to young Botswana researchers (master's and doctoral graduate students) on Jatropha research together with research guidance as project activities and use these as outcome indicators. On the other hand, Outcomes 1-5 are directly related to Indicators 1 and 3 of the project purpose, as the activities are carried out by both the Japanese and Botswana researchers, regardless of the schedule of the scholarship program for graduate students.

Based on the above, it was concluded that the project generally achieved its purpose, since (i) Outcomes 1-5 had been achieved by project completion, and (ii) Indicators 1 and 3 are directly related to Outcomes 1-5, and thus more weight was given to the achievement status of Indicators 1 and 3 in the evaluation judgment.

### 3.2.2 Impact

#### 3.2.2.1 Achievement of Overall Goal

No overall goals were set for this project. Therefore, as mentioned earlier in this ex-post evaluation, “Initiatives for social implementation” that should be achieved by the third to fourth year after project completion were identified and positioned as the overall goals of the project. The degree of achievement of the overall goals was then judged from the perspective of whether various requirements were in place for social implementation and whether progress toward the realization of social implementation was being made as of the ex-post evaluation. Table 2 shows the results of the overall goals.

Tale 2 Achievement Status of the Overall Goals identified in the Ex-Post Evaluation

| Overall Goals | Actual Status |
|---|---|
| (i) Preparation of Relevant Legislation on Transgenic Plants | • Legislation on transgenic plants is under discussion by the National Assembly and is expected to be approved by the end of 2022, according to the Ministry of Agriculture. |
| (ii) Application of Project Outcome to Energy Policy, Science and Technology Policy, Environmental Policy, and the Recycling Industry | • A guideline "Biofuel Guideline for Botswana" (May 2021) has already been prepared by the DOE/MMGE. This outlines the procedures for the production of biofuels, and is expected to be officially approved by the end of 2022. Once approved, the guidelines will be made available to the public. |
| (iii) Continuation of Empirical Research on Pilot Sites/Farms | • Since the project completion, no Jatropha has been cultivated in the four pilot farms in Sebele, Kang, Serowe, and Maun, with the exception of Sebele. Although the pilot farm in Sebele remains for the preservation of the accessions of Jatropha with high performance for biomass productivity and seed productivity selected from all 76 accessions of Jatropha in Botswana by the project, the cultivation of Jatropha has become difficult due to damage caused by frosts in winter and the theft of weather monitoring equipment installed on the pilot farm. |
| (iv) Verification of the Effects of Genomic Breeding | • At the time of the ex-post evaluation, the continuation of empirical research on the development of high-yielding and stress-tolerant Jatropha varieties (genomic breeding) by DAR/MOA had been substantially suspended due to the lack of the relevant legislation for transgenic plants required for the continuation of genomic research in Botswana, and a difficulty in importing the transgenic Jatropha varieties developed in Japan. DAR/MOA has shown its willingness to import the transgenic Jatropha varieties kept at Tottori University, and to resume empirical research on the effectiveness of genomic breeding after the passage of the legislation and to expand it from laboratory level to the field. |
| (v) Verification of the Protocols/Technologies for Utilization of Non-oil Jatropha Biomass | • DAR/MOA have continued an empirical study of agricultural fertilizer (compost) using biochar produced from Jatropha non-oil biomass. The empirical study researches the ratio of biochar which is appropriate to produce effective compost, this compost being provided free of charge to farmers as well as to vegetable growers at DAR/MOA's farms. Monitoring is being conducted to verify the effectiveness of the compost. According to DAR/MOA, this biochar has a high salt content, so when it is mixed with soil and used as compost, the content rate is limited to 10% or less.<br>• Based on the results of this empirical study, DAR/MOA plans to disseminate knowledge on the production and use of Jatropha biochar to farmers in the future. |
| (vi) Continuation and Deepening of Study on Evaluation of the Environmental, Social and Economic Impacts of Jatropha Biomass | • Although the research results anticipated during project implementation were obtained, the same research has not been continued after project completion. |
| (vii) Expansion /Dissemination of Pilot Farming to other areas in Botswana | • Although, after project completion, Japanese cooperating organizations such as Tottori University applied for a second phase of this SATREPS project through JST in 2018-2019, the application was not accepted. In addition, the project team planned to conduct a village electrification project using Jatropha diesel and a land improvement project using Jatropha biochar through the grassroots technical cooperation project scheme and submitted an application to JICA. This application was not adopted because the project plan was not sufficient. The Botswana executing agencies and Japanese cooperating agencies are continuing to conduct project formulation studies, including review and refinement of the project plan, with the aim of adopting the project as a grass-roots technical cooperation project. However, the global outbreak of COVID-19 has made travel from Japan to Botswana difficult and field surveys have been suspended.<br>• As described above, the Botswana executing agencies and the Japanese cooperating agencies had envisioned expanding and deploying the results of the empirical research obtained through this project to other areas in Botswana |

| Overall Goals | Actual Status |
|---|---|
| | through the implementation of a second phase of the SATREPS project and the utilization of the JICA grassroots technical cooperation project. |

Source: The responses to the questionnaires with the Botswana executing agencies and the Japanese cooperating agencies, and interview results.

Utilization of Non-oil Jatropha Biomass

Raw material of Jatropha biochar (Jatropha trunk branches)

Compost production facility using Jatropha biochar.

Compost produced.

Three of the seven initiatives for social implementation based on the research results of this project have been implemented or are being implemented, and four have not yet been implemented. Therefore, it is judged that the project has achieved its overall goal at a limited level.

3.2.2.2 Continuation Status of Project Effects

(1) Utilization of Research Outputs

The continuation status of the five outputs (five research areas) of the project is shown in Table 3. As mentioned in "3.1.2 Consistency with the Development Needs of Botswana", after the project completion, the Botswana Government changed its policy to the development of biodiesel by utilizing biomass other than Jatropha. In response, DOE/MMGE, DAR/MOA, and University of Botswana are collaborating and cooperating in the "Biofuels Production Project" (April 2018 - March 2023), which will utilize various forms of biomass available in Botswana. The above events have affected the continuation and progress of each project output after its completion.

Output 1 was not being continued at the time of the ex-post evaluation. Research relating to Output 2 was inactive at the time of the ex-post evaluation, although there is still a possibility that it will be restarted after the enactment of the relevant legislation on transgenic plants in Botswana. Research relating to Output 3 is being undertaken by doctoral and postgraduate students of

Jatropha

Jatropha seeds

Jatropha seedling

Jatropha in Sebele pilot farm

University of Botswana, and is continuing to a certain extent. Meanwhile, the main focus of research activities is no longer limited to the production of biodiesel from Jatropha seeds, but has expanded to include research on the production and utilization of biodiesel from other available options such as Trichilia and other plant species, waste cooking oil, beef tallow, etc. University of Botswana is producing biodiesel from waste cooking oil and beef tallow, and conducting field driving tests using university diesel vehicles. As for Output 4, an empirical study of fertilizer (compost) using Jatropha biochar is continuing at DAR/MOA, and University of Botswana is also continuing research on the use of Jatropha non-oil biomass as a raw material for solid fuel (pellets). Output 5 was not continued after project completion. However, since the emphasis has shifted to the research and development of biodiesel feedstock other than Jatropha, the need to continue Output 5 at the time of the ex-post evaluation did not appear to be as high as initially assumed.

Table 3 Continuation Status of Research

| Outputs | Continuation Status at Ex-Post Evaluation |
|---|---|
| Output 1<br>Jatropha farming protocol suitable for the climate of Botswana is established. | **[DAR/MOA]**<br>• Since project completion, no Jatropha has been cultivated in the four pilot farms in Sebele, Kang, Serowe, and Maun, although there is an exception at Sebele where the pilot farm remains for the preservation of the accessions of Jatropha with high performance for biomass productivity and seed productivity selected from all 76 accessions of Jatropha in Botswana by the project. It has become difficult to grow Jatropha due to damage caused by frost in winter and the theft of weather monitoring equipment installed at the pilot farm. Sebele pilot farm has been managed by DAR/MOA continuously.<br>• Meanwhile, DAR/MOA is conducting research on how to cultivate plants other than Jatropha (varieties such as Trichilia, Scythia, and Croton), which are available in Botswana as feedstock for biodiesel, and the research results of Output 1 are also helping in this research. |
| Output 2<br>Bases for developing high yield and stress tolerant-Jatropha varieties are established. | **[DAR/MOA]**<br>• Since the Jatropha varieties developed by the project are not sufficiently stress tolerant to low temperatures, research on the genome breeding of Jatropha resistant to cold weather in winter should be continued. However, this research activity is being suspended until the enactment of related legislations on transgenic plants (the legislation is expected to be enacted by the end of 2022).<br>• A map of Indigenous Potential Biomass was prepared.<br>• The scope of research is being expanded from the development of biodiesel using Jatropha to research and development of biodiesel using plants other than Jatropha (varieties such as Trichilia, Scythia, and Croton). For example, research on Ethiopian mustard (the oil is not edible), and comparative analysis of the properties of Jatropha and other plant-derived oils. |
| Output 3<br>The characteristics of Jatropha oil production become clear. | **[University of Botswana]**<br>• Jatropha-related research is being carried out by several PhD and master's students, and the research itself continues in part. |

| Outputs | Continuation Status at Ex-Post Evaluation |
|---|---|
| | • Meanwhile, the main focus of current research activities is not limited to the production of biodiesel from Jatropha seeds, but has expanded to include research on the production and utilization of biodiesel from other available options, such as other plant species such as Trichilia, waste cooking oil, and beef tallow (research on biomass utilization not limited to Jatropha).<br>• A machinery (Bio-Prob 380 EX processor) has been developed to extract biodiesel from waste cooking oil, beef tallow, etc., enabling the production of 380 liters of biodiesel per batch. This biodiesel is actually used in the vehicles provided by the project, and University of Botswana aims to produce enough biodiesel to supply all the university's diesel vehicles in the future.<br>  <br>Bio-Prob 380 EX processor |
| Output 4<br>Technologies to utilize non-oil Jatropha biomass are developed | **[DAR/MOA]**<br>• The empirical study on biochar production and fertilizer (compost) using biochar is ongoing. The compost is provided free of charge to farmers as well as to vegetable growers at DAR/MOA's farms, and monitoring is being conducted to verify the effectiveness of the compost.<br>**[University of Botswana]**<br>• Jatropha-related research, including studies on the use of Jatropha non-oil biomass as a feedstock for solid fuels (pellets), is being carried out by several doctoral and master's students at University of Botswana. |
| Output 5<br>Impact of Jatropha production and biomass use is evaluated environmentally, socially and economically. | **[University of Botswana]**<br>• Although the research results anticipated during project implementation were obtained, the same research has not been continued after the completion of the project. |

Source: The responses to the questionnaires with the Botswana executing agencies and the Japanese cooperating agencies, and interview results.

(2) Capacity Development of Researchers

University of Botswana recognizes that this project has made a significant contribution to the capacity building and development of researchers at the university. Based on the research results of this project, University of Botswana has selected a research theme for the doctoral and master's theses of graduate students in the Faculty of Engineering and Technology, and related research continues. Laboratory equipment provided to University of Botswana and DAR/MOA under this project has also been used in this research. According to DAR/MOA, conventional research areas were mainly crop cultivation and animal husbandry, but participation in the project has led to the expansion and advancement of DAR/MOA's research areas with the addition of biomass research.

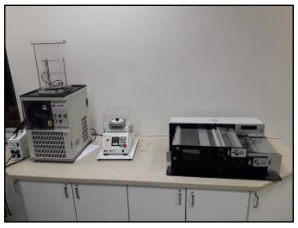
(3) Utilization, Operation, and Maintenance of the Equipment

The project provided various research and experiment equipment, including photosynthesis measuring equipment, denaturing gradient gel electrophoresis units, gel photography equipment, weather station units, leaf area meters, DNA electrophoresis equipment, freeze dry lyophilizers, and refrigerators for seed. These were still being used

for research at University of Botswana and DAR/MOA at the time of the post evaluation. There were no major issues in the maintenance of these items of equipment.

Equipment of DAR/MOA provided by the Project


Laboratory at DAR/MOA


leaf area meter


Protein Analyzer


High-temperature, high-pressure sterilizer

Equipment of University of Botswana provided by the Project


Laboratory at University of Botswana


Biodiesel Extraction Equipment


Biodiesel Extraction Equipment

Biodiesel Starter Kit

3.2.2.3 Other Positive and Negative Impacts

(1) Impact on Natural Environment

At the time of the ex-ante evaluation, it was recognized that the toxic substances and transgenic varieties of Jatropha handled in this project had a small but recognizable potential for adverse effects on the natural environment and human health. Therefore, it was planned that the project would incorporate into its activities research to characterize toxic substances and to conduct research on genetic modification in compliance with national and international regulations. This was carried out as planned. The research on transgenic (genome breeding research) was conducted mainly in Japan by Japanese collaborating institutions such as Shimane University, because Botswana had not yet developed the relevant legislation on transgenic plants.

During project implementation, the necessary environmental monitoring was carried out, and according to DAR/MOA, no negative impact of Jatropha was found either on the natural environment or on the health of project personnel on the pilot farms. Nor were any environmental impacts associated with transgenic observed.

(2) Resettlement of People and Land Acquisition

Since the four pilot farms, where the cultivation research on Jatropha was conducted, were located on land owned by MOA, there was no resettlement of people nor land acquisition associated with the project.

The project purpose was achieved through the implementation of the project. As for the initiatives for social implementation, which were set as the overall goals of the project, three out of seven have been implemented or are being implemented, and four have not yet been implemented. Regarding the continuation status of the project effects, Output 2, Output 3, and Output 4 were continued, while Output 1 and Output 5 were not continued. The project contributed to the development of the research capacity of researchers in the executing agencies in Botswana, and there were generally no problems in the utilization and maintenance of equipment. No negative impact on the natural environment, land acquisition, or resettlement of people was observed.

Based on the above, the project has produced positive project effects to some extent, therefore, the effectiveness and impact of the project is fair.

## 3.3 Efficiency (Rating: ③)

### 3.3.1 Inputs

Table 4 shows the comparison between the planned and actual inputs.

Table 4 Planned and Actual Inputs

| Inputs | Plan | Actual |
|---|---|---|
| (1) Experts | • Long-term: Coordination, Cultivation (number of experts, man-month not stated)<br>• Short-term:<br>• Cultivation, Plan molecular breeding, Postharvest processing, No-oil biomass production, other specialties (number of experts, man-month not stated) | • Lon-term: 4 persons<br>• Short-term: 15 persons |
| (2) Trainees received | N.A. | 29 persons |
| (3) Equipment | N.A. | Vehicles, photosynthesis measurement devices, various measurement devices and equipment, etc. |
| (4) Operational costs | N.A. | Approximately 23.2 million yen |
| Japanese Side Total Project Cost | 300 million yen | 296 million yen |
| Botswana Side Total Project Cost | Amount not stated.<br>(Personnel costs of the counterpart staff, labour costs of pilot farms, costs for laboratory equipment, costs for symposiums and workshops etc.) | Approximately 132 million yen<br>(Personnel costs of the counterpart staff, fuel costs for project vehicles, labour costs of pilot farms and security guards, costs for dispatching long-term trainees, costs for workshops, meetings, training etc.) |

Source: Documents provided by JICA.

3.3.1.1 Elements of Inputs

Nineteen experts/researchers (Lon-term: 4 persons, Short-term: 15 persons) were dispatched from Japan. The number of Botswana researchers received was 29.

As mentioned earlier, joint research in the five research areas was successfully conducted within the project period. A cultivation manual “Jatropha Cultivation in Botswana” was produced, together with a technical package, four academic papers were published in international journals, and a database was constructed. The equipment provided is generally well utilized and maintained.

The Botswana side made inputs of approximately 132 million yen for the personnel costs of the counterpart staff, costs for dispatching long-term trainees, costs for workshops, meetings, training etc., and it can be said that the project was implemented under the partnership of Botswana and Japan.

3.3.1.2 Project Cost

The actual project cost on the Japanese side was 296 million yen against the planned 300 million yen, which was within the plan (98% against plan).

3.3.1.3 Project Period

The actual project period was 60 months (April 2012 – April 2017) against the planned 60 months (March 2012 – March 2017), which was as planned (100% against plan).

Both the project cost and project period were within the plan. Therefore, efficiency of the project is high.

3.4 Sustainability (Rating: ③)

3.4.1 Policy and Political Commitment for the Sustainability of Project Effects

The development of renewable energy, including the use of Jatropha, is listed as a priority area in *the Eleventh National Development Plan (2017-2023)*, and *the National Energy Policy of Botswana (2020-2040)* also mentions the potential of Jatropha as a biofuel. In addition, legislation on transgenic plants, which is necessary for research on the genome breeding of Jatropha, is expected to be passed by the end of 2022. At the time of the ex-post evaluation, the Botswana Government’ policy has been promoting the development of biodiesel by utilizing biomass other than Jatropha as well, and DOE/MMGE, DAR/MOA, and University of Botswana will continue and develop the results of this SATREPS project through the ongoing “Biofuels Production Project” (2018-2023). Not limiting themselves to the development of Jatropha biodiesel, they are working to develop biodiesel using waste biomass, including resource crops indigenous to Botswana, tallow, and waste cooking oil,

as a continuation and expansion of the project outcomes.

Therefore, it can be seen that the policy and political commitment to sustain the project effects have been secured.

### 3.4.2 Institutional/Organizational Aspects for the Sustainability of Project Effects

In addition to its headquarters in Sebele, outside of Gaborone, DAR/MOA has numerous branches and offices throughout the country and is organized into four divisions: the Crop Research Division, the Livestock and Rangeland Research Division, the Support Services Division, and the Human Resources Division. The headquarters of DAR/MOA in Sebele has vast pilot farms and laboratory facilities for the chemical analysis of soil and other materials, DNA analysis, and so on. DAR/MOA also plays an important role as a seed provider for domestic agriculture, supplying 90% of the agricultural seeds used in the country. It is also responsible for the conservation of plant genetic resources and is in charge of biosafety, including the management of transgenic plants. At the time of the ex-post evaluation, 15 researchers were engaged in research related to the project at DAR/MOA.

University of Botswana, established in 1982, is a comprehensive university in Botswana. It has seven faculties: Business Administration, Education, Engineering and Technology, Health Sciences, Medicine, Humanities, and Social Sciences. Research on biodiesel, including Jatropha, is handled by the Faculty of Engineering and Technology, and at the time of the ex-post evaluation, six researchers (faculty members and doctoral and master's course graduate students) were engaged in related research. In addition, after project completion, there has been ongoing collaboration and cooperation with Tottori University and other cooperating institutions on the Japanese side, mainly on an individual basis.

Therefore, the institutional/organizational aspects to sustain the project effects has been secured.

### 3.4.3 Technical Aspects for the Sustainability of Project Effects

DAR/MOA has been engaged in collecting plant resources and cultivation experiments with Jatropha since the latter half of 2000. With the support of the “Biofuels Production Project” mentioned above, DAR/MOA has also been cultivating and conducting research on plants other than Jatropha (varieties such as Trichilia, Scythia, Croton, etc.), which can be used as raw materials for biofuels. DAR/MOA intends to continue the cultivation method (ICT farming) and molecular genome breeding of Jatropha suitable for the climate of Botswana after the relevant legislation on transgenic plants has been enacted, and to import the transgenic Jatropha varieties kept at Tottori University to Botswana, and therefore, the accessions of Jatropha with high performance for biomass productivity and seed

productivity selected from all 76 accessions of Jatropha in Botswana by the project is being preserved at the Sebele pilot farm. Research on the utilization technology of biochar made from Jatropha also continues. The laboratory equipment provided to DAR/MOA is in continuous use and is maintained generally in good condition.

University of Botswana earlier recognized the potential of circular energy and established the Clean Energy Research Centre (CERC) (a virtual research organization to which researchers related to the development and promotion of circular energy belong) to conduct interdisciplinary research that takes advantage of each researcher's expertise. The expertise of the individual researchers is high, and they have published many academic papers. With reference to the research results of this project, the Faculty of Engineering and Technology, University of Botswana, with the support of the "Biofuels Production Project", is also conducting research on biodiesel fuel using indigenous Botswana plants and other biomass (tallow, waste cooking oil, etc.). The university has developed equipment for producing biodiesel from tallow and waste cooking oil, and is also testing actual vehicles with fuel. The laboratory equipment provided to University of Botswana is in continuous use, and is also maintained generally in good condition.

Therefore, the technical aspect to sustain the project effects has been secured.

3.4.4 Financial Aspect for the Sustainability of Project Effects

University of Botswana received 2,080,000 Pula (approximately 21.4 million yen) in 2020 and 1,900,000 Pula (approximately 19.5 million yen) in 2021 from the "Biofuels Production Project". Similarly, DAR/MOA also received a research grant from the same project for the collection of plants that can be used for biofuels. Through the "Biofuels Production Project", DAR/MOA and Botswana will be provided with financial support for research into the development of biodiesel from biomass at least until 2023.

Therefore, it is judged that there are no major issues in the institutional/organizational aspects to sustain the project effects.

No major problems have been observed in the policy background nor in the institutional/ organizational, technical, financial aspects. Therefore, the sustainability of the project effects is high.

## 4. Conclusion, Lessons Learned and Recommendations

4.1 Conclusion

The project aimed to accumulate the technical knowledge and experience to produce Jatropha biodiesel in Botswana on a commercial basis by conducting research in five areas: (i) the establishment of a Jatropha farming protocol suitable for the climate of Botswana, (ii)

the establishment of bases for developing high yield and stress tolerant Jatropha varieties, (iii) research on the characteristics of jatropha oil and development of its utilization methods, (iv) development of technologies to utilize non-oil Jatropha biomass, and (v) evaluation of the impact of Jatropha production and biomass from environmental, social and economic perspectives. This is in line with the Botswana's development policies and needs, as well as with Japan's assistance policy, and thus its relevance is high. In all five areas, research outputs were produced according to the plan and the project purpose was mostly achieved. Regarding the initiatives for social implementation set as the overall goals, three out of seven initiatives have been already completed or are on-going, and the remaining four have been not implemented yet. The project has made a certain contribution to improving the research capacity of the implementing agencies in Botswana, and there were generally no problems with the operation and maintenance of equipment. No negative impact on the natural environment was observed, nor was land acquisition and the resettlement of people. Since this project has to some extent achieved the project purpose and overall goal, the effectiveness and impact of the project are fair. Both the project cost and project period were within the plan. Therefore, the efficiency of the project is high. No major problems have been observed in the policy background nor in the institutional/organizational, technical, and financial aspects. Therefore, the sustainability of the project effects is high.

In light of the above, this project is evaluated to be highly satisfactory.

## 4.2 Recommendations

### 4.2.1 Recommendations to the Implementing Agency

Since project completion, the pilot farm in Sebele (Gaborone), which is managed by DAR/MOA, has continued to grow Jatropha to preserve the accessions of Jatropha with high performance for biomass productivity and seed productivity selected from all 76 accessions of Jatropha in Botswana by the project. However, weather monitoring data cannot be collected and recorded due to the theft of the weather monitoring equipment provided by the project and installed at the pilot farm. It is desirable that MOA consider the re-procurement of weather monitoring equipment.

### 4.2.2 Recommendations to JICA

JICA has conducted projects related to research on biodiesel development using Jatropha (including SATREPS) in countries other than Botswana, such as Vietnam[12], Mozambique[13],

[12] Vietnam "Multi-beneficial measure for the mitigation of climate change in Vietnam and Indochina countries by development of biomass energy" (2011-2016).

[13] Mozambique "Sustainable Production of Biodiesel from Jatropha in Mozambique" (2011-2016).

and Thailand[14], However, there have not been many cases in which Jatropha biodiesel itself has been promoted and commercialized after project completion. The reasons for this include the difficulty of cultivating Jatropha due to differences in climatic conditions in different countries. Even when it is successfully cultivated, trends in market prices result in higher prices for Jatropha biodiesel compared to other biomass fuels and fossil fuels, reducing incentives for the production and sale of Jatropha biodiesel.

On the other hand, the knowledge and technology related to biodiesel production gained through research on Jatropha biodiesel are still being used in the respective countries after project completion. Therefore, for SATREPS projects related to research on biodiesel development, it is recommended that issues from project implementation to social implementation are analyzed across countries. Identification and analysis of how to devise measures that will lead to the social implementation aimed for by the SATREPS project should take place during project formulation, implementation, and after project completion.

### 4.3 Lessons Learned

(1) Necessity to reconfirm social implementation at the time of project planning and after project completion

The main focus of this project was research for the commercial production of biodiesel using Jatropha, and it is believed that it was initially thought that "Commercial production and dissemination of biodiesel using Jatropha" would be envisioned as a social implementation beyond the Outputs of the project. This would have taken such forms as (i) the establishment of a Jatropha farming protocol suitable for the climate of Botswana (ICT Farming Method), (ii) the establishment of bases for developing high yield and stress tolerant-Jatropha varieties (Genome Breeding), (iii) research on the characteristics of jatropha oil and development of its utilization method, (iv) development of technologies to utilize non-oil Jatropha biomass, and (v) evaluation of the impact of Jatropha production and biomass from environmental, social and economic perspectives.

Although, it was confirmed that through this project, the project has made some achievements in the development of transgenic Jatropha seeds and cultivation methods that are stress tolerant in the climatic conditions of Botswana, the needs became apparent for continued research on cultivation methods, genome breeding research, and the establishment of domestic laws in related fields before promotion of full-scale cultivation of Jatropha. The difficulties of growing Jatropha in Botswana were once again recognized. The energy policy of the Botswana government has also changed direction from the production of biodiesel from Jatropha to the production of biodiesel from biomass including Jatropha. For this

[14] Thailand "Innovation on Production and Automotive Utilization of Biofuels from Non-Food Biomass" (2010-2016).

reason, the social implementation of the project was redefined as the “Utilization and dissemination of technologies related to biomass utilization in Botswana”, broadly defined as the utilization of technologies for breeding bioresources and biodiesel production in this ex-post evaluation. While logically the above modification can be considered appropriate, the level of positioning of this project from the perspective of social implementation may have been relatively lower than originally envisioned. Thus, as a result of the implementation of SATREPS, there are cases in which the social implementation envisioned at the time of project planning should be reconfirmed, revised, or reviewed. Therefore, as well as at the time of project planning, the direction of the social implementation of the research results generated by the SATREPS should be discussed among project stakeholders during the project implementation period, and be revised or be amended as necessary.

In addition, it would have been recommendable if JICA and project stakeholders should have explained the significance of this project even more to the Botswana government department in charge of legalization and encouraged them to develop a domestic law on genetic modification throughout the project period.

(2) Necessity to identify and review Project Design Matrix (PDM) based on logic

Indicator 2 of the project purpose, “At least 6 researchers obtain a master/PhD degree related to Jatropha”, was not generated as a result of the activities of Outcomes 1-5. Thus, Indicator 2 was not necessarily appropriate as an indicator to measure the achievement status of the project purpose. Rather, it would have been logistically appropriate to add the provision of scholarships and research guidance for Jatropha research to young Botswana researchers (master's and PhD students) as a project activity, and also use this as an outcome indicator. Therefore, this ex-post evaluation made an evaluation judgement on the achievement status of the project purpose focusing on Indicator 1 and Indicator 3 of the three indicators. Since indicators of project purpose are important in measuring the effectiveness of a project, it is recommended that the relationship between, and the logic of, project outputs and project purpose be carefully checked regularly during the project implementation and the terminal evaluation, and that changes are made to the Project Design Matrix (PDM) and alternative indicators proposed as necessary.

(End.)